

Introduction

The use of Artificial Lights At Night (ALAN) has increased worldwide in recent decades. Despite relevant knowledge of its negative effects on wildlife, ecosystems and human well-being, there is an important scientific and technical information gap related to the negative effects of ALAN on biodiversity.

Nature conservation actions have generally focused on diurnal species and their threats, while nocturnal or crepuscular species, such as nocturnal insects, have been neglected, and so have their specific threats. General studies about insects have noted a global decline, mainly due to anthropogenic activities, such as light pollution, which increases their cascading effects on biodiversity.

The Macaronesia archipelagos are unique and fragile ecological systems that host a large number of endemic species, exposed to a great diversity of threats. Yet, the available information on endemic and endangered insects present in Natura 2000 areas in Macaronesia, which may be affected by light pollution, is scarce. This lack of updated information on their distribution and conservation status limits the ability to develop effective mitigation measures and makes it difficult to assess the impact of any conservation measures.

LIFE Natura@night project (2022-2025) aims to address light pollution threats to several groups of species in Macaronesia, including nocturnal insects, bats and seabirds.

Goals

- Fill knowledge gaps and increase the information available on this animal group in Macaronesia.
- Establish a baseline for conservation actions. Ensure that species management plans consider insects and include actions to reduce light pollution, a compromising threat.
- Expand and update the inventory of species in Natura 2000 areas. Update inventories of protected areas, reporting on European directives.

Material and Methods

The main Natura 2000 sites covered by the project were sampled to determine the presence of nocturnal insects during the project's duration in 2022. Sampling was carried out systematically in the Azores, Canary Islands and Madeira, and the number of sampling points was proportional to the number of sites surveyed.

Results

In the Azores, a total of **14** sampling points were conducted, collecting **6,275** insects. In Madeira, **46** sampling points were surveyed with a total of **7,300** insects collected and in the Canary Islands **6** sampling points with **3,340** insects obtained.

For the present, the fieldwork, triage and assembly of insects is completed in all of the archipelagos involved. Meanwhile the progression of the collected insect identification with support from specialists in each archipelago is being currently carried out.

- In the Azores:** The sampling data obtained in the fieldwork on the island of Graciosa gave a total of 6,275 insects (of which 6,185 were collected by light traps). In general terms, the vast majority (80%) have been identified. The lists of Lepidoptera species collected mention 37 different species. In terms of abundance and number of species, it is important to note that most of the Lepidoptera collected belonged to the family Noctuidae, Crambidae and Tortricidae.
- In the Canary Islands:** The total number of insects captured in Gran Canaria and Tenerife was 3,340. The order Lepidoptera is represented by 39%, 23% by the infraorder Isoptera, and 19% by the order Coleoptera. Extracting from the 39% of Lepidoptera, 59% are identified at the family level, where the most represented families were Noctuidae (39%) and Pyralidae (10%).
- In Madeira:** Out of the 7,300 insects collected in 2022, 16% have been identified at the species level and 19% at the genus level. However, not all specimens have been assessed and some need confirmation. A total of 69 species have been identified so far, of which, 58 belong to Lepidoptera order. Of the specimens assessed at the family level (20%), Geometridae was the most detected family, followed by Noctuidae and Crambidae.

Acknowledgements

This study was developed as part of the LIFE Natura@night project (LIFE20 NAT/PT/001098), with a financial contribution from the European Union's LIFE programme. This preliminary assessment of nocturnal insects has been undertaken as the best practice to ensure Natura 2000 areas conservation and monitor ecosystem health and conservation status, describing the presence of insects in well-conserved areas of Macaronesia. The studies have been conducted in all the areas where the project is implemented.

The LIFE Natura@night project (2022-2025) aims to reduce and mitigate the impacts of light pollution (social-health, economic and environmental impacts) in the Natura 2000 areas throughout Macaronesia (Azores, Canary Islands and Madeira) in order to raise awareness on the issue of light pollution and to sensitise the population. From the coordination of this action, it is fundamental to give a merited thank you to all the volunteers and interns who participated in this study. For more information, visit <https://naturaatnight.spea.pt/>.

References

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Sample design

- A minimum of three samplings per area were distributed among the different habitats (**Figure 1**).
- Sampling was carried out during **four hours each night** (from 9 p.m. to 1 a.m.) representing the period of maximum activity of insects.
- It was ensured to have **favourable atmospheric conditions** for the activity of nocturnal insects (adequate temperature, absence of rain, weak wind, suitable lunar cycle and distance from artificial light sources) to conduct the samplings.
- The specific devices used for nocturnal insect sampling had at least 250 metres of separation from each other.
- Sampling was conducted using light traps, and complemented with *winerope* method, to allow the attraction of those endemic species which are not attracted by light (**Figures 2 & 3**).

