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A Comparative Analysis of Island vs. Mainland Arthropod Communities in Coastal Grasslands Belonging to Two Distinct Regions: São Miguel Island (Azores) and Mainland Portugal

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Abstract: Coastal grasslands host diverse arthropod communities and provide important ecosystem services. Islands, being isolated environments, are expected to have simpler ecosystems than continental areas, with the few successful colonizing species often attaining high densities; however, these patterns are still poorly documented for coastal grassland arthropods. We conducted a comparative study of the biodiversity of arthropod communities in two distinct coastal grassland ecosystems (Portugal mainland and the Azores) with the following objectives: (a) to investigate the arthropod community composition in both locations; (b) to compare the diversity profiles in both locations; (c) to investigate potential density compensation in the island's arthropod communities. For four months, arthropods were collected on the Island of São Miguel, Setúbal Peninsula, and Sine's region and subsequently classified into taxonomic groups. With the data collected, Hill Numbers were calculated for each region. We confirmed that the richness on the mainland was higher than in the Azores, and we found some apparent abundance compensation in the Azores. At the same time, we also observed that many species in the Azores are also present in the continental coastal grasslands of mainland Portugal.

Keywords: arthropods; grasslands; diversity; density compensation

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Citation: Calado, H.R.M.G.; Borges, P.A.V.; Heleno, R.; Soares, A.O. A Comparative Analysis of Island vs. Mainland Arthropod Communities in Coastal Grasslands Belonging to Two Distinct Regions: São Miguel Island (Azores) and Mainland Portugal. *Diversity* **2024**, *16*, 624. https://doi.org/10.3390/d16100624

Academic Editors: Michael Wink and Spyros Sfenthourakis

Received: 26 July 2024
Revised: 1 October 2024
Accepted: 2 October 2024
Published: 9 October 2024

1. Introduction

Oceanic islands, which are characterized by their geographical isolation and natural barriers, present unique ecosystems with relatively simple architectures compared to mainland counterparts [1]. This simplicity makes island communities particularly susceptible to environmental perturbations [2], including biological invasions [3,4] and climate change [5,6]. The limited diversity and specialized niches in island species often lack the resilience necessary to withstand such disturbances. Consequently, these ecosystems face heightened vulnerability, which makes them crucial focal points for conservation efforts and scientific research [2,6,7]. At the same time, terrestrial arthropods are one of the most widely studied taxonomic groups and are also quite sensitive to environmental changes [8]. Although there are several studies of these communities in different island ecosystems, such as pristine and forest areas, crops, or marshes [9–13], there is still a lack of studies focused on arthropod communities in coastal island grasslands.

Grasslands are very rich and diverse ecosystems, not only due to their floristic and faunistic biodiversity but also for the diverse ecosystem services they provide (like nutrient recycling, carbon sequestration, and air purification, among others), most of which have already been identified and well-studied over the years [14–17]. Often called prairies, grasslands differ from the latter in that they no longer maintain most of their original native plants, having undergone major changes in their plant composition [18–20]. These environments also differ from their more inland counterparts in terms of temperature and humidity, typically being warmer and more humid [21].

Comparative studies on the composition and diversity of arthropod communities in coastal grasslands, contrasting ecosystems, such as insular and mainland, are very useful to ecology. They may provide greater insights regarding how these communities are organized, enabling us to discern the disparities in biodiversity, relative abundance, and ecosystem services these species provide [22]. In areas where specific richness is lower, an inverse relation to the density of organisms could occur (the so-called density compensation), which partially reduces the higher risk of extinction caused by the less complex communities [23]. There are species, such as birds and lizards, which, in island environments, show an increase in their abundance when compared to their continental counterparts [24–27]. There are also recent studies that have used trait-based approaches to explain patterns in organism densities [28,29]. For ladybirds, for example, species richness, diversity, and body mass tended to be lower in insular ecosystems [30,31].

