LIFE Natura@night

Deliverable - Preliminary report on bats survey on Natura 2000 areas

Funchal, June, 2023

COFINANCIAMENTO

PARCEIROS

COORDENAÇÃO

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No projeto **LIFE Natura@Night**, pretendemos a redução e mitigação do impacte da poluição luminosa nas áreas de Rede Natura 2000 da Macaronésia.

COFINANCIAMENTO

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Missão

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Deliverable - **Preliminary report on bats survey on Natura 2000 areas**

Sociedade Portuguesa para o Estudo das Aves, 2022

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SUMMARY

In the LIFE Natura@night project (action A8), we plan on surveying the bat communities in the different types of habitats in Macaronesia of the R2000. This study will help us complement the information about the bat population on the areas of the project. In Macaronesia, we can find c.a. 15 species (including species from Cape Verde), three endemic species: *Pipistrellus maderensis*, *Plecotus teneriffae* and *Nyctalus azoreum*. During Autumn of 2022, we conducted acoustic survey using AudioMoth passive acoustic recorders in the R2000 areas in Madeira Island and in Spring 2023 in Graciosa, Azores. All field work was concluded in May 2023 and the analysis is process. The mist-netting captures were done during spring in Madeira Island and Azores on the same areas where the acoustic surveys took place. The main issues in this action were the delay of the equipment for the captures to arrive, weather conditions and the dependance of volunteers for the fieldwork. Also, the audiomoths presented some technical issues in some nights that stopped the recordings and making it necessary to repeat the survey on those locations. In total only two bats were captured during the capture surveys (both in Madeira Island in Laurel Forest). In Madeira Island, a prevalence of the *P. maderensis* in Laurel Forest is very clear and the number of the detections of this species is consideratevely higher than the number of *N. leisleri.* In Graciosa, the opposite happened with greater activity and distribution of *N. azoreum* than *P. maderensis*. In the Canaries, the data provided was analysed and the description of the species present in the protected areas were made with greater species richness in Tenerife Island. Unfortunately, no comparative analysis between Canaries and the other archipelagos were possible yet with the data provided.

1. INTRODUCTORY NOTE

1.1 LIFE NATURA@Night

Artificial Light at Night (ALAN) plays a crucial role in the modern society, providing safety for its populations. However, its excess use during the night might have negative impacts on the environment, leading in some cases to the death of various animals such as marine birds. The implications of ALAN on the ecosystems and the unknown impacts on Macaronesia resulted on the creation of **LIFE NATURA@Night** in March 2022 to mitigate the effects of ALAN in the region.

The project aims to understand and mitigate the effects of ALAN on the biodiversity of protected areas such as Nature 2000 areas in the Azores, Madeira and Canary Archipelagos. The Macaronesian region, according to IUCN, is home to ca. 789 threatened species and ca. 481 species are animal. Among nocturnal animals, there are ca. 177 insect species, eight marine bird species and five bat species considered threatened and potentially affected by ALAN.

However, the precise effects of ALAN on these nocturnal animals are unclear in Macaronesia and further studies are needed to understand this issue. The project has the main aim of decreasing the light pollution in these regions and mitigating the effects of ALAN on the protected species.

1.2 Macaronesian Bats

Chiroptera is considered the second largest mammal group globally, with over 1.400 species (Simmons et al., 2021). Bats have diverse dietary patterns ranging from carnivores to frugivorous and can be present in all the continents except for the poles. This makes this group of animals a hugely distributed group and essential for many ecosystems (Patterson et al., 2003, Altringham, 2011). Insectivorous bats are important bioindicators and contribute to maintain the balance of insect populations including agriculture pest control and disease vectors (Jones et al., 2009a; Kunz et al., 2011; Ramírez-Fráncel et al., 2022). A significant number of these species can be found in insular ecosystems (ca. 60%) with many of them being endemic to islands (ca. 25%; Jones et al., 2009b; Conenna et al., 2017). However, according to IUCN, ca. 50% of the insular bat species are threatened and five species have gone extinct (Jones et al. 2009b, Conenna et al. 2017, IUCN 2018).

Macaronesia is a biogeographical region in the Atlantic Ocean, consisting of five archipelagos with a total of 39 islands larger than 1 km2. This region composes archipelagos from different countries such as Portugal (Azores, Madeira and Salvage Archipelago at the north), Spain (Canary Archipelago) and Cape Verde (south) (Masseti, 2010). Due to the diversity of habitats and climates, Macaronesia is recognized as a hotspot of biodiversity, home to numerous endemic species (Whittaker & Fernández-Palacios 2007; Brilhante et al. 2021, Florencio et al. 2021). However, the native terrestrial mammal species are mainly the 16 bat species and the

introduction of other mammal species such as Rat species (Masseti, 2010). Macaronesia is home to three endemic species: Azorean Bat (Nyctalus azoreum, Thomas 1901) restricted to Azores; Madeiran Pipistrelle (Pipistrellus maderensis, Dobson 1878) found in Azores, Madeira and Canary Archipelagos; and Canary Long-Eared Bat (Plecotus teneriffae, Barret-Hamilton 1904) restricted to the Canaries. According to IUCN, all these endemic species are classified as Vulnerable.

The effect of light pollution on bats in Macaronesia is currently unknown and further research is needed to understand its impact. The LIFE NATURA@Night, strongly associated to the Natura 2000 areas, aims to determinate the best methods to mitigate the effects of the current illumination plan and evaluate the benefit of the new ones. Conducting research on the bat populations on the region is essential to achieve this goal and understand the population dynamics in these areas.

2. Methodology

2.1 Technical Aspect

We conducted an assessed of bat activity and diversity within the areas of N2000 targeted by the project (16 locations, 48 recording sites). The research was carried out in the same areas targeted by Action A9 for comparative analysis. To ensure consistency, we standardized methodologies for bioacoustics and mist-netting across Madeira and Graciosa Island (Madeira and Azores archipelagos).

2.2. Study Areas

2.2.1 Azores Archipelago: Graciosa Island

The Azores archipelago consists of nine volcanic islands located ca. 1.400 km off Portugal. These volcanic islands are located between tectonic plates and experience constant volcanic activity. Graciosa Island is a small island (ca. 62 km^2), formed around 2.5 My ago (Rando et al., 2017). Although the island's highest area reaches ca. 402 m altitude, most of the land is situated at lower altitudes (under 300 m altitude; Teixeira et al., 2015). Graciosa is characterized for its low forest cover and high concentrations of introduced flora such as *Pittosporum ondutatum* (Silva et al., 2004; Teixeira et al., 2015). This is due to the island's easy terrain for fires and anthropogenic occupation (Reno et al., 2015). Unlike the other islands in the archipelago, Graciosa lacks natural water sources. Agricultural areas are the predominant land use on the island according to e Coordination of Information on the Environment CORINE Land Cover (CLC) (Castanho et al., 2006).

Figure 1 Map of the Audiomoth placement in the Graciosa Island, Azores. Black dots represent the extra recorders placed, green dots represent the ones required for the project, and the red circles represent the capture area.

2.2.2 Madeira Archipelago: Madeira Island

Madeira Archipelago is composed by Madeira, Porto Santo, and Desertas Islands, situated c.a. 700 km off African coast. The main island (Madeira) is c.a. 742 km^2 and emerged c.a. 7 – 5 Ma years (Ramalho et al., 2015; Góis-Marques et al., 2019). The highest peak on Madeira Island reaches an altitude of 1.862 m, making it a highly mountainous region. Its diverse microclimates contribute to a wide range of habitats on the island (Delgado et al., 2006). Despite being prone to wildfires and other natural disasters, the island sustains ca. 6.8% of its endemism density level (Castanho et al., 2019; Masseti & Gil, 2020). Madeira island also holds the highest endemism density levels of all Macaronesia with over 7500 plant species either endemics to the archipelago or Macaronesia (Borges et al., 2008; Masseti & Gil, 2020). Even though, agriculture is a huge source for the Madeiran Economy, the Forest and semi-natural areas occupy the largest extension of the island (Castanho et al., 2021).

