



Short Communication

The “Ants of Cyprus” website: a dynamic, online awareness raising and conservation tool

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Abstract

Ants are an important arthropod group due to their involvement in ecological processes amongst others as ecosystem engineers or predators, but some invasive alien species are also implicated in detrimental environmental, economic and human health effects. Despite recent advancements, the ant biodiversity of Cyprus is still in need of further research with previous online species inventories synthesising a checklist of just 65 native and 10 alien species. The “Ants of Cyprus” website (<https://sites.google.com/view/ants-of-cyprus>) aims to: (1) raise public awareness and increase local knowledge on the biodiversity and ecological significance of ants, (2) provide ecological data and (3) enhance conservation efforts and management practices for native and alien ant species,

respectively. This dynamic, user-friendly website has been designed for use by the scientific community, conservation officers and the wider public and it will be regularly updated as new information and data are generated. Additionally, this information will be critical for reporting on progress towards biodiversity targets and goals.

Keywords

biodiversity, community science, Formicidae, Google sites, online resources, website

Introduction

Access to entomological knowledge and stronger engagement with the public are amongst the emerging themes and future priority challenges to entomology (Luke et al. 2023). Biodiversity data platforms, repositories, fora, databases and websites contribute to these challenges by raising awareness, increasing local knowledge of biodiversity and promoting public participation in scientific research (McCormack 2007, Borges et al. 2010, Goula et al. 2013, Kalaentzis et al. 2021, Zotos et al. 2023). Furthermore, biodiversity databases have been extensively used for mapping and modelling species distributions, reporting on newly-detected or expanding alien species, as well as in studies on the ecology and conservation of rare or threatened species (Castañeda et al. 2019, Mesibov 2019, Avtaeva et al. 2020, Ruzzier et al. 2020, Wilson et al. 2020, Davranoglou and Karaouzas 2021, Angelidou et al. 2022, Krapf 2023, Lugo et al. 2023, Skvarla and Fisher 2023). Despite their high biodiversity, insects are amongst the classes with the lowest median observations per species and poorest taxonomic precision in the Global Biodiversity Information Facility (GBIF) (Troutet et al. 2017). This taxonomic bias is also evident in global conservation efforts, with insect conservation receiving minimal attention compared to vertebrates (Dunn 2005, Oberhauser and Guiney 2009, Donaldson et al. 2017).

Recently, large scale data syntheses have developed taxonomic resources for an exemplar invertebrate group, ants (Janicki et al. 2016, Guénard et al. 2017, Kass et al. 2022). Ants (Hymenoptera, Formicidae) belong to an ecologically important family of insects, with recent global estimates showing 20 quadrillion ants on Earth and their total global biomass reaching 12 megatons of dry carbon (Parker and Kronauer 2021, Schultheiss et al. 2022). They are considered “ecosystem engineers”, altering ecosystem dynamics and the availability of resources to other species directly or indirectly through the creation of their nests (Jones et al. 1997, Jouquet et al. 2006, Del Toro et al. 2012). Ants also form symbiotic relationships with animals (myrmecophiles), plants and fungi, with the latter relationship increasing soil biodiversity through mycorrhizal enrichment, dispersion of fungal spores, the development of plant rhizosphere fauna and enhancing the growth of ammonifying bacteria (Folgarait 1998). The nests and tunnels which ants excavate also increase soil drainage and aeration, making water and air more accessible to soil arthropods and plant roots (Folgarait 1998). Their movement between shallow and deeper soil layers transports faeces, corpses and other organic matter, enhancing their

availability to decomposers and, thus, enriching the soil with nutrients (Folgarait 1998, Del Toro et al. 2012, De Almeida et al. 2020). Regarding ant-plant interactions, myrmecochory, i.e. the dispersal of seeds by ants, plays an important role for at least 11,000 species of plants (Lengyel et al. 2010). Some ants have also been found to pollinate plants such as orchids (Del Toro et al. 2012, Claessens and Seifert 2017). In addition to their aforementioned roles in ecosystem processes, ants have direct benefits for people both as a food source and, more recently, in pharmaceutical and biomedical applications which use their silk cocoons or venom (Del Toro et al. 2012).

