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# Weaving together the past, present and future of Greek arachnofauna: Biodiversity, knowledge gaps and conservation

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## Abstract

1. Spiders are among the most species-rich groups of arthropods. As top predators of other arthropods, their ecological role is significant, yet they are often overlooked in conservation efforts. Greece is home to a rich spider fauna, including many newly discovered and endemic taxa.
2. In this paper, we present an updated, comprehensive dataset of the spiders of Greece, compiled using open standards aligned with the FAIR principles of data management. This update is based on the critical curation of 187 papers covering all available records of spider species occurring in Greece. The curated data contain geographic location (including coordinates and their accuracy) and taxonomic validity of all species.
3. In total, 1310 species are recorded across more than 18,000 unique occurrences, excluding *nomina dubia*, subspecies and incomplete or erroneous taxonomic identifications. Of these, 226 species are endemic to Greece. Furthermore, an analysis is performed to present the distribution of the spider families/species richness in the complex landscape of Greece, in mainland and 96 islands, and the identified geographical/taxonomic gaps in our knowledge.
4. The conservation status of 202 IUCN-assessed species is also presented, alongside a critical analysis of their documented threats and possible ways to promote their conservation.

KEYWORDS

Araneae, arthropods, endemics, FAIR data, Greece, IUCN, threats

## INTRODUCTION

Spiders (Arthropoda: Chelicerata) are one of the most species-rich orders in the animal kingdom, with over 52,000 species worldwide (World Spider Catalogue, 2024). They are adapted to a wide variety of ecological niches and play a key functional role in ecosystems as habitat providers, prey, predators, while also having a significant cultural footprint (Cardoso et al., 2025). In fact, spiders are estimated to consume between 400 and 800 million tons of—mainly—insects annually (Nyffeler & Birkhofer, 2017). Their position in higher trophic levels makes them valuable for pest control in both natural and agricultural habitats (Cotes et al., 2018; Michalko et al., 2019; Nyffeler & Benz, 1987), and suitable indicators of habitat destruction and degradation, as well as species extinction (Cardoso et al., 2010). Despite their functional importance and


**FIGURE 1** Selected photographs of Greek Spiders: (a 1 and 2) *Dysdera spinicrus* Simon, 1882, male, front view and dorsal view Lasithi plateau, Crete, Greece, photo D. Poursanidis; (b 1 and 2) *Cyrtocarenum cunicularium* (Olivier, 1811), female, dorsal and front view. Irakleio, Crete, Greece, photo D. Poursanidis; (c) *Eresus walckenaeri* Brullé, 1832, front view, female. West Crete, Greece, photo A. Trichas; (d) *Latrodectus tredecimguttatus* (Rossi, 1790), lateral view, female. Kryoneri, Messinia, Peloponnese, Greece, photo A. Trichas.

notable contribution to local and regional biodiversity, spiders are often overlooked in conservation planning (Branco & Cardoso, 2020). This neglect is common among many arthropods and other invertebrates, largely due to taxonomic, geographical and aesthetic biases (Cardoso, 2012; Cardoso, Borges, et al., 2011) and knowledge gaps (Branco & Cardoso, 2020; Cardoso, Erwin, et al., 2011). Nevertheless, these biases can be overcome with proper communication strategies, especially focusing on their conservational and cultural values (Cardoso et al., 2025) in order to mitigate harmful stereotypes associated with them (Correia & Mammola, 2024) (Figures 1 and 2).

Greece is renowned for its exceptional biodiversity, hosting numerous endemic and threatened species across various taxonomic groups (e.g., plants—Bilz et al., 2011; saproxylic Coleoptera—García et al., 2018; terrestrial snails—Vardinoyannis et al., 2018; reptiles—Cox & Temple, 2009). Spiders are no exception, with new species regularly recorded and species counts increasing after each review (see, for example, Bosmans & Chatzaki, 2005; and results from this paper—Figure 3). The shaping of these biotas has been a complex and continuous process with the participation of different forces such as tectonism, climatic phenomena (glacial/post-glacial cycles, eustatism), and


**FIGURE 2** Selected photographs of Greek Spiders: (a) *Lycosa praegrandis* C. L. Koch, 1836, female on the very edge of its burrow. Vitsi mountain, beech forest, 1500 m of altitude, Macedonia, Greece, photo A. Trichas; (b) *Uroctea durandi* (Latreille, 1809), female. Nemërçkë mountain, Epirus, Greece, photo A. Trichas; (c) *Chaetopelma lymberakisi* Chatzaki & Komnenov, 2019, immature female in defensive posture., Askyfou village, west Crete, Greece, photo A. Trichas; (d) *Argiope lobata* (Pallas, 1772), female. Venerato village, Crete, Greece, photo J. Charkoutsis; (e) *Sulcia cretica* Fage, 1945, male iridescenting. Katholiko cave (locus typicus), west Crete, Greece, photo S. Paragkamian; (f) *Macrothele cretica* Kulczyński, 1903, female. Patsos natural reserve, Crete, Greece, photo A. Trichas; (g) *Thomisus onustus* Walckenaer, 1805, female. Crete, Greece, photo J. Charkoutsis; (h) *Lachesana graeca* Thaler & Knoflach, 2004, male. Parnon mountain, Peloponnese, Greece, photo B. Knoflach.

human intervention (today and in the past), that gave rise to the idiosyncratic character of Greece, including insularity, steep relief, high habitat diversity and turnover (Kougioumoutzis et al., 2021; Triantis & Mylonas, 2009; Trigas et al., 2013).

