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***Domitius lusitanicus* (Araneae, Nesticidae)
- an umbrella species for the conservation
of troglobionts in the Estremenho Karst
Massif, Portugal**

Tomás Alves,  Ana Sofia P. S. Reboleira

Domitius lusitanicus (Araneae, Nesticidae) - an umbrella species for the conservation of troglobionts in the Estremenho Karst Massif, Portugal

Tomás R. L. Alves[‡], Ana Sofia P. S. Reboleira^{‡,§}

[‡] Centre for Ecology, Evolution and Environmental Changes (cE3c) & CHANGE - Global Change and Sustainability Institute, and Departamento de Biologia Animal, Faculdade de Ciências, Universidade de Lisboa, Lisbon, Portugal

[§] Museu Nacional de História Natural e da Ciência, Universidade de Lisboa, Rua da Escola Politécnica, Lisbon, Portugal

Corresponding author: Ana Sofia P. S. Reboleira (asreboleira@fc.ul.pt)

Abstract

Background

Domitius lusitanicus (Fage, 1931) is a troglobiont spider, endemic from caves in the largest karst massif in Portugal, the Estremenho. It was the first described cave-adapted species from Portugal, but the male of the species was only described in 1988.

New information

Over the last two decades, the knowledge on the distribution of *D. lusitanicus* increased significantly. We assess the conservation status of *D. lusitanicus*, providing new information on its extent of occurrence and the anthropogenic threats, and present a IUCN Red List profile. *D. lusitanicus* faces various anthropogenic threats, such as habitat loss, agriculture, pollution, and tourism impacts. Despite a large part of its distribution is included in a Natural Park, it expands outside of the areas deemed for protection in the Natura 2000 network. This species has the widest spread distribution of all troglobionts in the Estremenho Massif, therefore it may be used as an umbrella species for the protection of other cave-adapted species of the massif.

Introduction

Cave-adapted communities have high conservationist interest (Mammola et al. 2019), they are habitat specialists with high endemism patterns, reduced population numbers and low fertility traits (Deharveng et al. 2024). Cave fauna face direct anthropogenic threats, such

as groundwater contamination, habitat destruction due to quarrying activities and excess cave visitation (Castaño-Sánchez et al. 2020).

Nesticidae is a small family of spiders with a worldwide distribution that includes 16 genera and 289 described species (World Spider Catalog 2023). Seven genera and 56 species are known from Europe, distributed from the Iberian Peninsula to the Caucasus and the Ural Mountains (Ribera and Dimitrov 2023). Most of these European species are cave dwellers and many of them are troglobionts i.e., cave-adapted species. Due to these habitat preferences, many nesticids present small and confined distributions, as in cave habitats (Ribera and Dimitrov 2023). *Domitius* Ribera, 2018 is an independent evolutionary lineage of nesticids, a sister group to the clade formed by *Kryptonesticus* Pavlek & Ribera, 2017, *Carpathonesticus* Lehtinen & Saaristo, 1980 and *Nesticus* Thorell, 1869 (Ribera 2018).

Domitius lusitanicus (Fage, 1931) was described in 1931 under the genus *Nesticus* by Louis Fage, based on female specimens. Male specimens were only described 67 years later (Ribera 1988). It is an endemic troglobiont species of Portugal, only recorded in caves of the Estremenho Karst Massif, making it a priority species for conservation actions. This species was recently profiled for conservation (Branco et al. 2019), but a wide array of new information on its distribution and threats made necessary to update and develop its conservation profile. Additionally, it is the most widespread troglobiont species in the its karst area (Reboleira 2012), and can therefore be used as an umbrella species (Roberge and Angelstam 2004) for subterranean biodiversity endemic to its Estremenho Massif. We assessed the conservation profile of *D. lusitanicus* based on recently collected data.

Material and methods

Caves of the Estremenho Karst Massif were sampled by direct search for the past two decades, under permits of the Instituto de Conservação da Natureza e das Florestas. The specimens were sorted and identified to species level through dissection and microscopy.