In arthropods, however, there are still gaps in the knowledge about island coastal grasslands. Moreover, the islands are also seen as excellent places for studies on ecology and evolution [1,2,7], and this kind of study should include a comprehensive understanding of the causes of variation in species richness, how ecological communities are distributed, and what are the mechanisms that shape evolutionary processes [32–34]. By doing so, we gain insights into whether these distinctions are significant enough to drive ecological and evolutionary processes within existing communities. At the same time, these studies are also important for the establishment of new solutions for conservation and ecological restoration [35].

In this way and considering that current Azorean coastal grasslands are a highly modified ecosystem with a dominance of exotic and naturalized vegetation originating from nearby mainland with very few endemic plant species and, at the same time, have some similar characteristics to their mainland homologs (in terms of latitude and substrate), we investigate how arthropod communities are assembled in comparison with an equivalent mainland habitat. We aim to (a) investigate the arthropod community composition in both locations; (b) compare the diversity profiles in both locations; (c) investigate potential abundance compensation in the island's arthropod communities. Since oceanic islands are species-poor and disharmonic systems, we predict that: (i) local arthropod taxonomic diversity will be lower on the island-modified coastal prairies compared with that from the mainland; (ii) arthropod communities from the Azorean coastal grasslands will be composed mostly of exotic arthropods; and (iii) some density compensation will likely occur in the island arthropod communities.

2. Materials and Methods

2.1. Study Area

The Azores archipelago is in the middle of the North Atlantic, approximately 1600 km from mainland Portugal, with an extension of about 600 km between Santa Maria and Corvo (37°–40° N latitude; 25°–31° W longitude). Three island groups compose the archipelago: Eastern (Santa Maria and São Miguel islands), Central (Terceira, Graciosa, São Jorge, Pico, and Faial islands), and Western (Corvo and Flores islands). The different islands are aligned in a NW–SE orientation. São Miguel is the largest of the islands of the Azores archipelago and the largest of all the islands that make up the territory of Portugal, with an area of 748.82 km^2, measuring 64.7 km in length and 8–15 km in width [11,36] (Figure 1a). The archipelago's climate is affected by the surrounding ocean, namely, the effects of the Gulf Stream, as well as by island topography, being mild and very wet, often reaching an average annual relative humidity of 95% in high-altitude forests [11]. The oceanic temperate climate is reflected in high annual precipitation, high relative humidity, persistent wind, and low thermal amplitude [37].