Regarding spiders, the completeness of species lists within the various families and across the country is unbalanced, favouring areas which have attracted the interest of arachnologists in previous years, such as Crete, some islands of the North Aegean, the Ionian Islands and parts of northeastern Greece. Consequently, these areas inevitably harbour the highest known numbers of endemic species, since new species continue to be described over the years. Regarding the families, the state of knowledge on Amaurobiidae, Zodariidae,

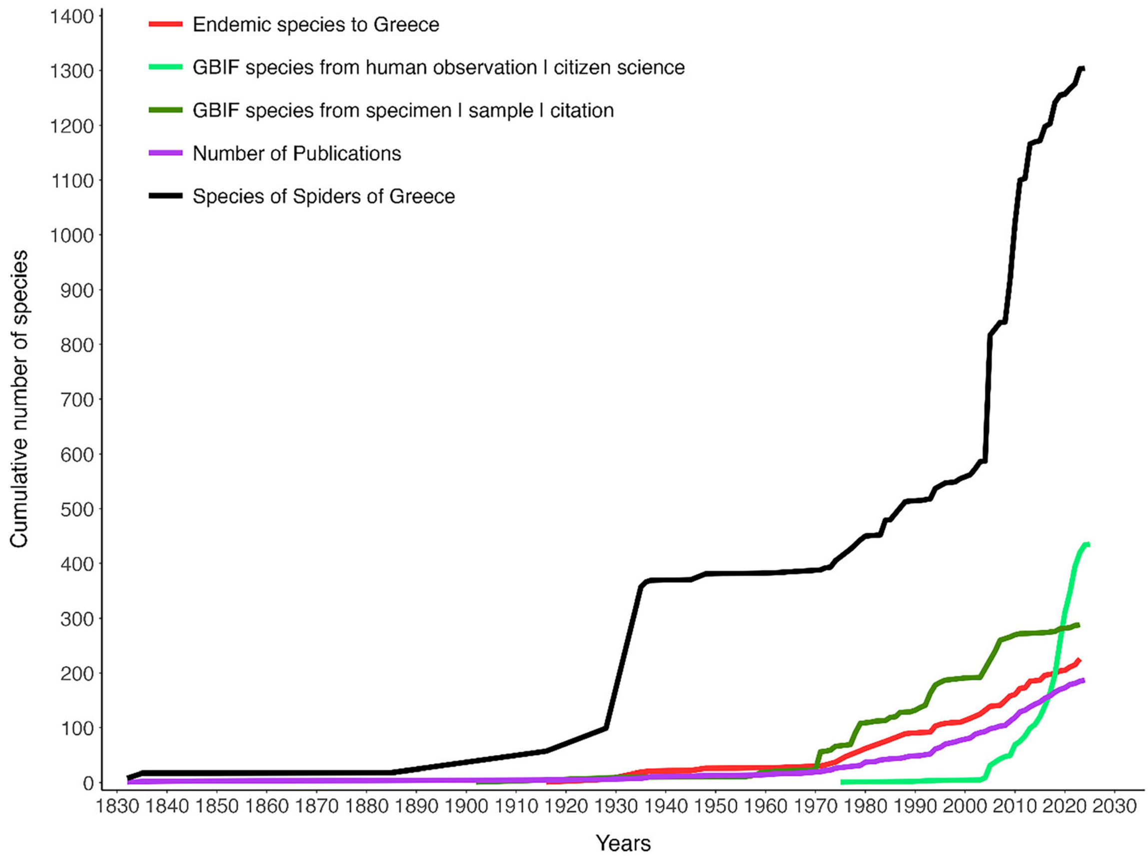


**FIGURE 3** Comparison of accumulated data over time between the presented dataset and GBIF records as of this publication. This includes species (black line), endemic species (red line), and publications (purple line) from this dataset. GBIF records include curated datasets (green line) and citizen science data (light green line).

Dysderidae, Theridiidae, Salticidae, Agelenidae, and Gnaphosidae is better than on others, which rather reflects the specific taxonomic interests of the researchers involved and is not fully aligned with the actual diversity of these taxa in the Greek territory.

Another concern for Greek spider diversity is the lack of conservation status and measures taken to mitigate existing and/or potential threats. Recently, significant scientific and political capital has been invested in the assessment of the Greek fauna and flora under the umbrella of IUCN, including spiders (NECCA, 2025). This led to the assessment of 202 spider species, the majority of which (161 species, i.e., ~80%) are endemic. Prior to this recent effort, only two species (0.15%) of the Greek arachnofauna had been assessed in the broader context of IUCN, and 33 (2.5%) species had been assessed in the first Red Data Book of Greece (Legakis & Maragos, 2009), highlighting the lack of a concrete, organised plan for the assessment of the threats and the conservation regime of this taxon locally. This neglect mirrors the absence of such a plan on a European level (Milano et al., 2021) with Greece consistently following the European paradigm.

Greek spiders hold considerable potential for scientific and conservation-oriented insights. To fully realise this potential, certain knowledge gaps must be addressed (Cardoso, Erwin, et al., 2011; Hortal et al., 2015). One crucial step toward this goal is to make data Findable, Accessible, Interoperable, and Reusable (FAIR) (Wilkinson et al., 2016) and global standards compliant (Michener et al., 1997), such as Darwin Core (Wieczorek et al., 2012). Manual curation and reconciliation of taxonomy and localities are required to homogenise centuries-old accumulated knowledge of the spiders of Greece. In this paper, we present the updated annotated checklist of the spiders of Greece, since its first online publication (Chatzaki et al., 2015). In parallel, we make a first analysis of the dataset, providing a preliminary insight into the distribution of the spider families/species richness in Greece, on endemicity and chorological trends, along with an analysis of the conservation status of the IUCN assessed species and the threats they face. Finally, we propose possible ways to promote and enhance their conservation.

## MATERIALS AND METHODS

### Data assembly

The dataset presented here is an updated version of the first electronic catalogue of the spiders of Greece, created as part of the scientific project SPIDOnetGR (Chatzaki et al., 2015) and uploaded to the platform of the Spiders of Europe (https://araneae.nmbe.ch/

spidonet). It compiles all available information on species recorded in Greece up to December 2024. All relevant papers and checklists were considered, including faunistic or ecological studies dedicated to the Greek arachnofauna. Online resources (e.g., iNaturalist) were not included. The papers were critically read and analysed with respect to taxonomic and geographical information.