On the other hand, some ant species are regarded as agricultural, commercial and household pests, often being reported as a nuisance for inflicting painful stings or bites and infesting food products, electrical appliances or timber (Klotz et al. 1995, Lee 2002, Wetterer 2009, Del Toro et al. 2012, Serge et al. 2019). These “disservices” impact human and animal health, cause substantial economic losses across the globe and are exacerbated by the impact of *Linepithema humile* (Mayr, 1868), *Solenopsis invicta* Buren, 1972, *Wasmannia auropunctata* (Roger, 1863) and other invasive alien species of ants. These invasive ants have affected ecosystems and their native biodiversity, leading, amongst others, to the decrease of native arthropod and vertebrate abundances (Wetterer and Porter 2003, Moreira et al. 2005, Lard et al. 2006, Del Toro et al. 2012, Zina et al. 2020, Gruber et al. 2022, Montgomery et al. 2022, Tercel et al. 2023).

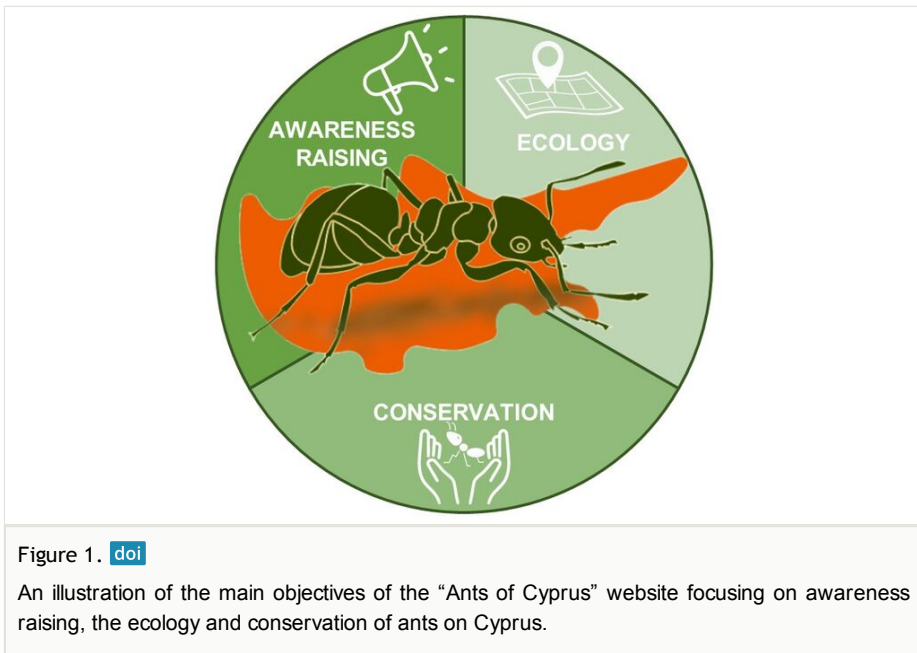
Cyprus has been identified as a biodiversity hotspot (Myers et al. 2000) and important area for small-ranged ants (Kass et al. 2022). The myrmecofauna of Cyprus has been reported through online catalogues which include a checklist of only 65 native and ten alien species (Janicki et al. 2016, Guénard et al. 2017). Some information and annotations on selected species can be found in Georghiou (1977), Edwards et al. (2016), the Biodiversity of Cyprus blogspot (<https://biodiversitycyprus.blogspot.com/search/label/Ants%20of%20%20Cyprus>) and AntWiki (<https://www.antwiki.org/wiki/Cyprus>). However, recent research has added several both alien and native species to the inventory of Cyprus (Demetriou et al. 2023, Salata et al. 2023a, Salata et al. 2023b, Salata et al. 2023c, Salata et al. 2024). There are a number of websites and platforms focusing on particular taxonomic groups for Cyprus, such as BirdLife Cyprus (<https://birdlifecyprus.org/>), the Flora of Cyprus (Hand et al. 2011), the Cyprus Database of Alien Species (CyDAS) (<https://ris-ky.info/cydas>), the Cyprus Herp Atlas (Zotos et al. 2023), the Chalcid Wasps of Cyprus (Koutsoukos et al. 2024) and Biodiversity of Cyprus (<https://biodiversitycyprus.blogspot.com/>); however, a portal providing information and data on the ants of Cyprus is lacking.

The “Ants of Cyprus” website aims to aggregate, summarise and present all available knowledge on the ants of Cyprus. This dynamic, user-friendly website has been constructed to be used by the scientific community, conservation officials and the wider public. The website’s main objectives are:

(1) To raise public awareness and increase local knowledge of the biodiversity and ecological significance of ants on Cyprus and beyond.