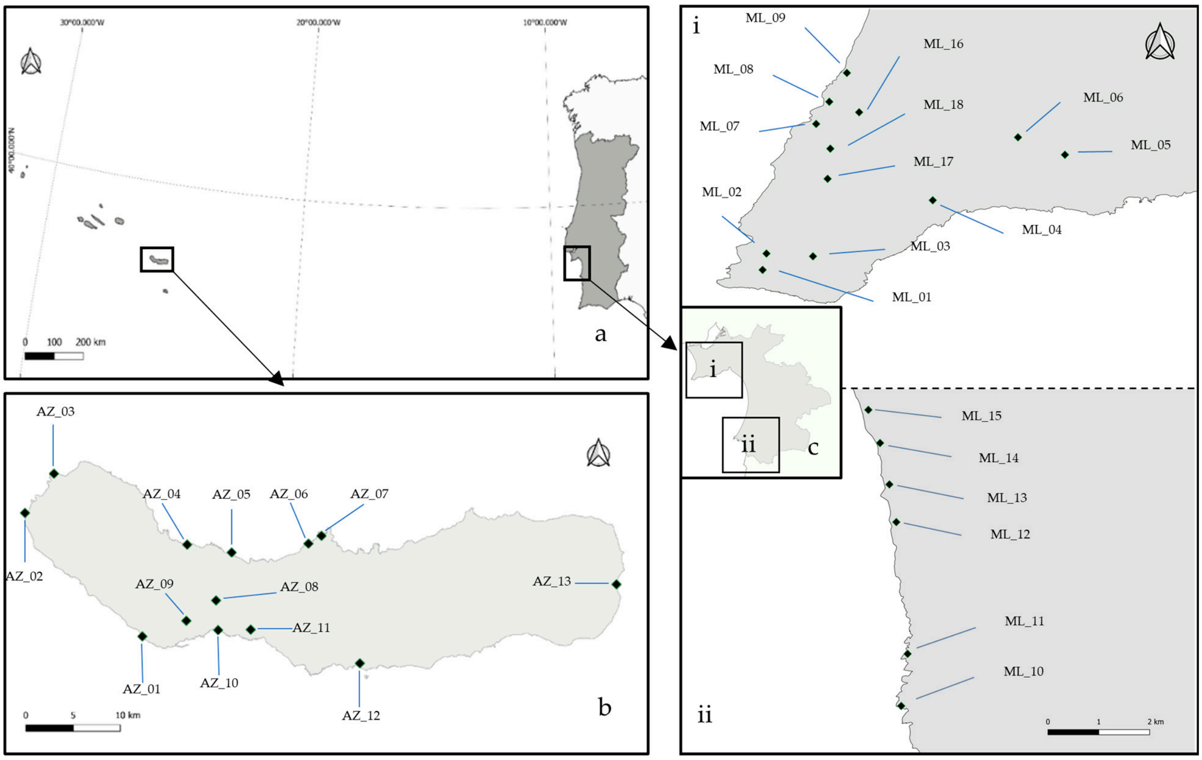

Figure 1. Maps of sampling areas with the plots indicated: (**a**) Azores Archipelago and Portugal mainland; (**b**) São Miguel's Island; (**c**) Setúbal district; (**i**) Sesimbra; (**ii**) Sines.

Mainland Portugal, on the other hand, is located in southwestern Europe and is confined between parallels 37° N and 42° N and within the relatively narrow meridional band that develops between 6.5° W and 9.5° W. It lies in the transitional region between the sub-tropical anticyclone and the sub-polar depression zones. In this territory, the latitude, orography, and effect of the Atlantic Ocean are the main driving forces of the climate [38].

The Setúbal district is located south of Lisbon, between parallels 37° N and 39° N, with an area of 5034 km^2, and encompasses the regions of Sesimbra and Sines. Sesimbra is c. 30 km south of Lisbon and has an area of 194.98 km^2, whereas Sines is located c. 150 km south of Lisbon and has an area of 195.47 km^2. Portugal has a Mediterranean climate characterized by warm and dry summers and cool and wet winters [39]. Precipitation ranges from more than 2000 mm in the northwest to roughly 400 mm in the most south-eastern part of the country [40].

2.2. Arthropod Sampling

For the study of arthropod diversity, 31 plots were selected in coastal grasslands. Thirteen plots were located on São Miguel Island (Figure 1b) and 18 on the mainland west coast, distributed across Sesimbra and Sines, in Setúbal district (Figure 1c). Plots were selected in both regions to have a similar general substrate (rocky), latitude, and elevation (See Appendix A—Table A1). For each one, an area of 2500 m^2 (0.25 ha) was defined. All selected plots were visited four times between spring and summer 2022.

In each plot, a randomly sweeping section was carried out using a nylon mosquito net 40 cm in diameter, 50 cm in length, and 0.25 mm mesh. For each section, an effort of 15 min was spent (3 min for sweeping and 12 min for processing and labeling of the collected material). All collected organisms were placed in flasks with 96% ethyl alcohol for later sorting and identification.

Since the climate conditions that occur in spring in the Azores normally begin one month later than in the mainland, we assume, for the purposes of this study, that March, April, May, and June on the mainland will be similar to April, May, June, and July for the Azores, respectively.

2.3. Species Sorting, Identification, and Diversity Measurements

In the laboratory, all arthropod specimens were sorted into different morphospecies and stored in 2 ml Eppendorf tubes with 99% absolute alcohol. For each morphospecies, three exemplars were selected and photographed, using a LEICA S9i stereo microscope with LAS X 5.2.1.27831, to create a photographic database to help the taxon identification. The senior author (PAVB) identified all morphospecies of the Azorean samples to the species level when possible. All species collected in the Azores were categorized into three colonization categories following the last checklist of Azorean arthropods [41]: endemic, native non-endemic, and introduced (See Appendix A—Table A2). In some cases, the colonization status was undetermined. A database for both events and occurrences was created using the Darwin Core criteria.