Species of incomplete identification status (e.g., *Xysticus* sp., *Zodarion* ? *graecum* etc.), *nomina dubia*, records considered erroneous, and subspecies were excluded. More specifically, subspecies considered valid were incorporated into the corresponding species record, while those with erroneous or doubtful taxonomic status were disregarded.

All data are available in the Supplementary material, Zenodo (https://zenodo.org/records/16683438—Bolanakis et al., 2025), and will also be published on GBIF, fully compliant with the Darwin Core (DwC) standards (https://www.tdwg.org/standards/dwc). The Darwin Core is a standardised format developed to facilitate the sharing and integration of biological and biodiversity data across different platforms and databases. It provides a stable framework of terms and vocabulary, ensuring interoperability and comprehensibility, regardless of data origin.

For the 202 species assessed for IUCN, threats to those falling into one of the main risk categories (CR, EN and VU) were identified. This information is soon to be available online at the official IUCN platform for the endemic species, while the assessments of all evaluated species are currently available at the National Red List (https://redlist.necca.gov.gr/en/home-copy/) (NECCA, 2025).

## Analysis and visualisation

The occurrences of the dataset were enriched with administrative regions of Greece from the GADM data (version 4.1) and the 1 km$^2$ European Environment Agency (EEA) reference grid. To have a comparative analysis of our dataset with other open access platforms, data occurrences were also downloaded from GBIF (25 March 2025) with the query: Country or area==Greece AND Scientific name==Araneae (GBIF, 2025). The data were further filtered to have coordinate data (hasCoordinate equals true) and to belong to the Araneae order.

The checklist and occurrence data were processed with the R Statistical Software (v4.4.1; R Core Team, 2023). The coordinate reference system of the dataset is WGS84—EPSG:4326 and the downloaded data were transformed to this system where necessary. The software packages used were: ggplot2 (Wickham, 2016) for visualisation, tidyverse (Wickham et al., 2019) for data handling, sf v1.0–14 (Pebesma, 2018) for spatial analysis. The code for the analysis is available here https://github.com/savvas-paragkamian/araneaa_checklist_gr.

# RESULTS/ANALYSIS

## Spider research in Greece

The history of spider research in Greece (Figure 3) is thoroughly described in Chatzaki and Kaltsas (2018). As with many other arthropod groups, it began in Peloponnese during the Greek War of Independence, when Brullé, accompanied by the French troops, gathered rich biological material from this part of the country (1828–1833) (Anastasiou et al., 2018). In the first half of the 20th century, the works of Roewer (1928), Bristowe (1935) and Hadjissarantos (1940) stand out, with the latter introducing arachnology as a subject to the Greek academia, although geographically, his study was restricted to the district of Attiki. The first 'complete' catalogue on the spiders of Greece appeared in 1935 by Bristowe, listing 373 species from the whole country.

After World War II, spider research in Greece was revitalised in the 1970s–1980s, with the works of the Italian arachnologist P.M. Brignoli, who focused on cave-dwelling families, and the Dutch arachnologist C. Deeleman-Reinhold, who focused on the family Dysderidae. These important contributions expanded the knowledge on the spiders of Greece geographically, covering more areas such as the islands of the Ionian Sea, Ipeiros, Thessaly, Peloponnese, and Crete. From the 1990s to the present, various international researchers have studied the Greek arachnofauna sporadically. Two Greek arachnologists completed their PhDs dedicated to Greek spiders: L. Paraschi (1988) studied maquis ecosystems in southern Greece, while M. Chatzaki (2003) focused on the ground spiders of Crete, providing the first faunistic and ecological analyses on the structure and functioning of the spider communities in Greek ecosystems.

In the 21st century, Crete, the Aegean and more recently parts of northeastern Greece (Figure 4) have become focal regions for spider research. This is due to the intense sampling efforts by members of the Natural History Museum of Crete, as well as by the Belgian team of arachnologists led by R. Bosmans. Along with the increase in species records and taxonomic research, important cataloguing was introduced (e.g., Bosmans & Chatzaki, 2005; Bosmans et al., 2013; SPIDOnet.gr—Chatzaki et al., 2015), taking the number of known species in Greece to over 1200.

In this dataset, 187 papers were analysed, and 1738 taxonomic entities were recorded (as of December 2024). After excluding all incomplete identifications, misidentifications, synonyms (as of current knowledge), *nomina dubia*, and subspecies, 1310 species are considered valid and are treated hereafter.

## Species richness, patterns and distribution

The 1310 valid spider species recorded in Greece belong to 54 families and 363 genera. Of these, 226 species (approximately 17.2%) are endemic, spanning 25 families and 83 genera. The most species-rich families are Linyphiidae, Gnaphosidae, Salticidae, Theridiidae and Dysderidae (Table 1). While Dysderidae ranks fifth in total species, it holds the highest number of endemics, followed by Gnaphosidae, Linyphiidae, Zodariidae and Agelenidae (Table 1). Some families, like Leptonetidae and Dysderidae, show extremely high endemism: 13 out of 14 Leptonetidae species (93%) and 54 out of 84 Dysderidae species (64%) are endemic. These families also show higher rates of conservation assessment in the IUCN Red List and Greek red data book (85.7%