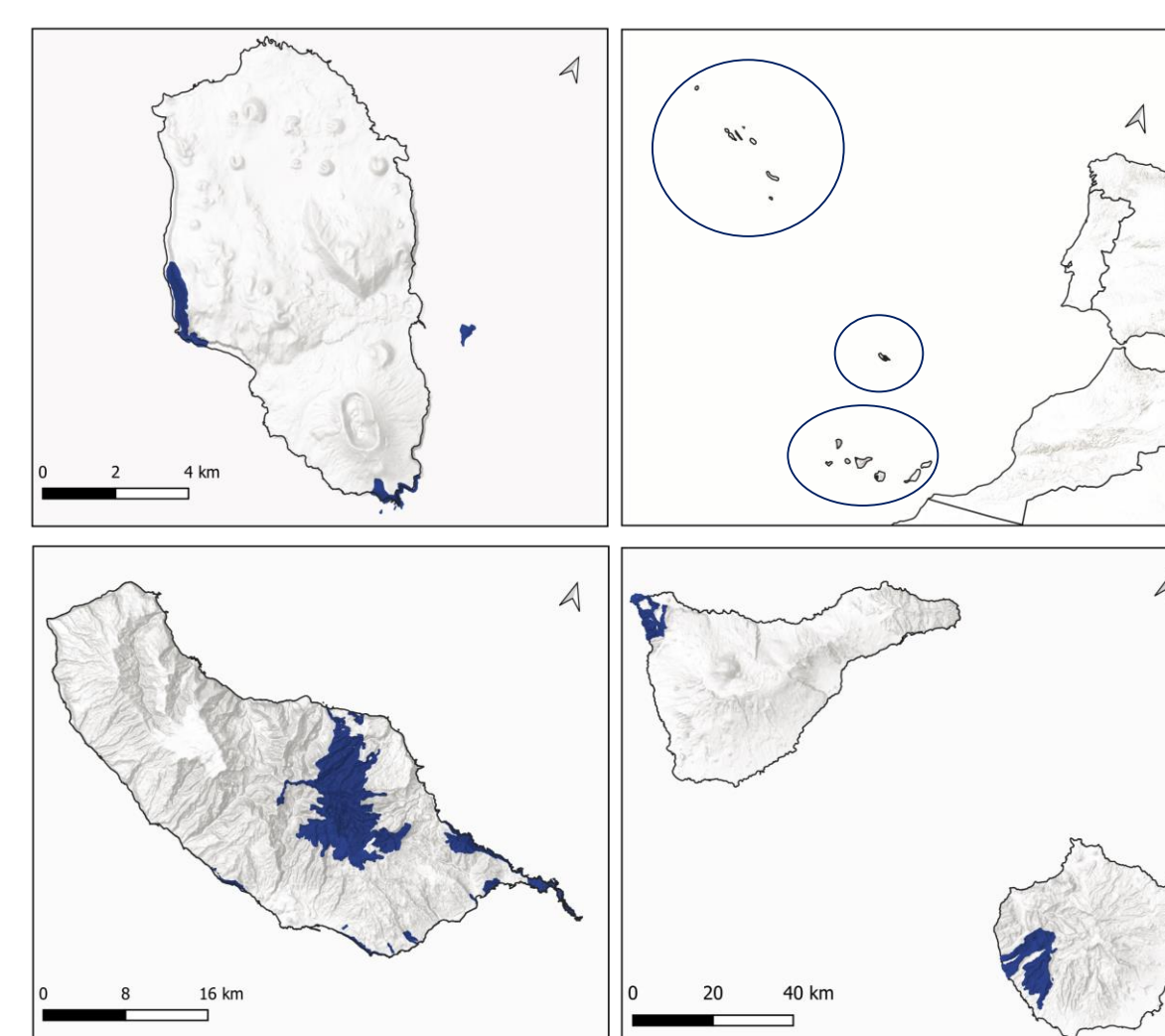


Figure 1 | Map of the sampled areas. In blue are the sampled Natura 2000 areas.