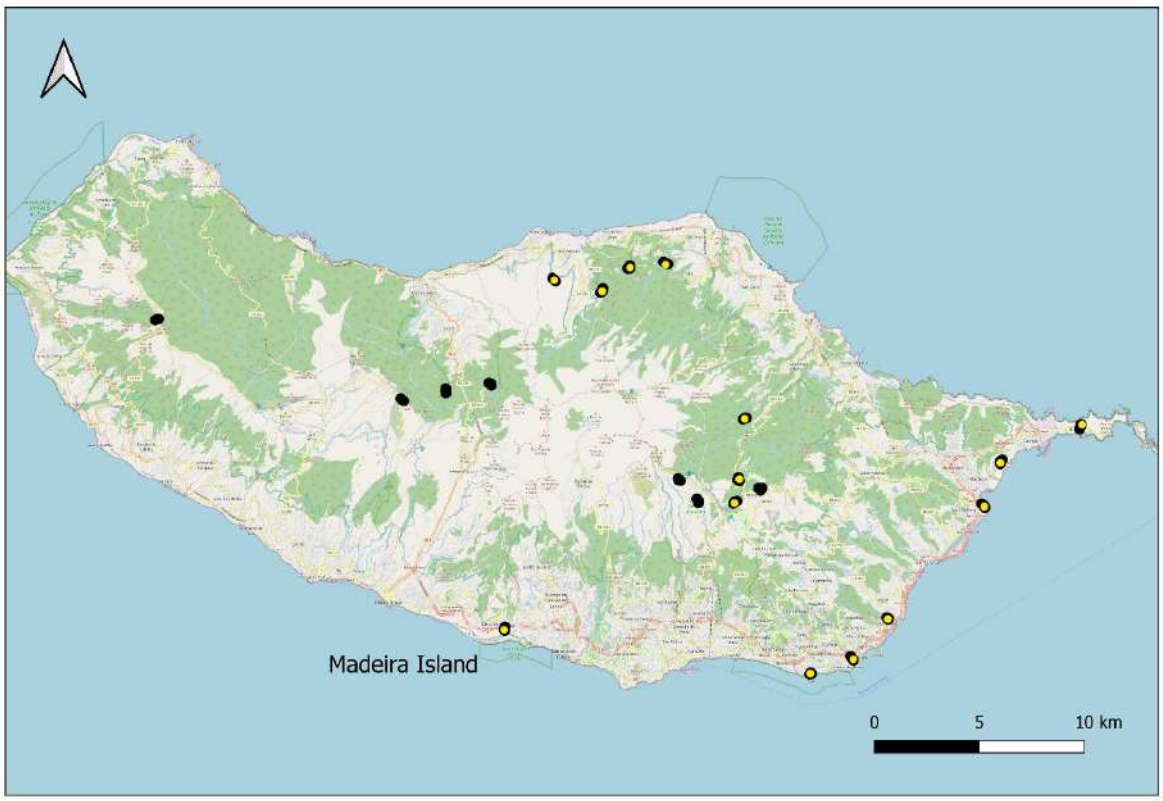

Figure 2 Placemente of the Audiomoths in Madeira Island, Portugal. The black dots represent the areas where Audiomoths were placed, the yellow dots represent the capture sites and the areas where captures did not take place were extra audiomoth research in the island.

2.2.3 Canary Archipelago

The Canary Archipelago consists of seven volcanic islands and numerous islets, located approximately 100 km northwest of the African coast (Nogales et al., 2006). The islands' elevations vary from 671 m (Lanzarote) to 3,718 m (Tenerife), resulting in a wide range of vegetation types across the archipelago. The islands closer to the east are influenced by the winds from the Sahara Desert, creating a xerophytic climate at lower altitudes. In contrast, the higher mountainous islands feature diverse vegetation, including humid forest habitats like the Laurel Forest and dry monospecific pine forests found at higher elevations (Nogales et al., 2006).

2.3. Bioacoustic Survey

In both Madeira and Azores, extensive efforts were made to conduct bat surveys using automatic ultrasound recording devices (Audiomoth v.1.2.0) in the Natura 2000 areas (14 in Madeira and two in Graciosa). In Madeira Island the recorders were placed from August till October 2022 while in Azores the survey took place in beginning of April 2023. In each sampling area, three Audiomoths were positioned c.a. 100 to 300 m from each other (46 and 6 recording

point in Madeira and Graciosa, respectably). Additionally, in Graciosa an island-wide survey was carried out with c.a. 60 acoustic random points distributed across the entire island.

The Audiomoths were configurated to record up to 384 kHz for the from 15 before the sunset until 15 min after sunrise coinciding with the same areas where the insect survey areas. In the case of the island-wide survey, the Audiomoths were configurated to record for 24 hours, one minute out of five. This comprehensive approach aimed to maximize the chances of detecting bat activity and gathering a comprehensive soundscape across the entire island.

Figure 3 Placement of the Audiomoths in the field (Copyright to Yasmin Redolosis)

The recorders were affixed to various structures such as poles, trees, shrubs, and even inserted into wall crevices. Resourcefulness was sometimes necessary due to the challenges encountered in locating appropriate spots for recorder placement. To overcome these obstacles, the recorders were positioned at a height ranging from 1 to 2 meters. Despite the difficulties in finding suitable locations, every effort was made to ensure the recorders were securely positioned, allowing for accurate and reliable recording of bat activity.

2.4 Bioacoustic Analysis

The recorded data was carefully analyzed using Kaleidoscope Pro, utilizing the AutoID program to facilitate the identification of bat species present in the recordings. To ensure accuracy, the results generated by the AutoID program were subjected to manual verification.

To assess the activity of bats, a detailed analysis was conducted focusing on bat passes. A bat pass was defined as a sequence of two or more echolocation pulses that occurred within a five-second sound file. By examining these bat passes, valuable insights into the behavior and patterns of bat activity were extracted and analyzed. This meticulous approach allowed for a comprehensive understanding of the presence and behaviors of bats within the surveyed areas.

2.5 Mistnetting and Captures

During March - May 2023 surveys conducted in the Natura 2000 areas, the capture areas were stratefically chosen to align with the research areas for the nocturnal insects. We used ground-level mist nets ranging from 3 and 12 m in length in the selected areas (Table 1). Whenever possible, the nets were positioned in strategical areas such as potential foraging areas or drinking areas, maximizing the changes of capturing bats.

The total number of nets used varied depending on the specific site, taking into consideration the availability of suitable areas and sufficient space for net placement. Between four and five nets of different lengths were used in each capture area. In rare instances, only three nets were placed due to specific circumstances such as space and terrain.

The capture and handling of bats strictly followed the recommendations approved by the American Society of Mammalogists (Sikes et al., 2011). All bats captured were released at the capture site. No surveys or captures were conducted on rainy or windy days and precipitation and wind speed were constant throughout the sampling period.

Figure 4 Placement of nets for the captures (A), Captures at the Caldeira (B), Captures at the Farol do Carapacho (C) (Copyright to Yasmin Redolosis)

Mist nets were set up and opened before sunset and remained in place for approximately four to five hours depending on the bat activity and the most active times. Additionally, in the capture nights a Audiomoths and a Echometer were used to determine the presence of bats near the capture areas. These devices help detecting and verifying the presence of bats in the capture areas during the survey.

Table 1 *Data on the Nets placed on each study area and the measures of the nets used in each area.*

Archipelago	Study area	Point	N. nets	3 m	6 m	9m	12 m
Madeira	Cabo Girão (PTMAD0011)	1	3	0	2	1	0
	Pináculo (PTMAD0007)	1	3	1	2	0	0
	Caniço de Baixo (PTMAD0012)	1	3	2	1	0	0
	Porto Novo (PTMAD0013)	1	4	1	3	0	0
	Machico (PTMAD0014)	1	4	0	3	1	0

	Pico do Facho (PTMAD0015)	1	4	2	0	0	2
	Ponta de São Lourenço (PTMAD0003)	1	5	1	3	1	0
	Maciço Montanhoso central (PTMAD0002)	10	5	1	4	0	0
		11	5	1	3	0	1
	Laurissilva (PTMAD0001)	5	4	0	1	2	1
		6	3	1	2	0	0
		7	4	0	3	0	1
		8	4	1	2	1	0
		9	5	1	4	0	0
Azores	Garapacho/Ilhéu de Baixo (PTZPE0029)	1	4	0	4	0	0
	Caldeira	1	3	0	3	0	0
	Pico Branco (PTGRA0016)	1	4	0	4	0	0

2.6 Equipment required

The majority of the fieldwork materials were acquired from Ecotome. The materials for the bioaccoustic arrived during autumn (September- October 2023) and the remaining during Spring (beginning of April). The following list of materials were acquired for this action:

- Mist nets (3, 6, 9 and 12 m length)
- Telescopic poles
- Ropes
- Pickets
- Cottom bags
- Audiomoths
- Audiomoth cages
- Batteries
- Micro SD cards
- Battery Rechargers
- Kaleidoscope Pro Licence
- Echometer
- Song Meter Mini

3. RESULTS AND DISCUSSION

3.1 Azores

The recordings conducted at Farol do Carapacho (Ilhéu de Baixo, GRA1) yielded only two bat passes of *P. maderensis* and a significant number of 1880 bat passes of *N. azoreum* (Fig. 5). However, during the captures in the area, only one bat was observed flying around the lighthouse and no bats were captured.

In the Ilhéu de Baixo area, most of the detections were recorded close to the lighthouse, which coincides with the capture location (Fig. 6). However, the captures took place during the first hours of the night (before midnight), and most bat passes were recorded in the area during the early morning hours (from 1 AM till 6 AM). The recordings of *P. maderensis* (2 bat passes) were recorded close to the lighthouse as well (Fig. 6).

On the other hand, the Caldeira (GRA2), characterized by abundant tree vegetation, with a small water source and protected from the ocean, exhibited a lower overall bat activity compared to the lighthouse area. However, both species were detected (*P. maderensis* and *N. azoreum*), with *P. maderensis* showing higher prevalence (Fig. 5). In the Caldeira, bats were recorded during the captures with the help of a Echometer (*P. maderensis* and *N. azoreum*). The three Audiomoths recorded uniformly the activity of *P. maderensis* and *N. azoreum*. The tree recorders detected both species in this area (Fig. 6). In the area, some detections were found that were not identified yet.