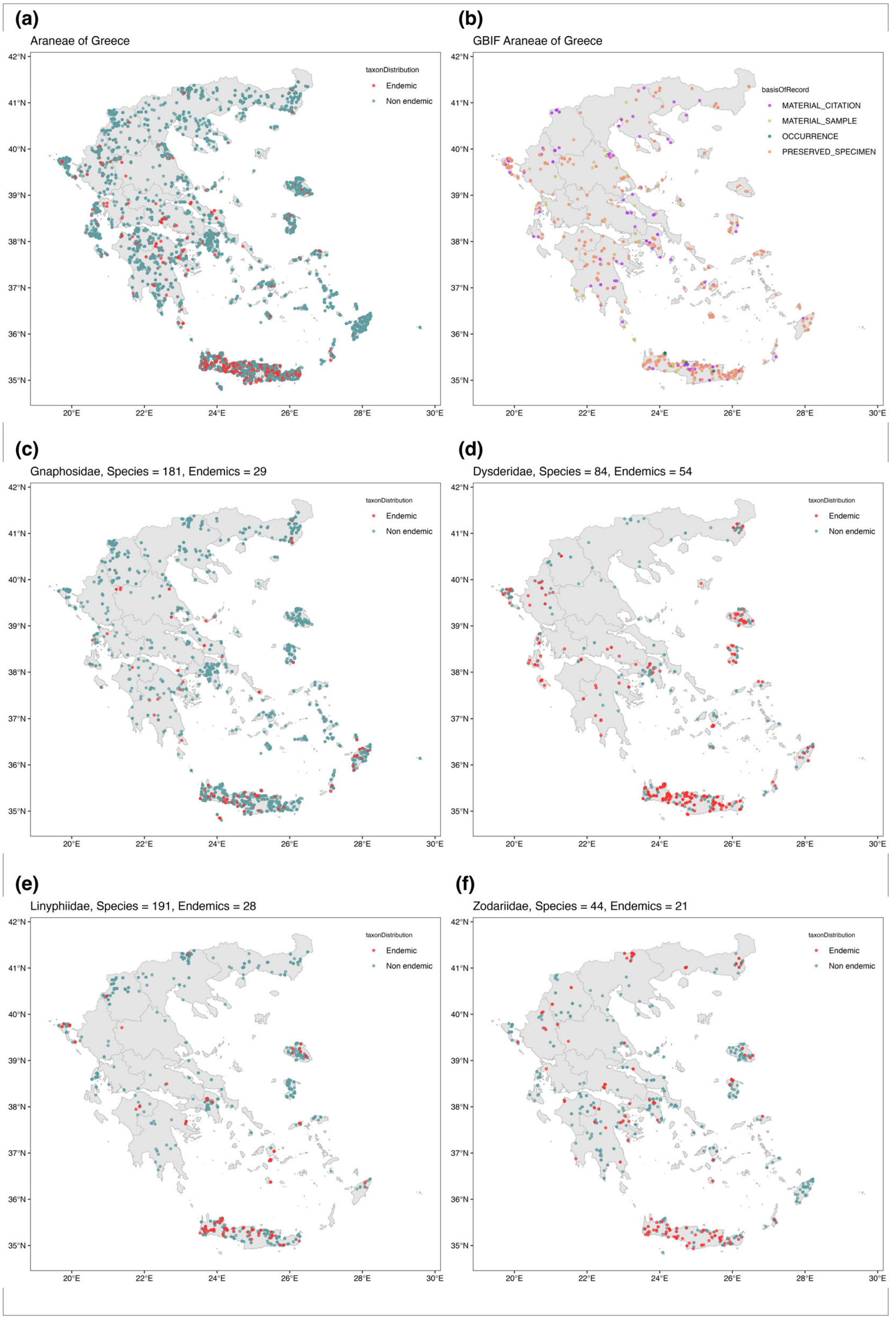


**FIGURE 4** (a) The sampling intensity in areas of Greece dedicated to spider collections (based on current publications). (b) The occurrences of Araneae from the GBIF database in Greece, excluding human observations from citizen science platforms; each colour corresponds to a different basis of record. (c) Distribution of species of Gnaphosidae, the dominant (with respect to both species richness and abundance) family of spiders in Greece. (d) Distribution of species of Dysderidae, the family with the highest number of endemic species in Greece. (e) Distribution of species of Linyphiidae, one of the most species-rich families in Greece. (f) Distributions of species of Zodariidae, a family with relatively high endemism and high representation in the national Red List.