(2) Provide data on the distribution (including downloadable occurrence records and distributional maps), phenology (monthly activity/presence), morphology (photographic material), habitats and interrelationships of ants with other insect species on Cyprus.

(3) Enhance conservation efforts and set a baseline for the future assessment of both native i.e. against IUCN categories and criteria and alien ant species i.e. using the Environmental Impact Classification for Alien Taxa (EICAT) and Socio-Economic Impact Classification of Alien Taxa (SEICAT) protocols (Blackburn et al. 2014, Bacher et al. 2017), to provide information and guide national conservation and management priorities, respectively (Fig. 1).



Materials and methods

Construction of the website

An online account (ants.of.cyprus@gmail.com) was set up for the website and all photographic material, infographics, documents, sheets and data were stored in the provided Google Drive file storage. The “Ants of Cyprus” website (<https://sites.google.com/view/ants-of-cyprus/home>) was constructed on Google Sites as part of the DPLUS200 project “Biodiversity and spatiotemporal patterns of ants on Akrotiri Peninsula” (<https://darwinplus.org.uk/project/DPLUS200/>), funded by the Darwin Initiative – Biodiversity Challenge Funds. Infographics and stylised images were created on Canva graphic design platform (https://www.canva.com/en_gb/). The platform has been paired with Google Analytics to monitor website traffic.

Construction of species profiles

Species taxonomy follows AntCat (Bolton 2024). The status of each species is assessed as either “native”, “native (endemic)”, “alien” or “alien (invasive)”. Species stated as “alien” represent non-native species introduced via human activities outside their native range (EU 1143/2014), whereas “invasive” are those alien species shown to adversely affect native biodiversity and, in some cases, people (Roy et al. 2024).

Photographs of specimens in species profiles were taken using a Nikon SMZ 1500 stereomicroscope, Nikon D5200 photo camera and Helicon Focus software. Whenever photographs were not available, we have used resources available online at AntWeb (2024). Usage of photographs for non-commercial purposes is permitted under proper attribution to source material, such as websites or scientific publications indicated in the “images” section on each species profile.

Occurrence records

A literature review on the ant biodiversity of Cyprus was conducted, compiling references and distributional records of various species (e.g. Emery (1909), Emery (1910), Santschi (1930), Santschi (1934), Santschi (1937), Georghiou (1977), Buschinger and Douwes (1993), Seifert (2003), Beibl et al. (2007), Ionescu-Hirsch (2009), Seifert and Schultz (2009), Salata and Borowiec (2015a), Salata and Borowiec (2015b), Salata et al. (2019), Seifert (2020), Demetriou et al. (2022), Demetriou et al. (2023), Salata et al. (2023a), Salata et al. (2023b), Salata et al. (2023c), Salata et al. (2024)). Occurrence records were added to *.csv and *.xlsx files from available scientific literature. Where available, coordinates of occurrence records in distribution maps and *.xlsx files are given in decimal degrees (DD) in WGS84 coordinate system. Where literature records refer to specific localities, but no coordinates were provided, these have been added by the authors, followed by the annotation “coordinates not given in text”. Observations referring to “Cyprus” in general, without reference to specific localities were not accounted for during the compilation of distributional data files. For each species, a *.csv file including distributional data was imported to QGIS in order to create maps embedded in each species profile.

The Area of Occupancy (AOO) and Extent of Occurrence (EOO) for each species (where appropriate) were calculated via GeoCat (<https://geocat.kew.org/editor>) developed by IUCN (Bachman et al. 2011). The establishment status of each species is assessed as either: “Established” (established populations in the wild), “Indoors introduced” (without established populations in the wild, for example in buildings, greenhouses, airports, quarantine surveys) or “Unknown” (data-deficient species) (Demetriou et al. 2023). Establishment means of each species were recorded as per Darwin Core Maintenance Group (2021) with species assessed as: native, native: reintroduced, introduced, introduced: assisted colonisation, vagrant or uncertain. Habitat classification scheme follows IUCN (<https://www.iucnredlist.org/resources/habitat-classification-scheme>), whereas in species conservation, the IUCN Red List category follows IUCN (<https://>

www.iucnredlist.org/). Threats classification scheme also follows IUCN (<https://www.iucnredlist.org/resources/threat-classification-scheme>) and presence in protected areas refer to the designated NATURA 2000 network sites on the island (<https://natura2000.eea.europa.eu/>) (92/43/EEC; 2009/147/EC) as well as the Akrotiri Peninsula RAMSAR site (site number: 1375) (<https://rsis.ramsar.org/ris/1375>).