Extent of occurrence (EOO) and area of occupancy (AOO) were calculated using the Geospatial Conservation Assessment Tool (GeoCAT) with an approximation to the standard IUCN 2 km × 2 km cells (4 km²). A map was created in the open-source software QGIS (v3.22.6; QGIS Development Team 2009), with the hypsometry of Portugal and the total protected area bound by “Parque Natural da Serra de Aire e Candeeiros” layers (DGT 2023, ICNF 2023).

Threats were identified *in situ*, complemented with literature surveys and satellite images provided by Google Earth software. These threats, as well as habitat classification and conservation measures were assigned based on the IUCN Red List criteria.

Species Conservation Profile

Domitius lusitanicus (Fage, 1931)

Species information

Taxonomy

Kingdom	Phylum	Class	Order	Family
Animalia	Arthropoda	Arachnida	Araneae	Nesticidae

Taxonomic notes

Distinct paracymbium shape and details in the palpal bulbs in male spiders, as well as clear morphological differences in the epigyne and vulva in the females (Ribera 1988).

Region for assessment:

- Europe

Figure(s) or Photo(s):

Figs 1, 2

Reviewers

Reviewers

Editor

Editor

Geographic range

Biogeographic realm:

- Palearctic

Countries:

- Portugal

Map of records (image):

Fig. 3

Map of records (Google Earth):

Suppl. material 1

Basis of EOO and AOO: Known habitat extent**Basis (narrative)**

The extent of occurrence (EOO) is 534.790 km² and the area of occupancy (AOO) is 84.0 km².

Min Elevation/Depth (m): 105**Max Elevation/Depth (m): 495****Range description**

Domitius lusitanicus was recorded from 27 caves distributed along the Estremenho Karst Massif across its four main subunits (Fig. 3): São Mamede Plateau/Aire Mountain Chain, Santo António Plateau, Candeeiros Mountain Chain, and Aljubarrota Plateau. In the São Mamede Plateau/Aire Mountain Chain subunit it was recorded in: Buraco Roto Cave, Lapa da Salgada Cave, Algar do Burro Cave, Mira de Aire Cave (Moinhos Velhos Cave), Contenda Cave (with underwater connection to Moinhos Velhos Cave), Santuário Cave, Almonda Cave, Algar da Lomba Cave. In the Santo António Plateau subunit it was recorded in: Lapa da Ovelha Cave, Morcegos Cave, Lapa da Chã de Cima Cave, Algar da Pena Cave, Pinheiro Cave, Algar da Cheira Cave, Algar da Arroteia Cave, Algar da Manga Larga Cave, Algar do Zé de Braga Cave, Algar das Marradinhas II Cave, Algar do Chou-Jorge Cave, Lapa dos Pocilhões Cave, Algar das Gralhas I Cave, Algar das Gralhas VII Cave, and Algar do Ladoeiro Cave. In Candeeiros Mountain Chain subunit it was recorded in: Alcobertas Cave, Senhora da Luz Cave, and Algar do Vale da Pena (=Algar dos Ursos) Cave. In the Aljubarrota Plateau subunit it was recorded in Ervideira Cave.

Extent of occurrence**EOO (km2): 534.79****Trend: Unknown****Causes ceased?: Unknown****Causes understood?: Unknown****Causes reversible?: Unknown****Extreme fluctuations?: Unknown**

Area of occupancy

AOO (km²): 84

Trend: Unknown

Causes ceased?: Unknown

Causes understood?: Unknown

Causes reversible?: Unknown

Extreme fluctuations?: Unknown

Locations

Number of locations: 27

Justification for number of locations

Domitius lusitanicus occurs in 27 caves of the Estremenho Karst Massif.