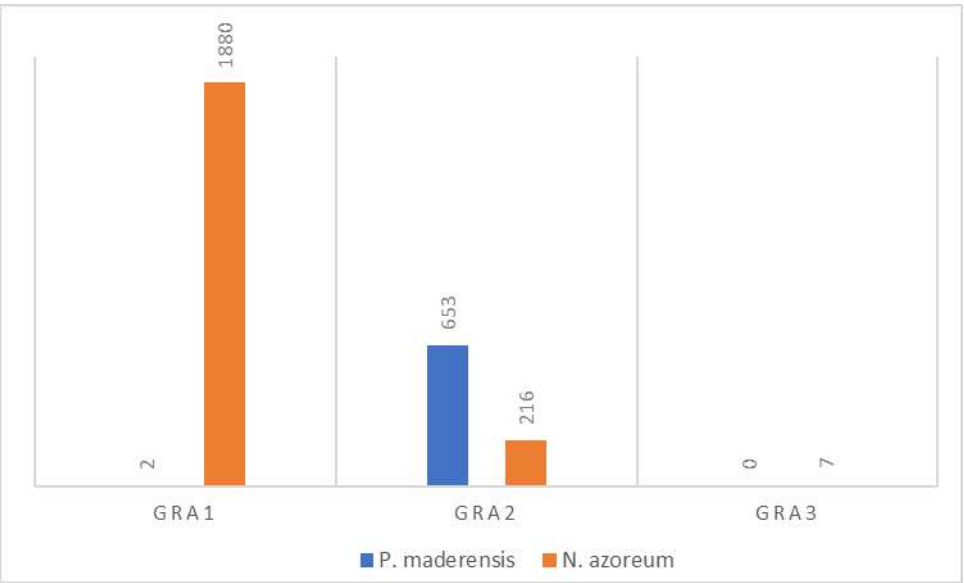

Figure 5 Bat Detections per site on the RN2000 areas (GRA1: Farol do Carapacho; GRA2: Caldeira, GRA3: Pico Branco)

Lastly, in the wind-swept grassland area of Pico Branco (GRA3), only seven bat passes were detected indication that bat activity might be more dispersed away from the coastline (Fig. 5). In GRA3, *N. azoreum* was the only species detected on the recorders. During the captures, no bats were detected visually. *Nyctalus azoreum* were detected on all the points on the area (Fig. 6).

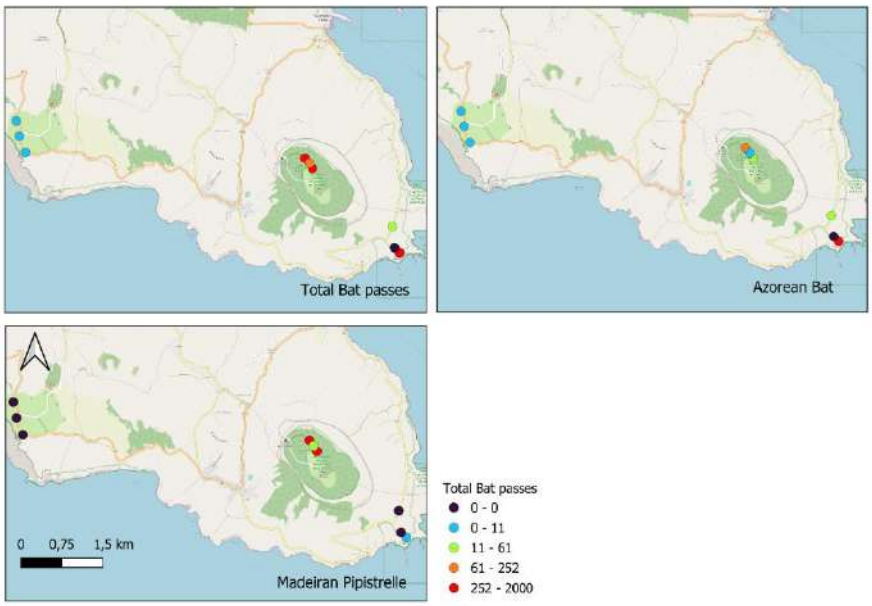

Figure 6 Bat passes per audiomoth on the areas of RN2000. Total number of bat passes (top left), Azoream bat (top right), Madeiran pipistrelle (bottom)

During the research survey in Graciosa, approximately 60 additional recording sites were established (Fig. 1). Among the recorded bat species, *N. azoreum* displayed the widest distribution and highest activity levels (Fig 7,8). The data collected suggests that bat activity was predominantly concentrated on the north side and east side of the island, particularly on the case of the *N. azoreum* (Fig. 8).

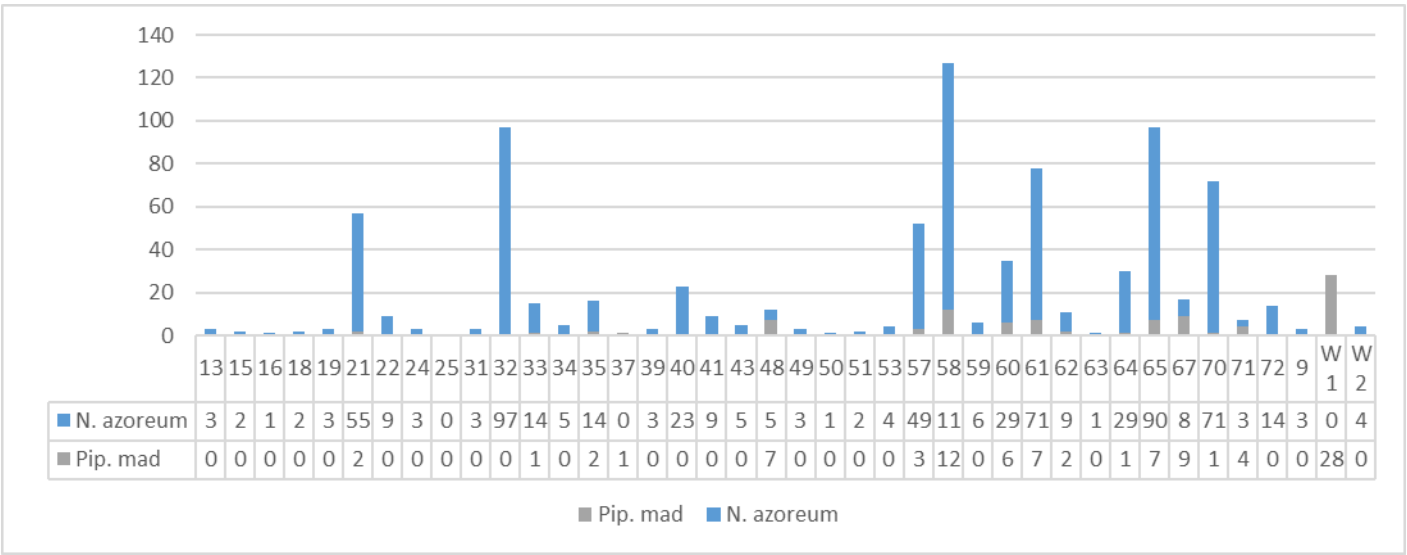

Figure 7 Number of bat passes per recorded site where bat passes were identified per species.

Pipistrellus maderensis, on a first map analysis, seems to be located close to city areas of Graciosa as well as forest areas. Most sites where *P. maderensis were detected had up to 10 bat passes and in the Caldeira area the highest number of bat passes were detected from the species (28).*

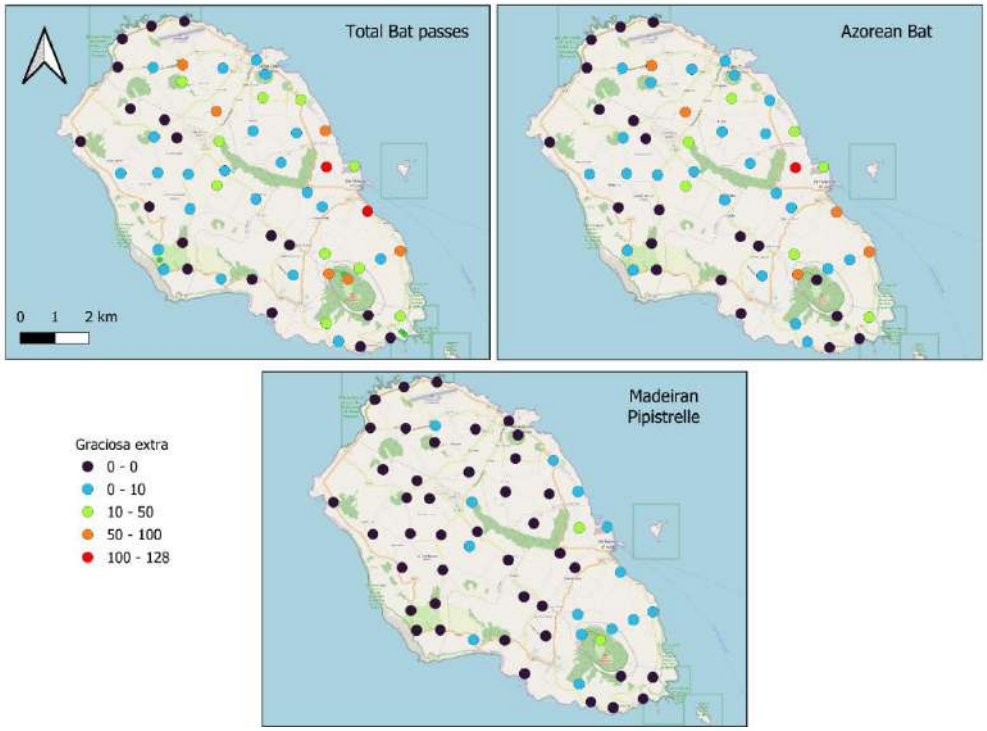

Figure 8 Bat passes in extra recording sites through out Graciosa island. Total number of bat passes (top left), bat passes of Azorean bat (top right) and Madeiran pipistrelle (bottom)

3.2. Madeira

During the research conducted on Madeira Island, only two individuals of the species *P. maderensis* were captured *(Fig. 9).* However, it is worth noting that the second individual managed to escape the net before rescued. Both captures took place in Laurissilva forest, one in LS6 and another one in LS2.

Figure 9 Male *P. maderensis* captured in Laurel Forest

The data collected reveals a distinct pattern of distribuition of the bat species in the various locations of Madeira Island. In areas such as Machico, Cabo Girão, Pináculo, Pico do Facho and Ponta de São Lourenço, the prevalent species detected with the recorders were *N. leisleri.* On the other hand, in Caniço Baixo, Laurissilva, Maciço Montanhoso Central and Porto Novo were *P. maderensis* (Fig. 9).