The occurrence data were mapped to the Darwin Core standard (Wieczorek et al. 2012) and published to the Global Biodiversity Information Facility (GBIF) with dwc:basisOfRecord set as Material Citation (Demetriou et al. 2024). As more data are added to the website, this data publication to GBIF is also planned to be updated along with it. No voucher codes or other identifiers identifying the deposited specimens were available, but an attempt was made to at least have a persistent identifier for either the collection or institution at the location where the specimen was deposited at, to facilitate linking the citations to the published specimens in the future. For private collections, the ORCID of the owner was used as dwc:collectionID.

Website overview

The main menu of the site is divided into the following top-level pages:

Home. Welcome page stating the funding declaration and the website's main objectives (Fig. 2).



Figure 2. [doi](#)

Ants of Cyprus homepage.

News. Blog page featuring the latest news on the ants of Cyprus, such as information on new publications, events or citizen-science initiatives taking place.

About ants. A menu section page further divided into the following pages: “How to spot an ant”, “Ants and other species”, “Ecological significance” and “Eusociality and lifecycle” providing valuable information on the morphology, species interrelationships and ecology of ants to the wider public.

Ants of Cyprus. A pull-down menu section in the form of a taxonomic backbone following Bolton (2024), with information on the subfamilies > genera > and species present on the island. On a subfamily level, the genera present in Cyprus are noted. Moving on to the genus level, an embedded map from the AntMaps website (Janicki et al. 2016, Guénard et al. 2017) shows the number of native species in the genus worldwide. The map is followed by a checklist of the species present on Cyprus, species previously reported, but dubious or erroneous (where applicable) and the relevant scientific literature. On a species level, profiles for all species found in Cyprus are provided including data on their status, distribution, phenology (monthly activity/presence), establishment status, ecology and habitats and conservation accompanied by photographic material, maps, downloadable occurrence records and relevant scientific literature.

Associations with other insects. This section provides an *.xlsx file on known associations of ants with other insects including myrmecophilous species and parasitoids, based on scientific literature. Myrmecophilous taxa, such as Brentidae, the genera *Cryptocephalus* (Coleoptera, Chrysomelidae), *Thorictus* (Coleoptera, Dermestidae) and lycaenid butterflies (Lepidoptera, Lycaenidae), whose host ants are unknown, have been also included in order to promote collaboration with and data collection from beetle and butterfly enthusiasts, ecologists, taxonomists and scientists. This file will be supplemented in the future with more species and associations as research on ants in Cyprus and associates develops.

Biological invasions. General information on biological invasions and the alien ants of Cyprus are provided, including clickable links to the species profiles of 17 alien ants currently detected on the island (Demetriou et al. 2023), with special reference to the presence and impacts of the little fire-ant *Wasmannia auropunctata* (Roger, 1863) (Demetriou et al. 2022, Demetriou et al. 2023) as well as measures to mitigate further spread. A full disclosure statement is provided as the authors are not involved with pest control, clarifying the ecological nature of the website.

Media and keys. A menu section divided into the sub-pages “Statistics and checklist”, “Distributional data (published)”, “Educational material” and “Identification keys”. The “Statistics and checklist” subpage includes a dynamic checklist of ants on Cyprus alongside their status. At the top of the page, the number of subfamilies, genera and species present on the island is given, including the number and overall percentages of endemic and non-native species. The “Distributional data (published)” subpage includes a link to the published GBIF dataset (Demetriou et al. 2024), a .csv copy of the dataset, a map with all published data, as well as the citation to the dataset. The subsection “Educational material” includes a photographic guide to identify main ant groups, a trifold brochure on the ANTovreis citizen-science initiative, informational material on the little fire ant *Wasmannia auropunctata* and posters on alien invasive species not yet reported from Cyprus, such as *Anoplolepis gracilipes*, *Linepithema humile* and *Solenopsis invicta*, all both in Greek and English. Links to research articles with identification keys, are provided in the appropriate section.

Glossary. Definition of entomological terms used throughout the website. A link to the “interpretative dictionary of entomological terms” in Greek by Buchelos (2012) is also provided to guide Greek-speaking readers.

Mapping and data standards. Listing materials and methods used for the construction of the species profiles as listed in the aforementioned section.

ANTovreis CSI. Information and encouragement to participate in a citizen-science scheme on Cypriot ants, which will be presented as the project evolves.