Accumulation curves were constructed using EstimateS program v. 9.1.0 [42], with 100 runs, for the observed number of species, species richness estimates, singletons, and doubletons, using the non-parametric estimators Chao 1 and Jackknife 1. From EstimateS, we also extracted the number of singletons, doubletons, uniques, and duplicates. Common indices of diversity were also calculated for the two geographic areas, following the Hill series: species richness (H_0); Shannon–Wiener exponent (H_1); inverse Simpson's index (H_2); inverse Berger–Parker index (H_3) [43].

$$H_0 = S \text{ (total number of species)}$$

$$H_1 = \text{exponent of Shannon–Wiener index } (H')$$

Shannon–Wiener index:

$$H' = -\sum_{i=1}^{n} p_i \, Ln \, p_i$$

$$p_i = \frac{n_i}{N_t}$$

n_i = species abundance;
N_t = Total species abundance;
p_i = relative abundance for each species.

$$H_2 = \text{Simpson inverse} = 1/D$$

Simpson index:

$$D = \sum_{i=1}^{n} p_i^2$$

$$H_3 = \text{Berger–Parker inverse} = 1/d$$

Berger–Parker index:

$$d = \frac{N_{max}}{N_t}$$

Evenness index:

$$E = \frac{H'}{Ln\,(S)}$$

The use of biodiversity indices allows us to analyze and understand in more detail the difference between two distinct ecosystems, as it presents important and simple information on how species are distributed in terms of richness and abundance (dominance or rarity). Hill numbers, in this sense, act as an extremely important tool for research into biodiversity and ecological assessments [43,44]. The Fisher's Alpha index was also calculated since it is considered to have low sensitivity to sampling effort.

Fisher's Alpha index:

$$S = \alpha * \ln\left(1 + \frac{N}{\alpha}\right)$$

S = number of taxa;
N = number of individuals;
α = Fisher's alpha.

To verify the dissimilarity between the Azores and Mainland communities, we computed a beta partition framework using the Jaccard index [44].

Jaccard index:

$$\beta_{Jac} = \beta_{repl} + \beta_{rich}$$

$$\beta_{Jac} = \frac{b+c}{a+b+c} = \frac{2\min(b,c)}{a+b+c} + \frac{|b-c|}{a+b+c}$$

a = the number of species common to both sites;
b = the number of species that occur in the first site but not in the second;
c = the number of species that occur in the second site but not in the first.

2.4. Data Analysis

The Kolmogorov–Smirnov and Levene's tests were performed to assess the normality and homogeneity of data variances, respectively. When the previous condition was not verified, data were log-transformed. The comparative analysis of arthropod species richness and abundance between the mainland and the Azores utilized either parametric t-tests or non-parametric Kruskal–Wallis tests. Mean values were considered significantly different when $p < 0.05$. All statistical analyses were conducted using SPSS v. 29.0.1 [45].

For the Hill numbers, Jaccard index, and Fisher's Alpha index calculation, we used only the morphospecies identified at least until the family taxonomic group.

3. Results

3.1. Species Richness and Abundance

A total of 13,515 specimens were collected in the two coastal grasslands (Azores = 7861; Mainland = 5654) belonging to 534 arthropod species and morphospecies. In the Azores, 210 species and morphospecies belonging to 3 classes were collected: Arachnida (22), Diplopoda (1), and Insecta (187). On the mainland, a total of 391 species and morphospecies were collected, belonging to 2 classes: Arachnida (55) and Insecta (336) (Table 1).

Table 1. Number of morphospecies and species collected in the Azores and mainland coastal grasslands by Class and Order.