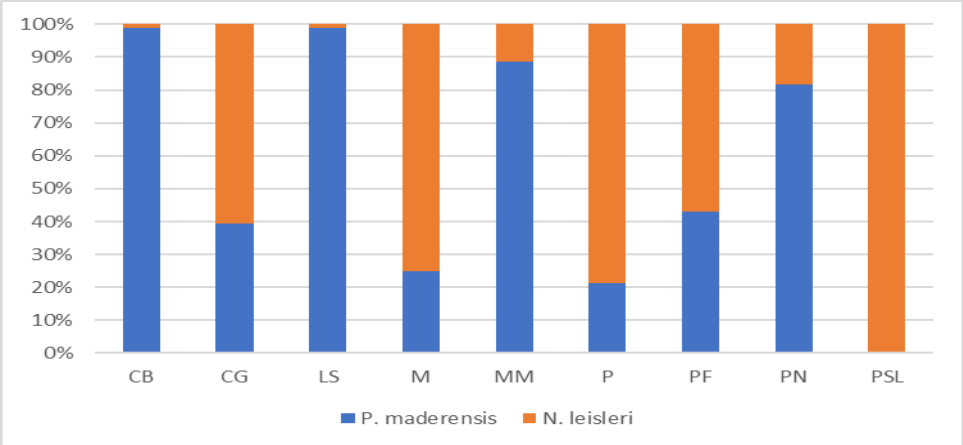

Figure 10 Percentages of species bat passes per study area. CB: Caniço de Baixo, CG: Cabo Girão, LS: Laurissilva, M: Machico, MM: Maciço Montanhoso Central, P: Pináculo, PF: Pico do Facho, PN: Porto Novo, PSL: Ponta de São Lourenço.

Cabo Girão is a coastal area near a city area and characterized by the presence of Eucalyptus trees. In this particular location (Fig. 10), it was possible to detect both species with a total of 216 bat passes during the night (85 *P. maderensis*, 131 *N. leisleri*). The maximum number of bat passes detected on a single recorder was 79 detections of *N. leisleri,* while the lowest was

two *P. maderensis* bat passes. On the day of the captures, the recorder placed detected more *P. maderensis* (35 bat passes) than *N. leisleri* (5), however no bats were captured during this night.

Figure 11 Number of bat passes per site on Cabo Girão. Total Number of bat passes per site (Background), Madeiran Pipistrelle (top right), Leisleri's Bat (bottom left).

The South Madeira areas (Pináculo, Caniço de Baixo, Porto Novo) are mainly urban areas with low vegetation, occasionally featuring fruit trees. All recorders detected *P. maderensis* and *N. leisleri* (Fig. 11).

In Pináculo, *N. leisleri* (max. 821 and min. 29 bat passes per recorder) was more detected than *P. maderensis* (max. 95 and min 89 bat passes per recorder). During the captures, no bats were captured, however *P. maderensis* was detected with the help of the Echometer (Fig. 12).

In Caniço de Baixo, *P. maderensis* (max 1341 and min 11 bat passes per recorders) was detected more than *N. leisleri.* (max. 9 and min 1 bat passes per recorders; Fig. 12). During the captures, no bats were captured however only *P. maderensis* were detected with Audiomoth (13 bat passes).

In Porto Novo, more bat passes from *P. maderensis* (max. 403 and min 72 bat passes per recorder) than *N. leisleri* (max. 66 and min 19 bat passes per recorder, Fig. 12). During the captures no bats were captured, no bats were detected on the furthest net from the route (Audiomoth) however *P. maderensis* was detected with the Echometer close to the route.

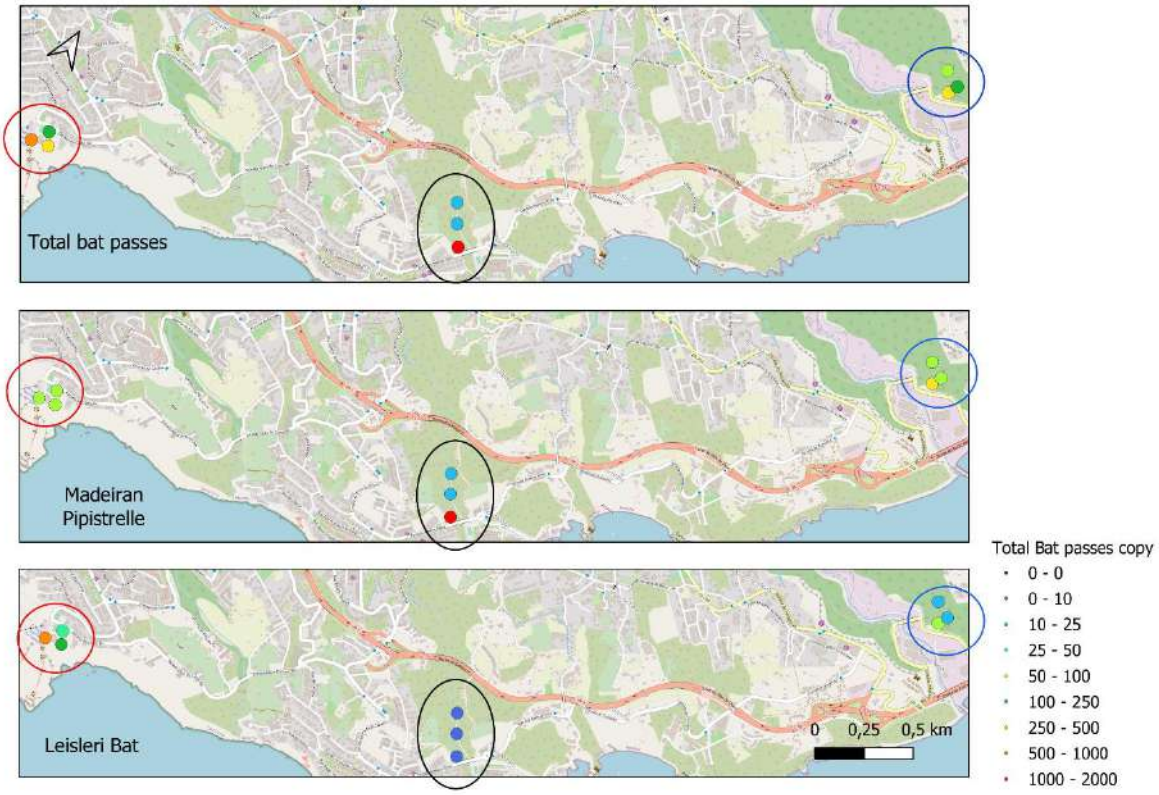

Figure 12 Number of bat passes per site on South areas of Madeira Island. Total Number of bat passes per site (top), Madeiran Pipistrelle (middle), Leisleri's Bat (bottom). Pinaculo (red circle), Caniço Baixo (black circle) and Porto Novo (blue circle).

On the mountain area (Maciço Montanhoso central), *P. maderensis* appear to be more active than *N. leisleri* (Fig. 12). The extra points where the recorders were placed in the Mountain areas were covered by shrubland (heathers) and a low tree density (sites outside the red circule map, Fig. 12), *N. leisleri* was not detected on the left side of the map, while in the main study areas where forest is prevalent (inside red circle, mid) the activity of both species are present as well as in the shrubland/heather area (right side of the map). The data from the extra points on the left side of the map were unusable due to the interference on the recordings. On the day of the captures, in the main study areas no bats were detected on the recordings of the south dots (MM10) while in the north points (MM11) *P. maderensis* (3) and *N. leisleri* (4) were detected but no bats were captured.

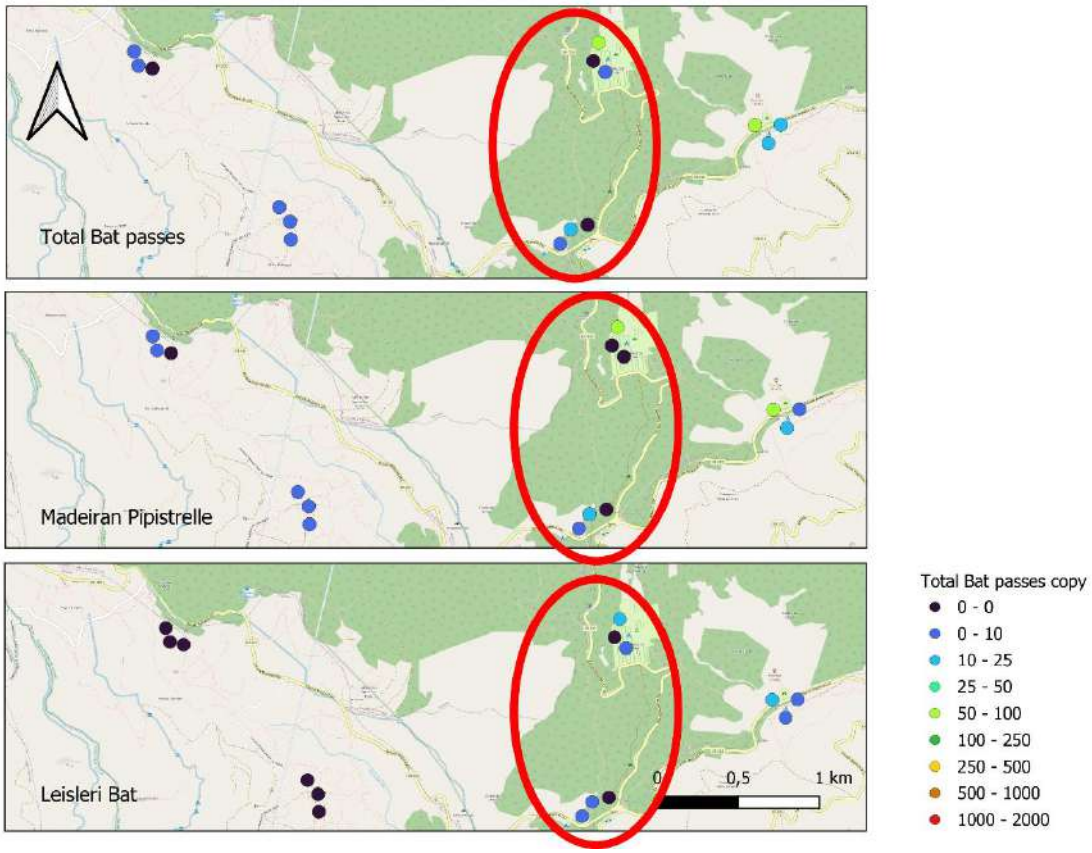

Figure 13 Number of bat passes per site on Central Mountainous areas of Madeira Island. Total Number of bat passes per site (top), Madeiran Pipistrelle (middle), Leisleri's Bat (bottom). Red circle (main areas of study).