**TABLE 1** Summary of the checklist of the Araneae of Greece at the family level.

| Category | Species | Endemics | Occurrences | Area (km$^2$) | CR | EN | VU | NT | DD | LC | N/E |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 1310 | 226 | 18,229 | 2276 | 39 | 43 | 17 | 26 | 44 | 30 | 1111 |
| Endemics | 226 | - | 1436 | 1390 | 33 | 35 | 14 | 21 | 38 | 17 | 68 |
| Agelenidae | 52 | 20 | 635 | 616 | 9 | 5 | 3 | 4 | 5 | 2 | 24 |
| Amaurobiidae | 17 | 9 | 156 | 153 | 1 | 3 | 1 | 2 | 0 | 1 | 9 |
| Anapidae | 2 | 0 | 10 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Anyphaenidae | 2 | 0 | 34 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Araneidae | 55 | 0 | 960 | 939 | 0 | 0 | 0 | 0 | 0 | 0 | 55 |
| Atypidae | 2 | 0 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Cheiracanthiidae | 10 | 0 | 130 | 126 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| Cicurinidae | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Cithaeronidae | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Clubionidae | 18 | 0 | 104 | 104 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| Ctenizidae | 2 | 1 | 49 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Cybaeidae | 3 | 0 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Dictynidae | 22 | 0 | 260 | 254 | 0 | 0 | 0 | 0 | 0 | 0 | 22 |
| Dysderidae | 84 | 54 | 591 | 577 | 11 | 8 | 1 | 3 | 14 | 3 | 44 |
| Eresidae | 6 | 0 | 154 | 154 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Filistatidae | 7 | 2 | 102 | 100 | 0 | 0 | 1 | 0 | 0 | 0 | 6 |
| Gnaphosidae | 181 | 29 | 3659 | 3567 | 1 | 5 | 1 | 6 | 8 | 7 | 153 |
| Hahniidae | 8 | 2 | 27 | 27 | 0 | 1 | 0 | 0 | 1 | 0 | 6 |
| Leptonetidae | 14 | 13 | 40 | 38 | 4 | 2 | 1 | 0 | 5 | 0 | 2 |
| Linyphiidae | 191 | 28 | 1083 | 1065 | 5 | 9 | 3 | 4 | 4 | 3 | 163 |
| Liocranidae | 20 | 6 | 164 | 162 | 3 | 0 | 1 | 1 | 1 | 1 | 13 |
| Lycosidae | 78 | 6 | 1109 | 1094 | 0 | 0 | 0 | 3 | 1 | 1 | 73 |
| Macrothelidae | 1 | 1 | 19 | 18 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Mimetidae | 6 | 0 | 86 | 85 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Miturgidae | 6 | 0 | 21 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Mysmenidae | 1 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Nemesiidae | 7 | 4 | 20 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| Nesticidae | 4 | 2 | 20 | 18 | 1 | 0 | 0 | 1 | 0 | 0 | 2 |
| Oecobiidae | 7 | 0 | 95 | 95 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| Oonopidae | 9 | 1 | 54 | 53 | 0 | 0 | 0 | 1 | 0 | 0 | 8 |
| Oxyopidae | 8 | 0 | 179 | 175 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| Palpimanidae | 3 | 0 | 132 | 129 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Philodromidae | 43 | 1 | 514 | 503 | 0 | 1 | 0 | 0 | 0 | 0 | 42 |
| Pholcidae | 15 | 4 | 388 | 366 | 0 | 0 | 0 | 0 | 1 | 2 | 12 |
| Phrurolithidae | 3 | 1 | 28 | 28 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| Pisauridae | 5 | 0 | 81 | 81 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Prodidomidae | 2 | 0 | 20 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Salticidae | 152 | 10 | 3432 | 3384 | 0 | 2 | 1 | 0 | 0 | 1 | 148 |
| Scytodidae | 3 | 0 | 182 | 179 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Segestriidae | 8 | 2 | 53 | 53 | 0 | 0 | 0 | 1 | 1 | 0 | 6 |
| Selenopidae | 1 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sicariidae | 1 | 0 | 134 | 127 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sparassidae | 6 | 0 | 150 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |

(Continues)

**TABLE 1** (Continued)

| Category | Species | Endemics | Occurrences | Area (km$^2$) | CR | EN | VU | NT | DD | LC | N/E |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tetragnathidae | 13 | 0 | 190 | 180 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| Theraphosidae | 1 | 1 | 7 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Theridiidae | 100 | 6 | 1511 | 1486 | 0 | 1 | 0 | 0 | 0 | 0 | 99 |
| Theridiosomatidae | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Thomisidae | 67 | 1 | 873 | 861 | 0 | 0 | 0 | 0 | 1 | 0 | 66 |
| Titanoecidae | 8 | 0 | 43 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| Trachelidae | 1 | 0 | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Uloboridae | 5 | 0 | 85 | 84 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Zodariidae | 44 | 21 | 558 | 546 | 4 | 5 | 2 | 0 | 2 | 9 | 22 |
| Zoropsidae | 2 | 0 | 54 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Synaphridae | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

*Note*: Number of species, endemics and IUCN categories (IUCN, 2025; NECCA, 2025) are also presented: CR, critically endangered; DD, data deficient; EN, endangered; LC, least concerned; N/E, not evaluated; NT, near threatened; VU, vulnerable. The area (km$^2$) refers to 1 × 1 km grid, where the area of a species is the sum of unique 1 × 1 km grids that it appears in.

**TABLE 2** The sampled area (1 × 1 km grid cells), species and endemic species recorded for each administrative region of Greece.

| Region | Occurrences | Species | Endemics | Sampled area (km$^2$) | Total area of administrative region (km$^2$) | Relative area sampled per region (%) |
|---|---|---|---|---|---|---|
| Athos Mountain | 6 | 6 | 1 | 5 | 337 | 1.5 |
| Attica | 1344 | 350 | 30 | 127 | 3845 | 3.3 |
| Central Greece (Sterea Ellada) | 419 | 200 | 20 | 110 | 15,583 | 0.7 |
| Central Macedonia | 1449 | 460 | 4 | 146 | 18,884 | 0.8 |
| Crete | 4905 | 465 | 72 | 598 | 8373 | 7.1 |
| Eastern Macedonia and Thrace | 1627 | 486 | 14 | 117 | 14,164 | 0.8 |
| Epirus | 300 | 178 | 13 | 91 | 9218 | 1 |
| Ionian Islands | 1409 | 347 | 27 | 194 | 2337 | 8.3 |
| North Aegean | 2626 | 412 | 22 | 176 | 3879 | 4.5 |
| Peloponnese | 675 | 291 | 39 | 172 | 15,515 | 1.1 |
| South Aegean | 1894 | 476 | 48 | 270 | 5449 | 5 |
| Thessaly | 239 | 135 | 12 | 73 | 14,097 | 0.5 |
| Western Greece | 394 | 178 | 14 | 114 | 11,279 | 1 |
| Western Macedonia | 942 | 314 | 8 | 83 | 9510 | 0.9 |

and 47.6%, respectively), unlike some larger families with lower assessment coverage (e.g., Theridiidae, Salticidae).

In most cases, the spatial coverage of sampling effort is positively correlated with the sampling intensity and the diversity of spiders per family. For instance, Gnaphosidae (181 species) are represented by 3659 occurrences across 3567 km$^2$ all over the country, and Salticidae (152 species) by 3432 occurrences across 3384 km$^2$ (Table 1 and Figure 4). In other cases, though there is low spatial coverage over the country, the species richness of the related family is high, like for example in Linyphiidae, in which the 191 recorded species present 1083 occurrences and only cover 1065 km$^2$ (Figure 4).