Class	Order	Azores	Mainland
Arachnida		**22**	**55**
	Araneae	21	54
	Opiliones	1	1
Diplopoda		**1**	
	Julida	1	
Insecta		**187**	**336**
	Coleoptera	26	109
	Diptera	42	42
	Hemiptera	44	73
	Hymenoptera	51	86
	Lepidoptera	12	12
	Mantodea		1
	Neuroptera	1	
	Orthoptera	7	11
	Phasmida	1	

Table 1. *Cont.*

Class	Order	Azores	Mainland
	Psocodea	3	1
	Thysanoptera		1
Total		**210**	**391**

Of the 210 morphospecies collected in the Azores, only four are endemic, with the others considered introduced (39), native non-endemic (42), or not yet specified (125) (see Appendix A—Table A2). The class with the highest abundance in the Azores coastal grasslands was Class Insecta, with 7313 specimens, of which 2958 belonged to order Hemiptera (44 species and morphospecies). The group with the largest taxa number was the Hymenoptera, with a total of 51 morphospecies. In the mainland coastal grasslands, the class with the greatest abundance was also Insecta, with a total of 4816 specimens. Of these, 1634 belonged to the order Coleoptera, also the one with the largest number of identified morphospecies (109).

In total, 67 species were common in both ecosystems (Table 2), with 54 of these more abundant in the Azores than in the mainland coastal grasslands.

Table 2. Common species in the Azores and mainland grasslands.

Class	Order	Family	Species	Total Abundance Azores	Total Abundance Mainland
Arachnida	Araneae	Araneidae	*Mangora acalypha* (Walckenaer, 1802)	16	117
			Neoscona crucifera (Lucas, 1838)	8	1
			Zygiella x-notata (Clerck, 1757)	42	66
		Linyphiidae	*Oedothorax fuscus* (Blackwall, 1834)	11	4
			Prinerigone vagans (Audouin, 1826)	52	15
		Salticidae	*Chalcoscirtus infimus* (Simon, 1868)	73	13
			Macaroeris diligens (Blackwall, 1867)	16	6
			Salticus mutabilis Lucas, 1846	31	28
			Synageles venator (Lucas, 1836)	61	7
		Thomisidae	*Xysticus nubilus* Simon, 1875	90	97
Insecta	Coleoptera	Apionidae	*Aspidapion radiolus* (Marsham, 1802)	72	3
		Chrysomelidae	*Psylliodes marcida* (Illiger, 1807)	11	49
		Coccinellidae	*Rhyzobius litura* (Fabricius, 1787)	38	5
			Scymnus interruptus (Goeze, 1777)	129	2
			Scymnus suturalis Thunberg, 1795	2	1
		Curculionidae	*Mecinus pascuorum* (Gyllenhal, 1813)	286	18
		Nitidulidae	*Brassicogethes aeneus* (Fabricius, 1775)	54	8
		Phalacridae	*Stilbus testaceus* (Panzer, 1797)	14	10
		Staphylinidae	*Tachyporus chrysomelinus* (Linnaeus, 1758)	1	1
	Diptera	Agromyzidae	*Chromatomyia nigra* (Meigen, 1830)	10	1
		Calliphoridae	*Lucilia sericata* (Meigen, 1826)	16	3
		Chloropidae	*Thaumatomyia notata* (Meigen, 1830)	32	35
		Lonchopteridae	*Lonchoptera bifurcata* (Fallén, 1810)	67	69
		Muscidae	*Coenosia humilis* Meigen, 1826	65	8
			Musca osiris Wiedemann, 1830	70	6
			Stomoxys calcitrans (Linnaeus, 1758)	123	71
		Opomyzidae	*Geomyza tripunctata* (Fallén, 1823)	4	3
		Rhinophoridae	*Melanophora roralis* (Linnaeus, 1758)	82	15
		Syrphidae	*Eristalis tenax* (Linnaeus, 1758)	4	3
			Eupeodes corollae (Fabricius, 1794)	15	7
			Sphaerophoria scripta (Linnaeus, 1758)	34	12
		Tephritidae	*Dioxyna sororcula* (Wiedemann, 1830)	220	1
	Hemiptera	Anthocoridae	*Orius laevigatus laevigatus* (Fieber, 1860)	44	3
		Aphididae	*Aphis fabae* Scopoli, 1763	58	2