On the east side of the island (Machico, Pico do Facho, Ponta de São Lourenço), the habitat is xeric with low vegetation with low density of introduced trees (Eucalyptus on the first two areas and pinacea on the last one). The bat activity appears to decrease to the east (Fig. 14).

Pipistrellus maderensis is not detected at all in Ponta de São Lourenço and only one *N. leisleri* bat pass was detected. No bats were captured or detected during the mist netting night.This is probably due to the dry area without water sources that are usually not frequented by bat populations (Fig. 14).

In Pico do Facho, the detections of bat activity seem to be closer to the route and has lower rates than Machico (left side of the map). *Pipistrellus maderensis* (41 bat passes) was detected in similar numbers as *N. leisleri* (57 bat passes) in Pico do Facho (Fig. 14). No bats were captured and both species (*P. maderensis* and *N. leisleri*) were detected using an Echometer.

On Machico area (right next to the airport of Madeira), the number of bat passes detected was high for both species. *Pipistrellus maderensis* appears to be more active towards the south area (543, 40, 6 bat passes from south to north recorder) contrary to *N. leisleri* (60, 226, 1.484 bat passes) (Fig. 14). No bats were captured, however *N. leisleri* were detected with an Echometer.

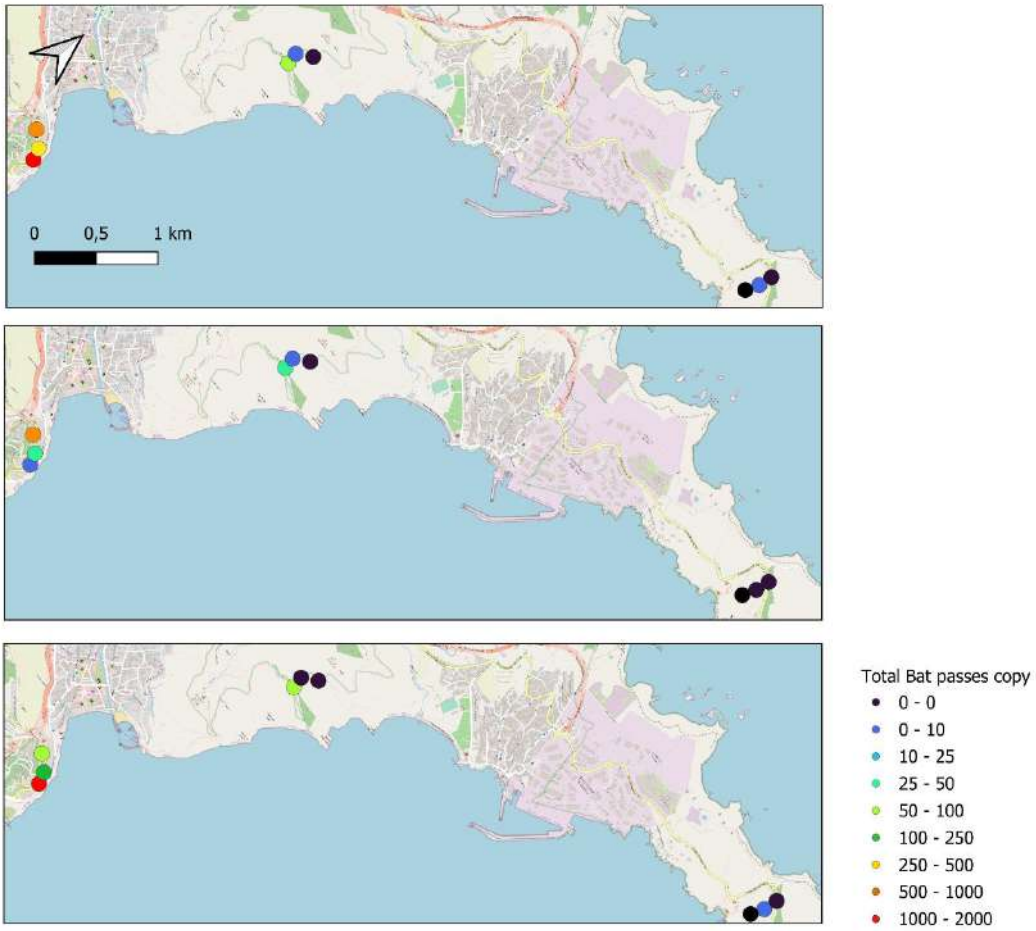

Figure 14 Number of bat passes per site on East areas of Madeira Island (Machico left, Pico do Facho middle, Ponta de São Lourenço right). Total Number of bat passes per site (top), Madeiran Pipistrelle (middle), Leisleri's Bat (bottom).

In Laurissilva Forest, the activity of *P. maderensis* is prevalent compared to *N. leisleri. Nyctalus leisleri,* in Laurissilva, the greatest number of detections was 24 bat passes while for *P. maderensis* was 1602 (sites 100m apart from each other in LSS7). Two captures occurred in Laurel Forest site (LSS6 and LSS7). During the captures, in LSS7 and LSS6, there were visual detections of *P. maderensis,* in LSS6 also close to the mist nets. In LSS5, no bat detections during the capture survey. In LSS8, only three bat detections (*P. maderensis*) and one *P. maderensis* detected on the LSS9.

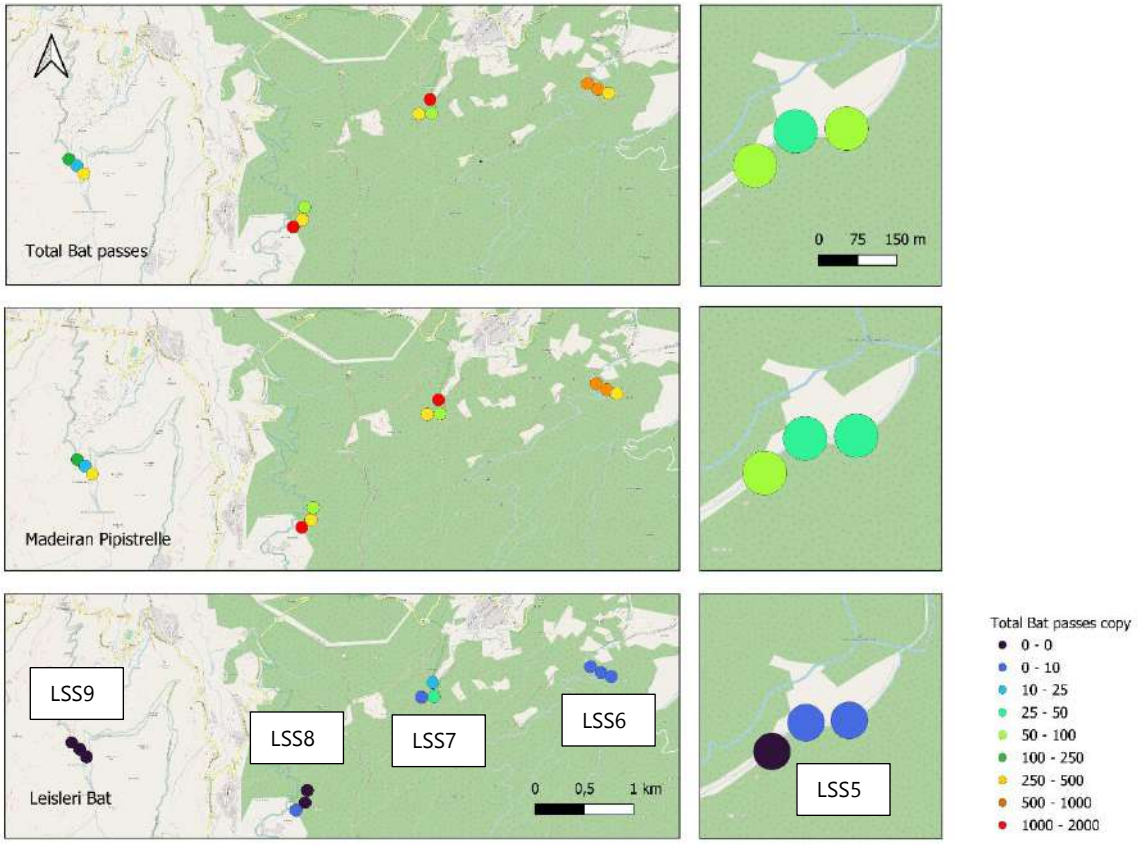

Figure 15 Number of bat passes per site on Laurissilva areas of Madeira Island. Total Number of bat passes per site (top), Madeiran Pipistrelle (middle), Leisleri's Bat (bottom).