Trend: Unknown

Extreme fluctuations?: Unknown

Population

Number of individuals: Unknown

Trend: Unknown

Causes ceased?: Unknown

Causes understood?: Unknown

Causes reversible?: Unknown

Extreme fluctuations?: Unknown

Subpopulations

Trend: Unknown

Extreme fluctuations?: Unknown

Severe fragmentation?: Unknown

Habitat

System: Terrestrial

Habitat specialist: Yes

Habitat (narrative)

The caves are located at an elevation ranging from 105 to 495 m above sea level. The Buraco Roto Cave (Fátima) limits the distribution at North, while the Senhora da Luz Cave (Rio Maior) is the southern and westernmost locality of the distribution. The Almonda Cave (Torres Novas) represents currently the easternmost locality for the species' distribution.

Trend in extent, area or quality?: Decline (inferred)

Habitat importance: Major Importance

Habitats:

- 7.1. Caves and Subterranean Habitats (non-aquatic) - Caves

Ecology

Size: 2.9-3.5 mm

Generation length (yr): 1

Dependency of single sp?: Unknown

Ecology and traits (narrative)

Domitius lusitanicus is a troglobiont species, it is blind depigmented and has elongated legs. This species is usually found in the walls of caves of Estremenho Karst Massif with high relative humidity, after the twilight zone throughout the deepest parts. We have observed that without disturbance, the females stay in the same web for more than year. Males are more rare, and are found normally walking through the caves.

Threats

Threat type: Ongoing

Threats:

- 1.1. Residential & commercial development - Housing & urban areas
- 1.2. Residential & commercial development - Commercial & industrial areas
- 2.1. Agriculture & aquaculture - Annual & perennial non-timber crops

- 3.2. Energy production & mining - Mining & quarrying
- 3.3. Energy production & mining - Renewable energy
- 6.1. Human intrusions & disturbance - Recreational activities

Justification for threats

The overall area of distribution of *Domitius lusitanicus* is highly disturbed by human activities (Fig. 4). Almonda Cave and Pinheiro Cave are located 50 m from a factory that extracts water from the spring feed by its subterranean river and 420 m from a village, which has many agricultural fields. Algar do Ladoeiro Cave entrance is 840 m from the closest urbanisation. The subterranean streams in Mira de Aire and Contenda caves (connected underwater) have a high input of sewage from the surface and are located below the village of Mira de Aire; therefore, both caves are extremely contaminated by pollutants produced at the surface (Reboleira 2007). The Mira de Aire Cave is the largest show cave of Portugal with around 140,000 visitors per year and, since the 1960s, has had much infrastructure built for touristic exploitation, with a 300 m long show cave section (Reboleira et al. 2015). Santuário Cave is also located in the Mira de Aire village, with a parking lot three meters from its entrance. Alcobertas Cave has been exploited for touristic activities since the 70s, and an artificial secondary entrance has been opened, drastically changing the climatic conditions (Reboleira 2007, Reboleira et al. 2009), it is located 640 m from a field of energy windmills, 1 km from a quarry, 850 m from agricultural lands and 690 m from the nearest village. Algar do Vale da Pena Cave is in an abandoned quarry, 700 m from the closest village. Algar do Burro Cave is located 500 m from a quarry, 560 m from the A1 highway and 600 m from the closest village. Lapa da Chã de Cima Cave is located 500 m from a quarry. Algar do Zé de Braga Cave is located below intensive agricultural olive production, where the use of pesticides and fertilizers are prevalent. Pesticides and fertilizers are known to have a harmful effect on subterranean biota and easily infiltrate into underground habitats (Reboleira et al. 2013b, Castaño-Sánchez et al. 2020). Algar do Pena Cave hosts an interpretation centre and received visitation since 1997 (Popova 2022), it is located 300 m from a quarry. Algar das Gralhas I Cave and Algar das Gralhas VII Cave are located 125 m and 168 m from the same quarry, respectively. Algar das Marradinhas II Cave is located 1.5 km from the nearest village in an area of olive and cattle production (Reboleira et al. 2022). Algar da Arroiteia is located 112 m from the closest urbanisation and 1.3 km from a quarry. Lapa da Salgada Cave is located 270 m from a road used by large trucks to transport produce from warehouses 600 m away, it is also located 1 km away from the closest town. Lapa dos Pocilhões Cave is located 270 m from the nearest urbanisation and 545 m from a quarry. Algar do Chou-Jorge Cave is located 500 m from the nearest village. Algar da Manga Larga Cave is located 300 m from the nearest village. Algar da Cheira Cave is located 460 m from the nearest urbanisation, and has cattle maintainance on the surface. Algar da Lomba Cave develops below the A1 highway, it is located 30 m from the closest urbanisation, 350 m from a village, and 2 km from a wind farm. Buraco Roto Cave is located 125 m from the closest village and 450 m from a quarry. Senhora da Luz Cave is located 35 m from the closest urbanisation, 760 m from a quarry, and 1.9 km from the A15 highway. Ervideira Cave stands between two quarries, 715 and 990 m away, and is located 590 and 750 m from the nearest villages.