Credits. Acknowledging and listing data contributors and supporting organisations.

About us. Includes the website’s citation, project members and contact information (ants.of.cyprus@gmail.com).

Data usage

Awareness raising

Insects are commonly perceived as pests by the wider public. However, being involved in nature conservation from a young age, participating in insect-focused public activities or promoting insects in culture has been shown to enhance the development of a more positive perception (Leandro and Jay-Robert 2019, Kawahara et al. 2021, Vlasák-Drücker et al. 2022). Negative perspectives alongside the lack of taxonomic knowledge by the public can be altered through educational tools and awareness raising campaigns (Lemelin et al. 2017, Weeks and Oseto 2018, Kawahara et al. 2021, Vlasák-Drücker et al. 2022). The “Ants of Cyprus” website aims to disseminate all available scientific knowledge of the island’s ants providing species profiles for all known species. Some information are more relevant to the scientific community, for example, occurrence records as .xlsx files although visualised data, i.e. distribution maps and photographic material, can better help the public understand the biodiversity and spread of species. Furthermore, upon communication with education professionals, informational sources and educational material on taxonomy and morphology, alien species and citizen-science initiatives are presented in both Greek and English. Additionally, the “About ants” section is devoted to disseminating knowledge and scientific research on the morphology, species interrelationships, ecosystem functions and lifestyle of ants. Such material can be used during school field trips and biology classes when discussing the role of arthropods or insects and the biodiversity of Cyprus. This website will be further promoted to the public through Social Media. The website will be also promoted in and its data will be made available to established international repositories, such as AntWiki and AntMaps according to best practices’ recommendation to scholarly publishing biodiversity data of Penev et al. (2017).

Taxonomy

The “Ants of Cyprus” website offers an up-to-date, dynamic checklist of the myrmecofauna of Cyprus including statistics on the number of genera, species, endemic and alien taxa (see Statistics and Checklist page). These data are particularly important in assessing the overall biodiversity of ants on the island, as well as the relative percentages of endemic and alien species. Based on the latest published data, the island hosts 76 species of ants, including 17 endemic (22.37%) and 17 alien species (22.37%). This shows that Cyprus is an important biodiversity hotspot and endemism centre of ants, which has also been revealed in global scale analyses (Kass et al. 2022). However, the high percentage of alien species is also alarming. Nevertheless, correlating the island’s ant biodiversity with that of neighbouring Crete, an island of similar area that hosts more than 100 species (Salata et al. 2020, Borowiec and Salata 2022, Borowiec et al. 2023, Schifani et al. 2024), it is evident that the myrmecofauna of Cyprus is still largely under-sampled. Data on new records and species, detected during the course of the Darwin Fellowship (DPLUS200), published in scientific literature and discovered by citizen scientists (e.g. through iNaturalist or citizen-science initiatives) will be made available online as soon as these are published. Furthermore, the provision of photographic material from both own and online sources can enhance the aesthetic appeal of the website to non-taxonomists, as well as taxonomic investigations from specialists. The latter is further strengthened by the provision of sources regarding identification keys on the ants of Cyprus.

Ecological data

On each species profile, a corresponding *.xlsx file is available, providing all published occurrence records. Data rows on each file are extracted from the published ant records dataset (Demetriou et al. 2024). Such data can be potentially utilised in analyses, such as species distribution modelling under climate change scenarios or potential impacts of land-use change. In addition, data on species interrelationships such as myrmecophiles, slave-making and slave species, predators, and parasitoids are given for each species and are databased for the whole island (in Media and Keys) in the hope of constructing ecological networks between ants and other species of the island. When used collectively, all occurrence records reveal under-sampled or unsampled areas where research is necessary.

Conservation value

Following the application of the IUCN guidelines on reporting and assessment of species on a regional level, we provide data on the occurrence of species within protected areas, i.e. the NATURA2000 network, their AOO, EOO, lower and upper altitudinal limits, as well as relative information regarding their habitats. These can be used in future assessments on the extinction risk of Cypriot ants, as no species have been evaluated. Nevertheless, these data also provide valuable information on the biodiversity hosted by protected areas and can better help us map and evaluate the

spread of alien and alien invasive species, such as the little fire ant *Wasmannia auropunctata* and *Trichomyrmex destructor* (Demetriou et al. 2023). Regarding alien species, the future application of EICAT and SEICAT impact assessment protocols is also needed in order to guide management practices.

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Conflicts of interest

The authors have declared that no competing interests exist.

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