The regions with the highest spider diversity are Crete, Macedonia, Thrace and the Aegean Islands. Crete, the Aegean Islands and the Peloponnese host the highest numbers of endemic species. The Ionian islands and Crete are the regions with the highest coverage of sampled area, followed by North Aegean and Attica. Overall, 1.7% of the Greek territory has been searched for spiders (i.e., total area sampled per total area of the country) and species records have been produced. Sampling effort is unevenly distributed (Table 2)., r example, less than 1% of the mainland has been sampled, compared with 6.2% of the insular territory. The Greek spider fauna has been sampled from 96 different islands, and of the 1310 total species, 407 occur

**TABLE 3** Summary of the species distribution occurring exclusively in the mainland or on islands of Greece (i.e., singular species).

| Taxon distribution | Region type | Singular species | Occurrences |
|---|---|---|---|
| Endemic | Island | 124 | 1161 |
| Endemic | Mainland | 67 | 286 |
| Non endemic | Island | 203 | 10,010 |
| Non endemic | Mainland | 340 | 6937 |

**TABLE 4** Summary of the species' threats record for the IUCN assessments (simplified)—The numbers in parentheses signify the IUCN number for each threat (IUCN, 2025).

| Threat | Species affected |
|---|---|
| Fire (7.1) | 51 |
| Droughts (11.2) | 34 |
| Tourism and recreation areas (1.3) | 31 |
| Recreational activities (6.1) | 22 |
| Small-holder grazing, ranching or farming (2.3.2) | 16 |
| Housing and urban areas (1.1) | 9 |
| Diseases of unknown cause (8.6) | 8 |
| Air-borne pollutants (type unknown/unrecorded) (9.5.4) | 8 |
| Agricultural and forestry effluents (soil erosion, sedimentation) (9.3.2) | 8 |
| Logging and wood harvesting (5.3) | 7 |
| Small-holder farming (2.1.2) | 5 |
| Renewable energy (3.3) | 5 |
| Roads and railroads (4.1) | 5 |
| Garbage and solid waste (9.4) | 2 |
| Abstraction of groundwater (7.2.6.7) | 2 |
| Other ecosystem modifications (7.3) | 1 |
| Small-holder plantations (2.2.1) | 1 |
| Storms and flooding (11.4) | 1 |
| Habitat shifting and alteration (11.1) | 1 |
| Sewage (9.1.1) | 1 |
| Nutrient loads (9.3.1) | 1 |
| Herbicides and pesticides (9.3.3) | 1 |

exclusively in mainland Greece and 327 are found only on islands (Table 3). Approximately one-third of the island-exclusive species are endemic.

### IUCN status and threats

Of the 1310 recorded species, 202 (15.4%) have been assessed under the IUCN framework—the highest number in the European Union, followed by Portugal with 82 species (IUCN, 2024). Among the assessed species, 161 (79.7%) are endemic, representing 71.8% of all Greek endemic spiders.

Threatened species (classified as Critically Endangered, Endangered or Vulnerable) make up 50.4% (102 species) of assessed taxa, and 52.7% when considering only endemics (Table 1). Additionally, 26 species (12.8%) are Near Threatened, while 44 (21.7%) are listed as Data Deficient.

The most prevalent threat to Greek spiders is wildfire, affecting 51 (50%) of the threatened species, followed by drought induced by climate change (33.3%), and development associated with tourism and recreational activities (Table 4).

## DISCUSSION

### Species richness and distribution patterns

This dataset comprises the full list of spider species recorded from Greece up to December 2024. Compared with the open data knowledge from GBIF, it contains three times more species and 16 times more occurrences (Figure 4). While largely consistent with the data provided in the Spiders of Europe (https://araneae.nmbe.ch)—with only minor discrepancies due to differences in data handling—it provides critical spatially explicit records, with coordinates carefully curated for accuracy. These data allow for extrapolations about Greek spider diversity and can help identify geographical gaps to guide future research and conservation efforts.

The 18,229 species records that span across the country (see Figure 4) correspond to a very low spatial completeness, since they represent only about 2% of the total surface of Greece. In terms of overall spider diversity, Greece ranks high in Europe, with 1310 species and 363 genera across ~132,000 km$^2$. Only France (1603 species/447 genera, 544,000 km$^2$), Italy (1586 species/430 genera, 301,000 km$^2$) and Spain (1427 species/414 genera—excluding the Canary Islands, 498,000 km$^2$) (Nentwig et al., 2024), surpass these numbers, as they cover significantly larger areas.

Furthermore, a substantial number of these species are endemic, with 226 (17.2%) found exclusively in Greece. The value of the Greek islands which support this high and unique diversity is highlighted by the high percentage of species found exclusively on them, either endemic or not (327 out of 1310, i.e., ~25% of the total species numbers). On a regional level, Eastern Macedonia and Thrace are the regions of Greece with the highest numbers of recorded species, followed by South Aegean, Crete, Central Macedonia and North Aegean. Among these, Crete stands out for its exceptional sampling coverage, high species and endemic richness, and spatial completeness of sampling, making it the best-studied region and a key biodiversity hotspot.

In general, the biodiversity hotspots are split between a northern continental region (Macedonia and Thrace) and a southeastern island region (Aegean and Crete). This diversity pattern echoes findings from other taxa, such as land snails (Vardinoyannis et al., 2018), land isopods (Sfenthourakis & Schmalfuss, 2018), and vascular plants

(Kougioumoutzis et al., 2021). However, it could still be partially affected by the special focus attributed to those areas mostly by Greek arachnologists (e.g., Chatzaki, 2018, 2021; Chatzaki et al., 2002a, 2002b, 2003; Chatzaki & Van Keer, 2019; Komnenov et al., 2016; Pitta & Chatzaki, 2022), and the serious lack of information in other important areas of Greece, such as the Peloponnese.