From some extra recording sites done on the West side of the island, the greater number of bat passes from *P. maderensis* is observed in Laurissilva and Mountanous areas. The number of detections of the species *N. leisleri* is very low in the east Laurissilva forest (right side of the map), but high on higher altitude (on Paul da Serra, left side of the image).

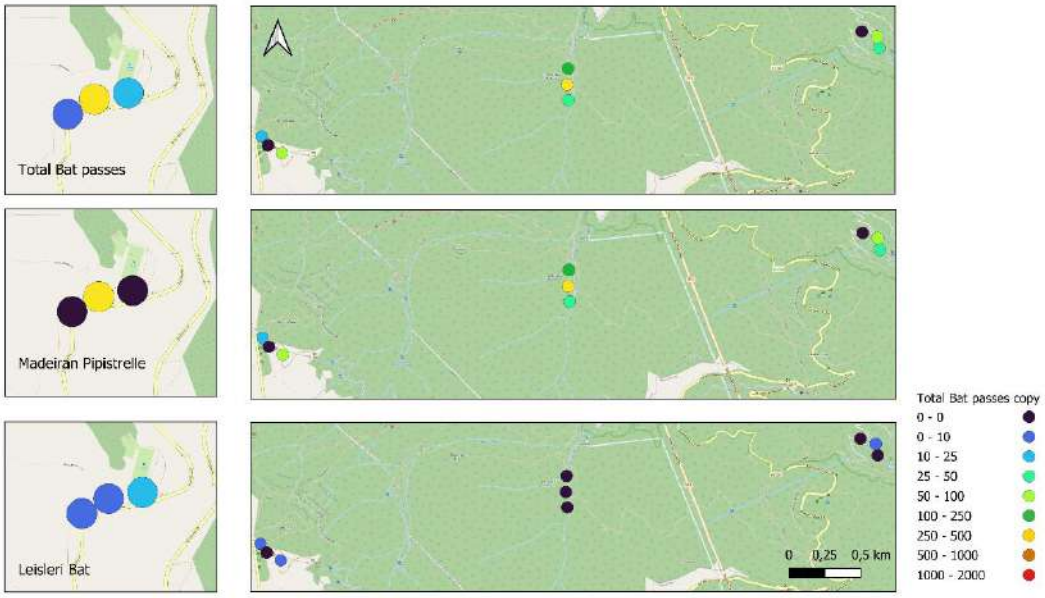

Figura 15 Number of bat passes per site on West Mountainous areas (middle dots) and Laurissilva (right and left side) of Madeira Island. Total Number of bat passes per site (top), Madeiran Pipistrelle (middle), Leisleri's Bat (bottom).

3.3. Azores vs Madeira

By comparing the detections in Madeira and Graciosa Island, it is possible to observe that the *N. azoreum* is more frequent in Graciosa compared to *P. maderensis* (2103 *vs* 655 bat passes). Contrary to Graciosa, on Madeira, the most common detections are *P. maderensis* (10173 *vs* 3263 bat passes).

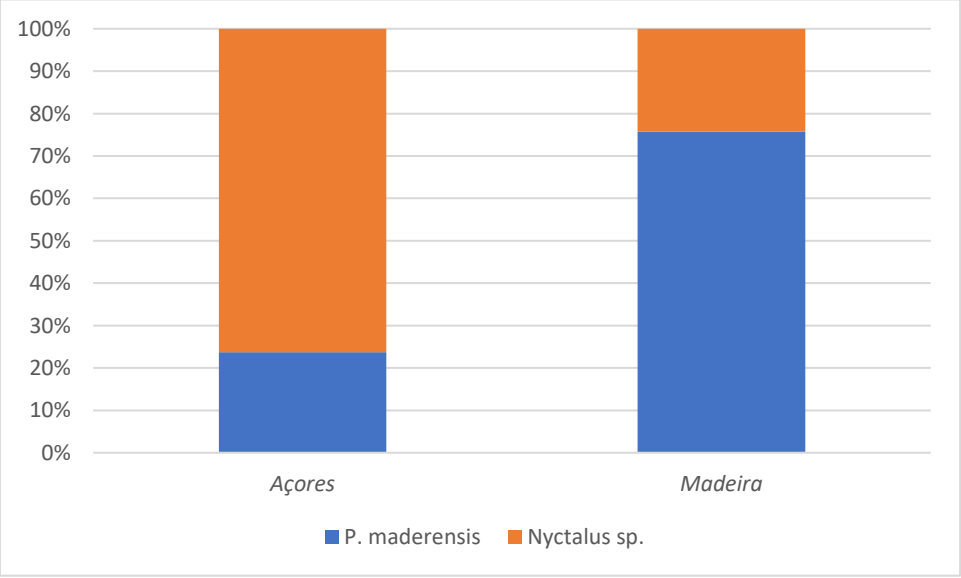

Figure 16 Percentages of P. maderensis and Nyctalus spp. activity in Madeira and Açores

3.4. Canaries

According to the data provided from Canaries, bats are found in all islands from the archipelago except for Lanzarote Island. The data include data on the species European free-tailed bat (*Tadarida teneotis*), Kuhli Pipistrelle (*Pipistrellus kuhlii*), Madeiran Pipistrelle (*Pipistrellus maderensis*), Savi's Pipistrelle (*Hypsugo savii*), Leisleri's bat (*Nyctalus leisleri*), Western Barbastelle (*Barbastella barbastellum*) and Canary Long-Eared bat (*Plecotus teneriffae*).

In Fuerte Ventura, the only species found in the data is *P. kuhlii.* The species is found in different areas of the island including in the protected areas of the island.

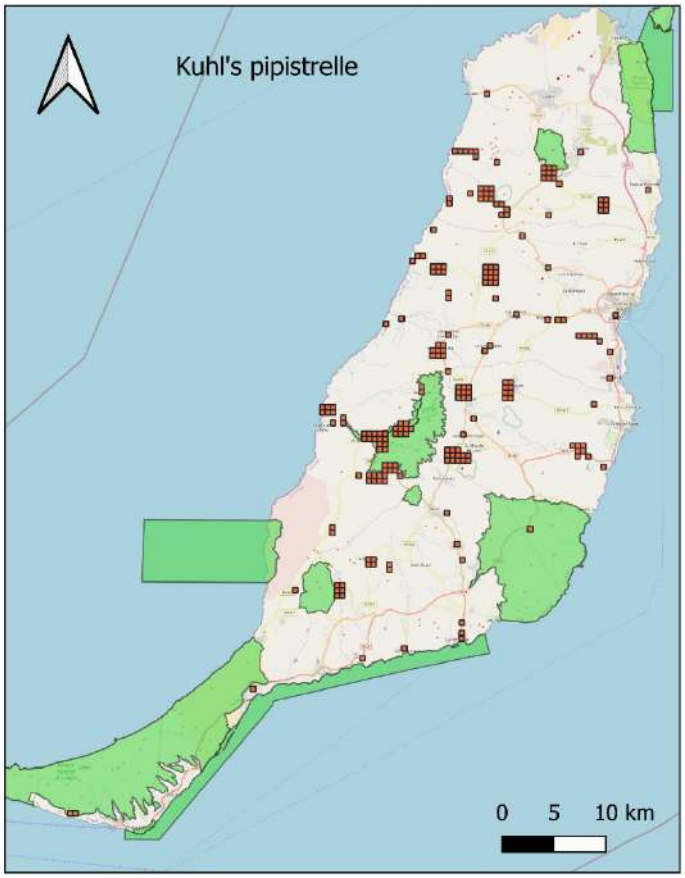

Figure 17 Kuhl's Pipistrelle in Fuerte Ventura. ZPE areas in green

In Gran Canary, three species were detected: *Tadarida teniotis, Pipistrellus kuhli* and *Hypsugo savii.* Some areas of the island two species were found (*P. kuhlii/ T. teniotis* and *H. savii*). *Hypsugo savii* appears to have the widest distribution throughout the island. On the other hand, *P.kuhlii* and *T. teniotis* were detected in smaller areas and did not coincide on site areas. Most detections of the species were detected in the protected areas of Gran Canary.