Lapa da Ovelha Cave is located 900 m from the nearest village. Morcegos Cave is located 390 m from the nearest urbanisation and 410 m from a quarry.

Conservation

Conservation action type: Needed

Conservation actions:

- 1.1. Land/water protection - Site/area protection
- 1.2. Land/water protection - Resource & habitat protection
- 2.1. Land/water management - Site/area management
- 4. Education & awareness
- 5.1.3. Law & policy - Legislation - Sub-national level

Justification for conservation actions

The Contenda and Mira de Aire caves are located below the village of Mira de Aire and infiltration of sewage is observed underground. To prevent wastewater run-off into subterranean galleries and groundwaters, measures to improve sewage treatment are necessary. Almonda Cave is protected due to its archaeological heritage and classified as a Property of Public Interest (IIP) since 1993 (Hoffmann et al. 2013). Despite that, the archaeological protection figure do not contemplate protection of cave-adapted fauna, so it is urgent to set protective measures appropriate this species. Of the 27 caves, only 20 are protected under legislation by the "Rede Natura 2000" (Directive H 1992, ICNB 2000). All caves with this endemic species should have a protected area delimited at surface that includes all drainage area of the caves. The caves Algar do Burro, Almonda, Pinheiro, Buraco Roto, Ervideira, Lapa da Salgada, and Senhora da Luz should be included in protection figures, as they are currently located out of protected areas. Moreover, it is recommended to carry out studies to better understand the extent of this species distribution, population size, abundance, life cycle, ecology, and the development of a conservation plan for *Domitius lusitanicus*. Environmental education about the importance of subterranean habitats and species is fundamental for long-term conservation, specifically targeted mainly for children in local schools and workers from the municipalities included in the distribution area of this species.

Discussion

Troglobionts as *Domitius lusitanicus* have reduced extent of occurrence (EOO) and area of occupancy (AOO), exhibiting highly endemic patterns of distribution (Reboleira et al. 2011). These species have reduced populations, inhabit habitats with specific environmental conditions, and are very sensitive to anthropogenic pressure, such as climate change and pollution, being fundamental for global biodiversity conservation (Castaño-Sánchez et al. 2020). Therefore, they constitute a unique biodiversity heritage that is at the brick of extinction (Mammola et al. 2019). The risk of extinction can be avoided by implementing

protection figures for the species and habitats that are specific for troglobionts (Wynne et al. 2021).

Extensive sampling over the last two decades shown that *Domitius lusitanicus* has a wide distribution across the Estremenho Karst Massif and towards the Aljubarrota Platform, where it is confined (Reboleira 2012). This increased the area of occupancy and extent of occurrence of *D. lusitanicus*, from the previous 199.936 km² (Branco et al. 2019) to 534.790 km². A large area in this karst is threatened by anthropogenic activities, such as pollution, habitat degradation, tourism, alteration of the surface natural cover, urbanism, industries and agriculture (Reboleira and Eusébio 2021, Reboleira 2012, Reboleira et al. 2022, Reboleira et al. 2013b, Reboleira et al. 2011). Although many of these threats have been identified previously, no specific conservation measures have been put in place (Reboleira and Eusébio 2021, Reboleira et al. 2022, Reboleira et al. 2013b). Additionally, *D. lusitanicus* is distributed in several caves left out of protected areas.