Notwithstanding the geographical and taxonomic gaps in knowledge, chorological trends of species distribution may be identified and reveal filtering patterns of species composition between the north–south and east–west axes of the country (Chatzaki & Kaltsas, 2018). These patterns are considered to reflect transition zones of European–Mediterranean and European–Pontic-Asiatic respectively (Pitta & Chatzaki, 2022). The high diversity in the northern parts of Greece may be explained by the presence of European, Balkan and Asian faunal elements, which penetrate the Greek peninsula. Indeed, when analysed to chorotypes, there is a filtering of European, Turanean and Pontic species from north to south (Chatzaki & Kaltsas, 2018). This trend aligns with the overall rich Balkan arachnofauna (Nentwig et al., 2024). The filtering process of species along the north–south axis of the country is compensated in southern areas and in insular systems by the dominance of Mediterranean species and by higher rates of endemism, with the most striking case met in the arachnofauna of Crete (see Bosmans et al., 2013).

Crete harbours the highest number of endemic species, followed by the Aegean Islands and the Peloponnese. This trend of increasing endemic species moving southward is also observed in other groups, such as land molluscs (Vardinoyannis et al., 2018) and vascular plants (Kougioumoutzis et al., 2021). The processes shaping these endemic faunas and floras are complex, involving the interaction of the geological evolution, climatic variation and ecological diversity of each region. However, untangling these processes seems to be difficult and remains a taxon-specific challenge. For instance, Vitali and Schmitt (2017) suggest that Crete's endemism in long-horn beetles is driven by its long isolation, while Trigas et al. (2013) attribute the island's rich endemic plant diversity to the rising of the Cretan massifs in the Pleistocene. A phylogeographic study of the Cretan trap-door spider *Cyrtocarenum cunicularium* (Olivier, 1811) showed that palaeogeographical history (e.g., barriers, splits) is equally or even more influential than the ecological and climatic variation in shaping the modern distribution patterns of spiders (Thanou et al., 2017). In the Aegean, *in situ* evolution due to isolation, adaptive or even non-adaptive radiation has contributed to the islands' diversity (Sfenthourakis & Triantis, 2017). These processes are driven by geological events, such as eustatic fluctuations, which often lead to vicarianistic incidents, but also the active or passive dispersal of the species (Poulakakis et al., 2014; Sfenthourakis & Triantis, 2017). As for spiders in the Aegean, patterns of high spider assemblages' turnover may be observed which partly reflect the aforementioned forces that shape the habitat heterogeneity of the Greek landscape and support high diversity locally (Pitta et al., 2017).

As shown by the taxonomic and geographical data presented in this paper (Table 1, Figure 4), only Gnaphosidae appear adequately studied to support robust ecological conclusions. This family thrives in Greece's maquis and shrubland habitats, shows clear elevation trends (peak diversity at 400–700 m) (Chatzaki et al., 2005), and tolerates anthropogenic pressures like grazing and urbanisation (Chatzaki & Kaltsas, 2018; Kaltsas et al., 2014, 2019).

## IUCN status

The assessment of 78.1% of endemic Greek spiders is the first step toward the understanding of their conservation status and needs. This is a major step, even in a continental perspective (Milano et al., 2021). Regarding the estimate of extinction risk, the mid-point value (that is, [CR + EN + VU]/[Assessed-DD] species, IUCN, 2022) is 64.5% for all species and 69.1% for the endemic species. These findings are concerning; however, they must be viewed cautiously due to the common caveats of arthropods assessments. The traditional biodiversity shortfalls, namely, knowledge gaps in taxonomy, distribution, ecology and so on (Hortal et al., 2015) are even more pronounced for arthropods (Cardoso, Erwin, et al., 2011; Wagner et al., 2021). Furthermore, the IUCN Criterion B used in these assessments may be inadequate for arthropods, often leading to a more pessimistic view of their conservation status (Cardoso et al., 2011). Nevertheless, these curated assessments align with coarser preliminary assessments (Bolanakis et al., 2024). Unfortunately, we can only compare our results with those from Portugal, where 29 (43.9%) of the assessed species are threatened (excluding DD) (IUCN, 2025).

## Threats

The nature and extent of threats faced by spiders in Greece have been largely addressed since a high percentile of species (especially the endemics) have been assessed. However, concrete actions for their conservation remain an open challenge. Fire appears to be the most significant threat to Greek spiders, affecting 50% of threatened species (Table 4). Fires exert pressure on spiders globally, causing mortality (direct effect) and habitat/niche modification (indirect effects leading to plausible shifting in phenology and assemblage structure). The response to fire events depends on the fire intensity and repetitiveness, the original habitat type and its diversity prior to fire, the climate and other environmental factors, and differs among functional and ecological guilds (Martínez et al., 2022; Niwa & Peck, 2002; Yekwayo et al., 2019). It is therefore considered a perplexing issue for spider conservation (Branco & Cardoso, 2020) not easily interpreted and addressed. For example, ground-hunting spiders (e.g., Gnaphosidae and Lycosidae) are favoured by the post-fire habitat simplification, which facilitates their prey capture strategy and can thus dominate in burned areas by increasing their abundance (McLean et al., 2023; Poulakakis et al., 2014). Other guilds, e.g., web-building spiders, may be more sensitive to fire (McLean et al., 2023), but they can use ballooning (Foelix, 2011) to colonise the newly formed habitats from long distances. As a general trend, depending on the intensity and repeatability of the fire incidents (Moretti et al., 2002), changes in beta diversity related to species turnover are the most significant effect, favouring opportunistic species at the expense of more sensitive specialised groups (Martínez et al., 2022). Typically, fire is not considered a primary threat to invertebrates, with habitat degradation, fragmentation, pollution, agricultural intensification and climate change being more commonly cited (Cardoso et al., 2020; Wagner, 2020; Wagner et al., 2021). In fact, agroforestry, urbanisation, climate change and pollution are recognised as the leading threats to spiders (Cardoso et al., 2020). However, fire can interact synergistically with other threats, such as climate change-induced droughts (Wagner, 2020), or contribute to habitat loss (Wagner et al., 2021). Whether the importance of fires as a major threat is an idiosyncrasy of Greece and of south Mediterranean countries in general or represents a bias caused by the recent severe wildfires in the country is a question that remains to be answered in the long term.