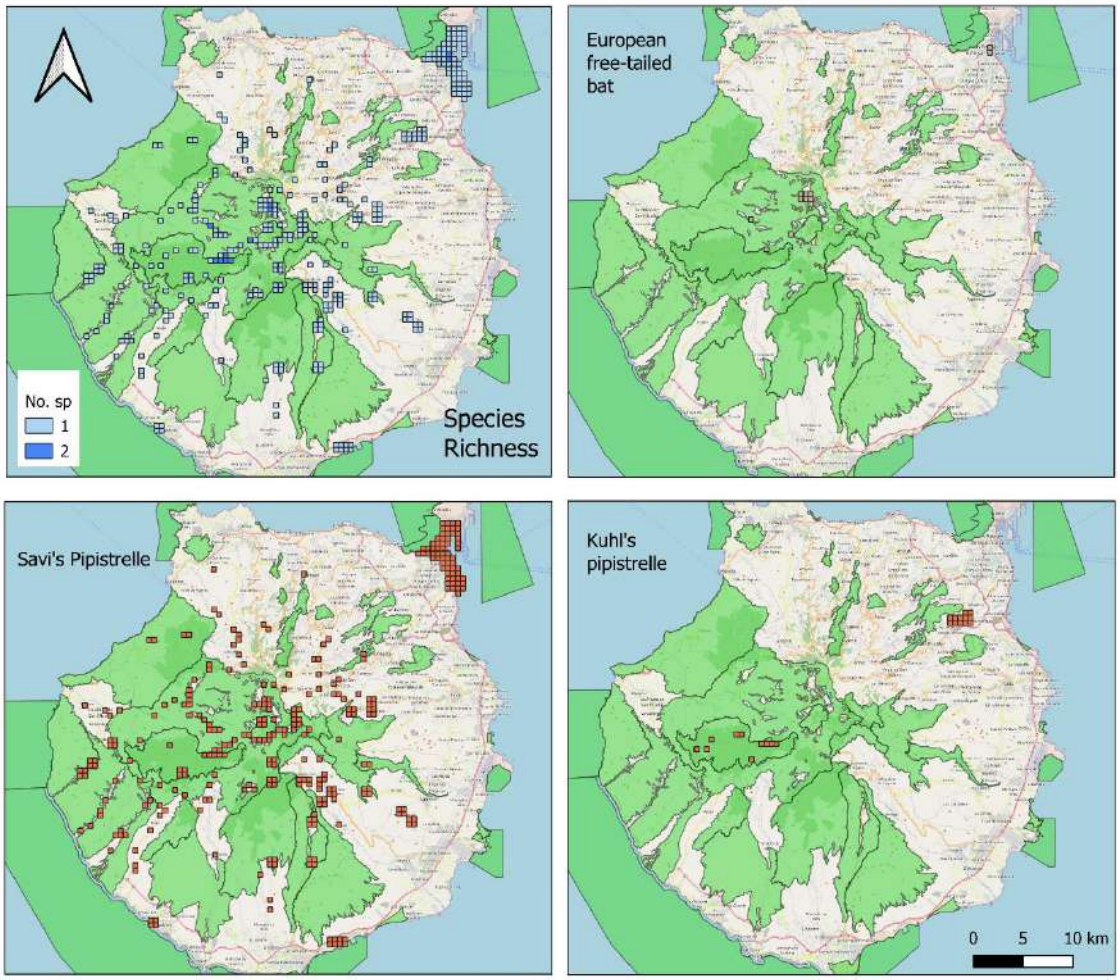

Figure 18 Bat species detected in Gran Canaria. Species richness per site (top left), Detections of European Free-tail bat (top right), Detections of Savi's Pipistrelle (bottom left), Detections of Kuhl's Pipistrelle (bottom right). Green areas represent the ZPE protected areas.

Tenerife is the island where most species described for the archipelago were detected. All the species mentioned before were detected in the data. Two sites recorded six species in the area and five sites recorded five species. *Pipistrellus maderensis, T. teniotis* and *P. teneriffae* were the species with the widest distribution in the island. *Pipistrellus kuhlii* was the species with the smallest distribution on the island. Most species seem to be detected the most in the north side of the island, however *P. kuhlii* were only detected in the middle of the island. Except for *P. maderensis* and *T. teniotis,* most species were mostly detected in the protected areas while these two species were more generally distributed across the island.

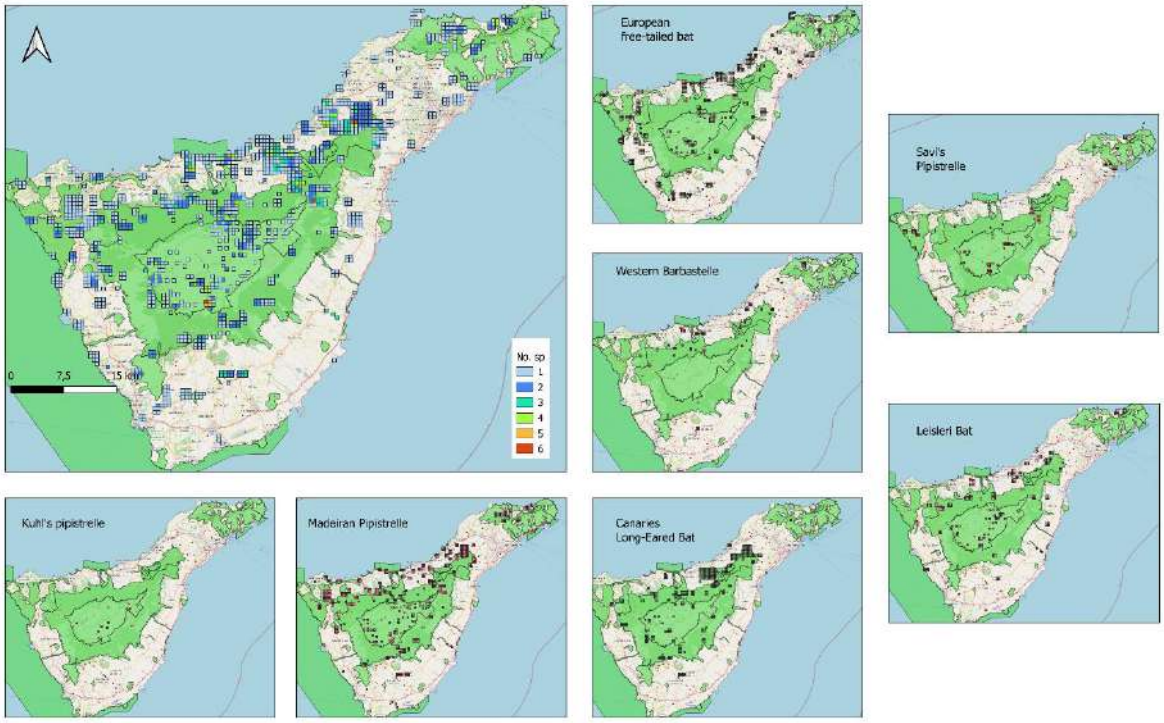

Figure 19 Bat species detected in Tenerife. Species richness per site (top left).

In La Gomera, four species of bats were detected: *P. maderensis, H. savii, T. teniotis* and *B. barbastellus.* In three locations, the four species were detected. *Pipistrellus maderensis* and *T. teniotis* were the species with the widest distribuition across the island while *B. barbastellus* was the species with smallest distribuition. The most common species were widely distributed across the protected and unprotected areas while *B. barbastellus* and *H. savii* appear to be more concentrated on the protected areas of the La Gomera island.

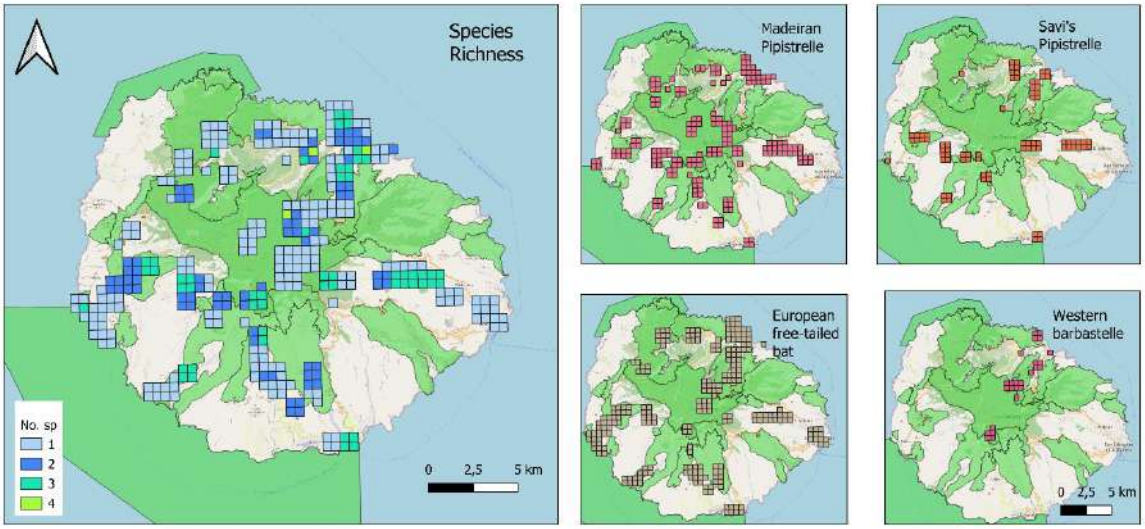

Figure 20 Bat species detected in La Gomera. Species richness per site (left), Detections of Madeiran Pipistrelle (Middle top), Detections of European Free-tail bat (bottom middle), Detections of Savi's Pipistrelle (top right), Detections of Western Barbastelle (bottom right). Green areas represent the ZPE protected areas.

In la Palma Island, five species of bats were detected: *H. savii, N. leisleri, T. teniotis, P. maderensis* and *P. teneriffae.* According to the data, *T. teniotis* appears to have the widest distribution in the island followed by *P. maderensis* and *P. teneriffae*. *Tadarida teniotis* and *N. leisleri* appear to be mostly detected outside of the protected areas while *P. teneriffae* appears to be equaly detected inside and out of the protected areas. Meanwhile, *H. savii* and *P. maderensis* appear to be mostly detected in the protected areas of the la Palma Island.