Domitius lusitanicus is the most widespread troglobiont in the Estremenho Massif, distributed in all caves known to harbour troglobiont species in the massif (Reboleira et al. 2013a). Therefore it is a key species for biological conservation in this region. It can act as umbrella species for all other cave-adapted species of the Estremenho Massif, because the protection measures concerning this species will ensure the conservation of all other cave-adapted species in this area, and by extension of subterranean ecosystems in general.

This study can contribute to territory management and planning, and to aid in delineating protection strategies for cave-adapted species of the Estremenho Karst Massif in Portugal. We offer detailed information about the distribution *Domitius lusitanicus* and the current threats to its survival. It is also essential to improve the knowledge on its life cycle, population size, functional ecology, extent of subterranean distribution, and sensitivity to disturbance. This information is fundamental to raise awareness through school programs and national campaigns on the threats that subterranean fauna and habitats face, which will allow for the implementation of conservation efforts to prevent the extinction of endemic species.

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Conflicts of interest

The authors have declared that no competing interests exist.

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Figure 1.

Cave-adapted spider *Domitius lusitanicus* (Fage, 1931), female carrying an egg sac in the Ervideira Cave, Aljubarrota Platform, Portugal.



Figure 2.

Cave-adapted spider *Domitius lusitanicus* (Fage, 1931), male walking on the cave wall in the Santuário Cave, Mira de Aire, Portugal.

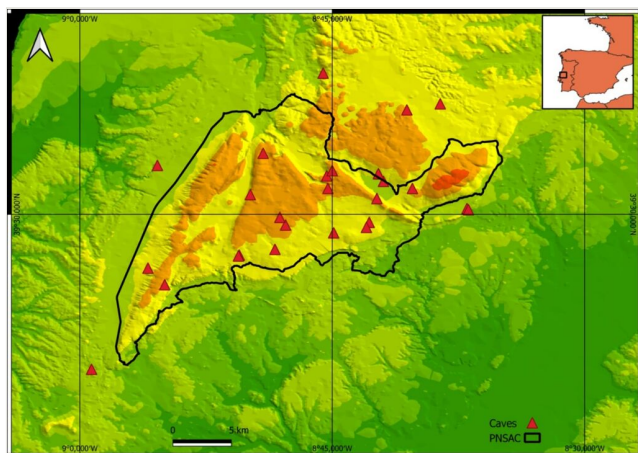


Figure 3.

Distribution of the cave-adapted spider *Domitius lusitanicus* (Fage, 1931). Serras de Aire e Candeeiros Natural Park (PNSAC) delimited by the black line.

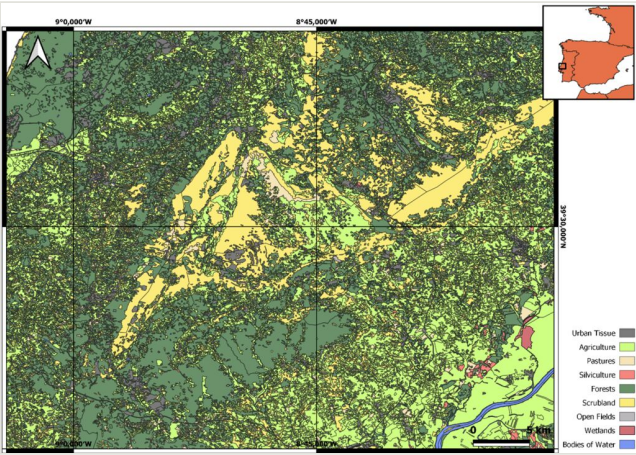


Figure 4.

Map of the land use in the Estremenho Karst Massif, the surface of the distribution area of *Domitius lusitanicus* is highly disturbed by human disturbance.

Supplementary material

Suppl. material 1: Distribution of *Domitius lusitanicus*

Authors: Alves T. & Reboleira A.S.P.S.

Data type: occurrences

Brief description: Distribution of the cave-adapted spider *Domitius lusitanicus* (Fage, 1931).

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