Other major threats to Greek spiders include residential and commercial development, recreational activities and agriculture, particularly livestock farming (Table 4). These activities are primarily associated with natural habitat loss and degradation. Both livestock agriculture and urbanisation are global pressures for spider taxonomic and functional diversity as well as abundance (Branco & Cardoso, 2020). However, such generalisations risk the possibility of neglecting special conditions that act locally and may change the generally observed patterns (see Kaltsas et al., 2019). For example, although the opportunistic species hypothesis (OSH) and hence, patterns of retrogression to dominance by opportunistic species (Gray, 1989) have been verified for epigeal spiders along urban–rural gradients (Horváth et al., 2012; Kaltsas et al., 2014) it has not been showcased at differing grazing levels. Ecological analyses of functional traits along grazing gradients in Crete show positive responses to grazing with species richness of ground spiders (Gnaphosidae) increasing with increasing disturbance (Kaltsas et al., 2019). This is attributed to the combined effect of reduced competitive pressure by the otherwise dominant species which are excluded from the assemblage and the ability of others to withstand the conditions of a highly degraded environment. It also signifies a successful long-term response of this taxon to the occurring habitat changes toward degradation. Even in that case though, overgrazing threatens local endemics (Kaltsas et al., 2019). Overall, these findings clearly demonstrate that spiders cannot be seen as a uniform group and that analyses, at least at family level, are more accurate for detecting the variable effects of environmental or disturbing factors on the diversity of this taxon and the level of threats involved.

## Knowledge gaps

Several knowledge gaps emerge from this dataset. First, there is a strong sampling bias toward Crete, the Aegean Islands, and northern Greece (Table 1). While the inception of biodiversity research in Greece is in Peloponnese with the expeditions of Brullé (Anastasiou et al., 2018), in recent decades the focus has shifted primarily to Crete, the Aegean Islands, as well as the northeastern part of Greece largely driven by the activities of the Natural History Museum of Crete. A more thorough survey of regions such as Peloponnese, western Greece (Ipeiros and Ionian Archipelago), central Greece, and Thessaly is imperative and should be prioritised. However, even well-studied regions continue to yield new discoveries, highlighting the need for ongoing taxonomic work (e.g., Chatzaki, 2021; Chatzaki & Komnenov, 2019; Pitta & Chatzaki, 2022).

There is also an evident bias at the family level, in favour of families such as Gnaphosidae, Salticidae, Zodariidae and Dysderidae. Other families which are species-rich globally, like Linyphiidae and Theridiidae, would probably represent a much higher percentage in the Greek arachnofauna if properly studied. Evidently, there is still much to be discovered about the diversity of the families which are considered to be more thoroughly investigated, especially Gnaphosidae, which are dominant in almost all Greek habitats. Special attention should be paid also to families which tend to present high endemicity through adaptive radiation (e.g., Dysderidae) and those which prefer or live exclusively in caves, like Leptonetidae, Oonopidae, Nesticidae. In these families, high numbers of stenoendemics are expected to be found when the cave spider fauna of Greece is fully explored.

The lack of information for Greek arachnofauna is clearly underlined by the assessment of 44 (of which, 38 are endemic) species as Data Deficient. Data Deficient species are likely to be threatened (Borgelt et al., 2022), so it is crucial to reassess them when new data and information become available (Cazalis et al., 2023). This relates to knowledge shortfalls, such as the lack of distributional data, as well as gaps in understanding the ecology and evolutionary history of species (Hortal et al., 2015).

## Conservation perspectives

A key priority for spider conservation in Greece is to address persistent data shortfalls. Compared with central Europe, Greece faces significant gaps in both taxonomic and distributional knowledge, rooted in historical limitations and the country's complex biodiversity—characterised by high topographic heterogeneity, insularity, and a rich but understudied cave fauna.

Closing these gaps requires more intensive and geographically balanced sampling, particularly in under-surveyed regions (see Table 2), as well as the use of analytical and modelling tools to better understand the ecological processes shaping spider communities. Targeted research on specific habitats—such as wetlands, coastal zones, caves and forests—can provide vital insights, especially where unique or endemic taxa are likely to occur but remain undocumented.

Beyond data on species distributions and ecology, there is also a pressing need to better understand the threats facing Greek spiders. Most IUCN Red List assessments rely on broad habitat-related pressures, but detailed *in situ* studies—such as population monitoring and ecological assessments—are essential to accurately identify direct threats and inform conservation planning. Finally, campaigns aiming at the overcoming of common folk-tales and misconceptions regarding spiders, while focusing on more positive aspects of theirs (Cardoso et al., 2025), should be encouraged.

In summary, spider conservation in Greece is highly data-dependent and will require sustained scientific effort and conservation investment. Equally important is raising awareness among the public and policymakers. Building recognition of the ecological value of spiders is crucial to integrating them into national biodiversity strategies and ensuring their protection in the decades to come.

## AUTHOR CONTRIBUTIONS

**Giannis Bolanakis:** Conceptualization; investigation; methodology; validation; data curation; writing – review and editing; writing – original draft. **Savvas Paragkamian:** Methodology; conceptualization; data curation; visualization; writing – review and editing; formal analysis; software. **Leonidas Maroulis:** Conceptualization; methodology; data curation; writing – original draft; writing – review and editing. **Panagiotis Kontos:** Data curation; writing – review and editing. **Dimitris Poursanidis:** Data curation; writing – review and editing. **Manolis Nikolakakis:** Data curation; writing – review and editing. **Apostolos Trichas:** Writing – review and editing. **Maria Chatzaki:** Conceptualization; methodology; data curation; supervision; validation; investigation; writing- original draft; writing – review and editing; project administration.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

## DATA AVAILABILITY STATEMENT

The data supporting this study are publicly available in Zenodo (https://zenodo.org/records/16683438).

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