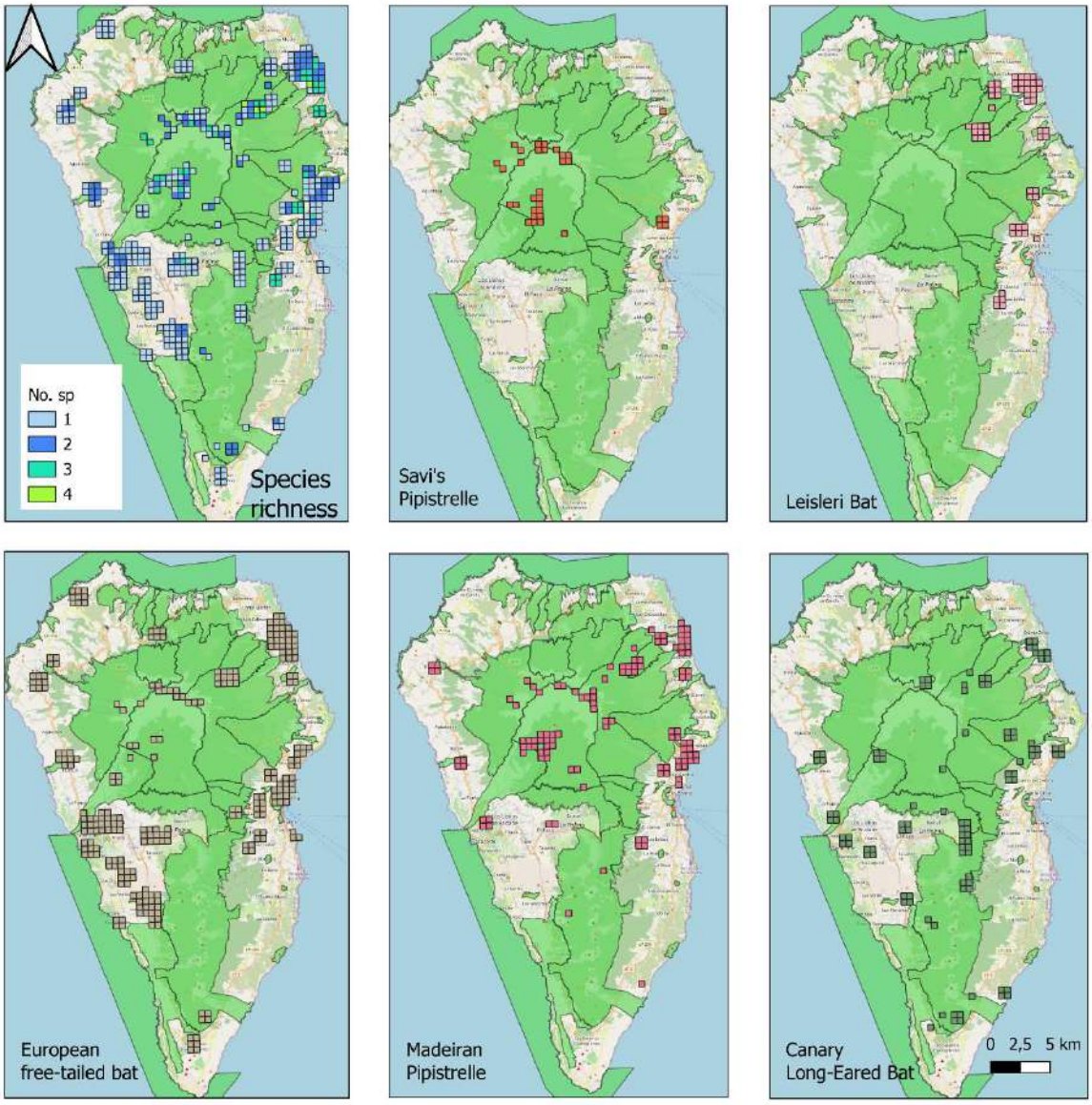

Figure 21 Bat species detected in La Palma. Species richness per site (Top left), Detections of Savi's Pipistrelle (top middle), Detections of Leisleri's bat (top right), Detections of European Free-tail bat (bottom left), Detections of Madeiran Pipistrelle (bottom middle), Detections of Canary Long-Eared Bat (bottom right). Green areas represent the ZPE protected areas.

El Hierro Island, harbours four species of bats: *H. savii, P. maderensis, T. teniotis* and *P. teneriffae. Tadarida teniotis* was the species with the widest distribution in the island with a distribution mostly outside of the protected areas. *Plecotus teneriffae* and *P. maderensis* appear to be mostly detected in the protected areas of the island.

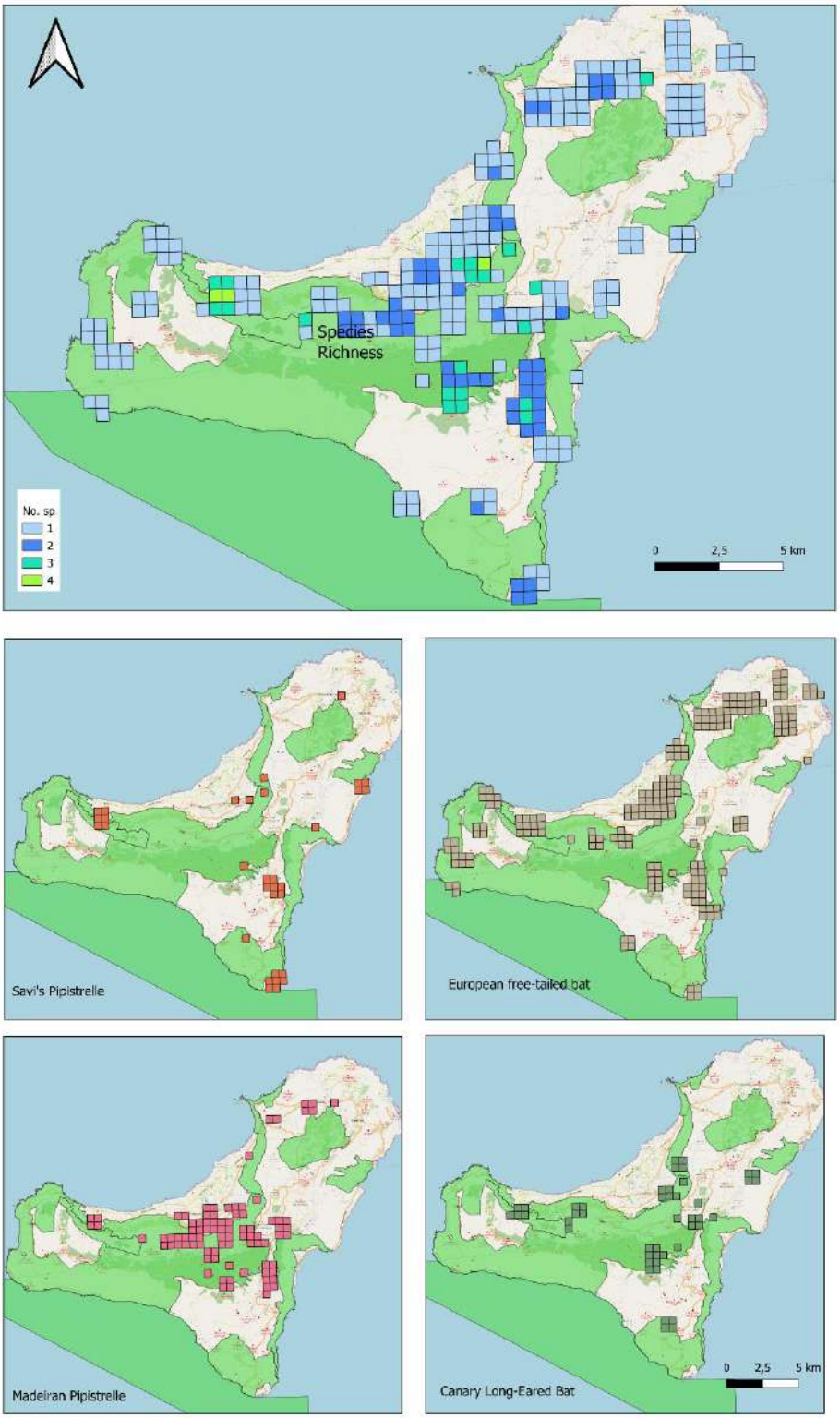

Figure 22 Bat species detected in El Hierro. Species richness per site (Top), Detections of Savi's Pipistrelle (middle left), Detections of European Free-tail bat (middle right), Detections of Madeiran Pipistrelle (bottom left), Detections of Canary Long-Eared Bat (bottom right). Green areas represent the ZPE protected areas.

4. DISCUSSION

In Macaronesia, the knowledge on bat populations has increased recently, however many aspects remain largely unknown. We decided to study the populations of bats in the different types of habitats and N2000 areas and bat populations in the archipelagos.

Comparing the results between N2000 areas on Madeira Island and Graciosa Island proved to be challenging due to their stark differences in composition and species. However, a key finding was that the prevalent species differed between archipelagos. In Azores, the most common species is *Nyctalus azoreum* across the island, while in Madeira Island *P. maderensis* was the most common. In the case of the Canaries, *T. teniotis* appears to be the species with the largest distribution followed by *P. maderensis*. Unfortunately, data regarding bat activity in the Canaries was not available for comparison with the other islands.

Pipistrellus maderensis is strongly associated with forest areas (especially Laurel Forest, Ferreira et al., 2021). The bioacoustic analysis shows that in Madeira Island the species is detected most frequently in the Laurel Forest areas and in the south area of the island (coastal areas). Contrary, in Graciosa Island, the species was mostly detected in the Caldeira (N2000) and might be associated mostly with urban areas and forest areas, however more analysis are needed to detail the habitat preferences.

Nyctalus leisleri, in Madeira Island, appears to be mostly associated to the coastal areas in both sides of the island including Machico in the east side of the island. The species had lower activity in the Laurel Forest in the north side of the island and mountainous areas of the island. In Graciosa Island, the species was very active in two out of the locations in the N2000 areas (Farol do Carapacho and Caldeira). Overall, in the island, the species was mostly distributed in the northeast areas of the island.

According to Rainho et al. (2021), *N. azoreum* seems to be mostly associated to larger islands while *P. maderensis* is mostly associated to smaller islands in Azores. Graciosa Island is the second smallest island in Azores and the prevalent species during our survey was *N. azoreum.* The species is highly associated to streetlights and water areas where they forage while *P. maderensis* is mostly associated to green areas on low altitude coastal areas.

Further analysis is necessary to understand the populations of bats in the different N2000 and more data will be necessary to compare the populations from the Canaries with the other archipelagos. In the recordings in Graciosa Island, unidentified data was detected that need further investigation until the next report.

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ANNEXES

A –