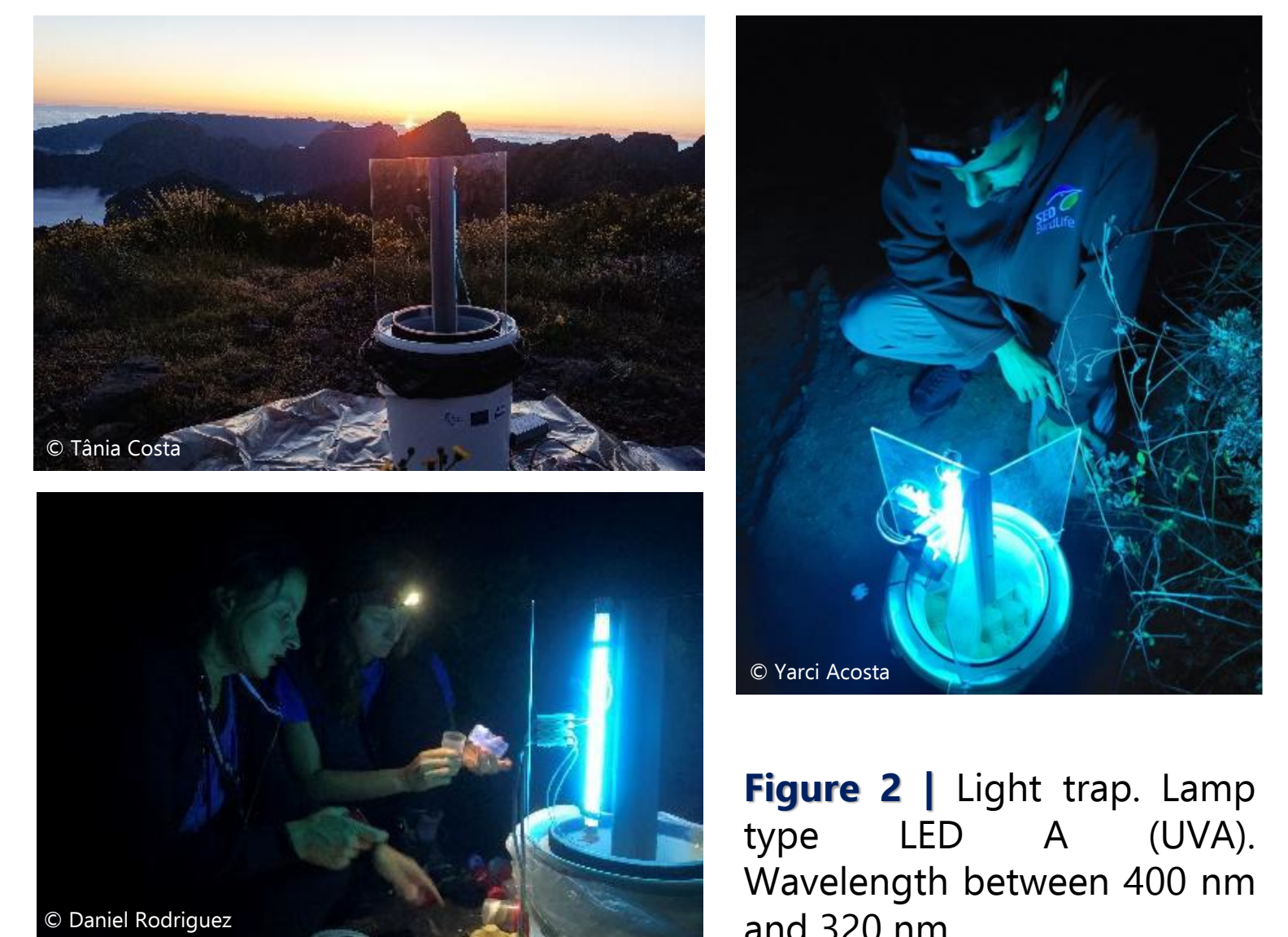
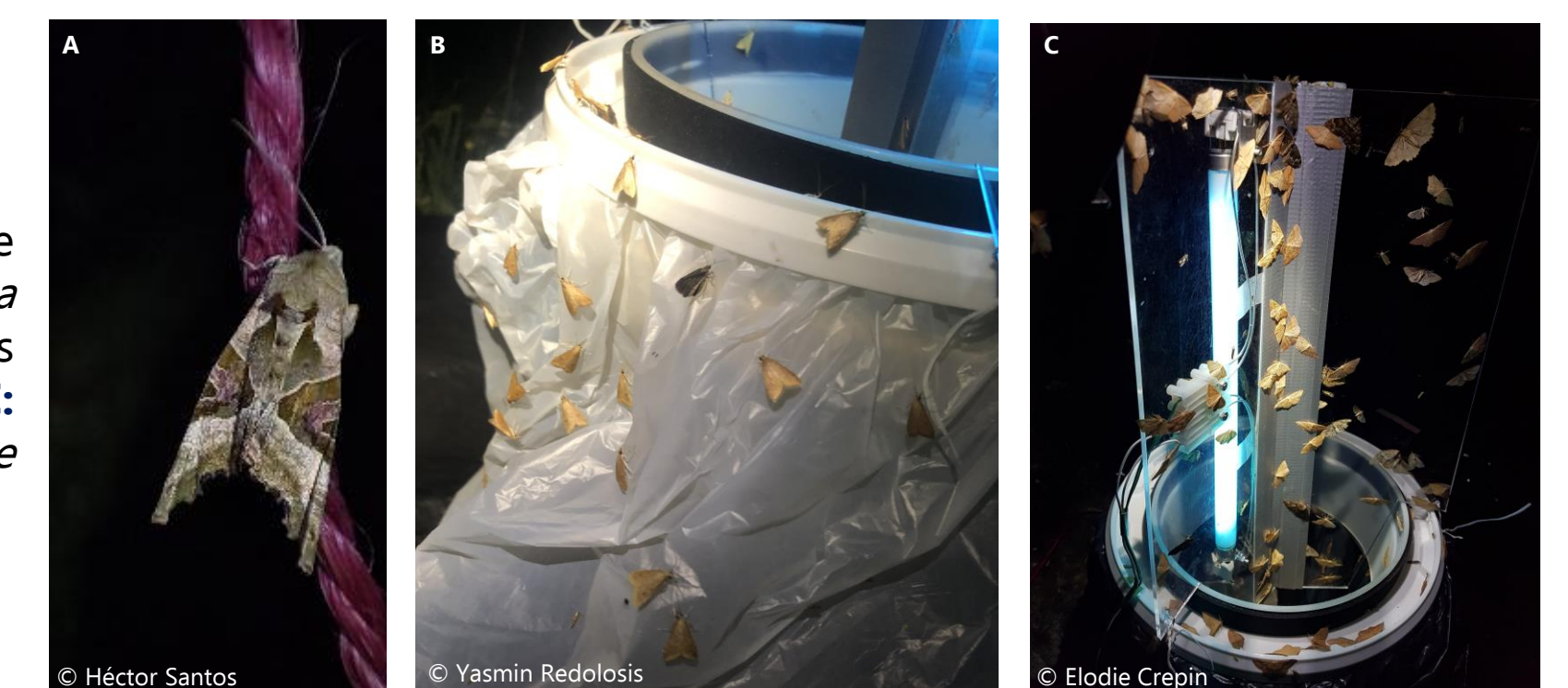


Figure 2 | Light trap. Lamp type LED A (UVA). Wavelength between 400 nm and 320 nm.

Figure 3 | Diverse Lepidoptera found using the different sampling methods. **A:** *Phlogophora meticulosa* found in the *winerope* method. **B:** Various individuals of *Udea ferrugalis* found in light trap. **C:** *Cyclophora* sp., *Menophra maderae*, *Xanthorhoe rupicola* found in light trap.



Discussion

- Fieldwork and sample triage are completed in this study. However, as some specimens are yet to be fully identified, the results presented should be considered preliminary. Nevertheless, as it is widely observed that moths are attracted to ALAN, it can be affirmed that the most abundant order found was, as expected, **Lepidoptera**. The species identified so far are mostly native or endemic, with the presence of exotic species.
- The main ecosystem services provided by insects are **habitat maintenance and pollination**. The role of nocturnal Lepidoptera and other nocturnal insects as effective pollinators has become increasingly recognized. The aforementioned contribution, in addition to the role they play as an important food source to other living beings, should urge the protection of natural darkness and the absence of artificial light within Natura 2000 protected areas.
- Once the final identification of specimens is achieved, the results of this study will provide a baseline for conservation actions and identify the species susceptible to being most affected by light pollution. Additionally, it will be possible to conduct more robust data analyses including the effect of environmental variables and light pollution at the study site, based on other measures taken within the project. Furthermore, these analyses will also guide the monitoring scheme to be adopted for the pilot actions planned in the LIFE Natura@night project and will produce information that will be relevant to promote the change in public lighting policies in favour of nocturnal biodiversity conservation and the ecosystem services they provide.
- Despite these being preliminary, it can be affirmed that the information gathered in this study will **increase the general knowledge** about the distribution of nocturnal insect species and their habitats in the Natura 2000 sites included in this project, and **promote the conservation** of a group in rapid decline.