Table 2. *Cont.*

Class	Order	Family	Species	Total Abundance Azores	Total Abundance Mainland
			Aphis nerii Boyer de Fonscolombe, 1841	42	2
			Melanaphis donacis (Passerini, 1862)	257	48
			Myzus persicae (Sulzer, 1776)	127	45
			Therioaphis trifolii (Monell, 1882)	19	10
		Aphrophoridae	*Philaenus spumarius* (Linnaeus, 1758)	285	241
		Cicadellidae	*Macrosteles sexnotatus* (Fallen, 1806)	301	14
		Delphacidae	*Megamelodes quadrimaculatus* (Signoret, 1865)	44	3
			Sogatella nigeriensis (Muir, 1920)	252	45
		Lygaeidae	*Kleidocerys ericae* (Horváth, 1909)	49	6
			Nysius ericae ericae (Blackwall, 1867)	14	15
		Miridae	*Taylorilygus apicalis* (Fieber, 1861)	433	26
		Nabidae	*Nabis capsiformis* Germar, 1838	180	3
		Pentatomidae	*Nezara viridula* (Linnaeus, 1758)	53	13
		Psyllidae	*Acizzia uncatoides* (Ferris & Klyver, 1932)	15	21
		Rhyparochromidae	*Beosus maritimus* (Scopoli, 1763)	1	9
		Saldidae	*Saldula palustris* (Douglas, 1874)	4	1
	Hymenoptera	Aphelinidae	*Encarsia formosa* Gahan, 1924	9	2
		Apidae	*Apis mellifera* Linnaeus, 1758	19	6
			Bombus terrestris (Linnaeus, 1758)	16	3
		Encyrtidae	*Pseudaphycus maculipennis* Mercet, 1923	13	2
		Eulophidae	*Baryscapus galactopus* (Ratzeburg, 1844)	69	86
			Diglyphus isaea (Walker, 1838)	6	4
		Formicidae	*Hypoponera eduardi* (Forel, 1894)	5	5
			Lasius grandis Forel, 1909	593	6
			Tetramorium caespitum (Linnaeus, 1758)	20	4
		Ichneumonidae	*Aritranis director* (Thumberg, 1822)	1	1
			Diplazon laetatorius (Fabricius, 1781)	32	4
		Mymaridae	*Litus cynipseus* Haliday, 1833	6	2
		Pteromalidae	*Pteromalus puparum* (Linnaeus, 1758)	8	7
	Lepidoptera	Pieridae	*Colias croceus* (Fourcroy, 1785)	4	1
	Orthoptera	Acrididae	*Locusta migratoria* (Linnaeus, 1758)	3	1
		Trigonidiidae	*Trigonidium cicindeloides* Rambur, 1838	69	3
	Psocodea	Caeciliusidae	*Valenzuela flavidus* (Stephens, 1836)	48	3
Total				**4848**	**1332**

We found a significant difference in the abundance of the common species between the Azores (72.36 ± 13.33) and mainland (19.88 ± 4.53) coastal grasslands (Paired T-test: t = 4.073; df = 66; $p \leq 0.001$) (Figure 2).

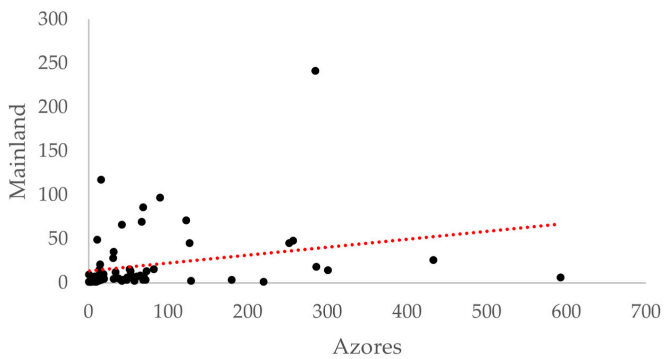

Figure 2. Abundance of common species between the Azores and Mainland coastal grasslands.

In relation to the completeness of the sampling, based on the Chao 1 and JackKnife 1 estimators (Figure 3), both ecosystems present a very high completeness for both estimators.

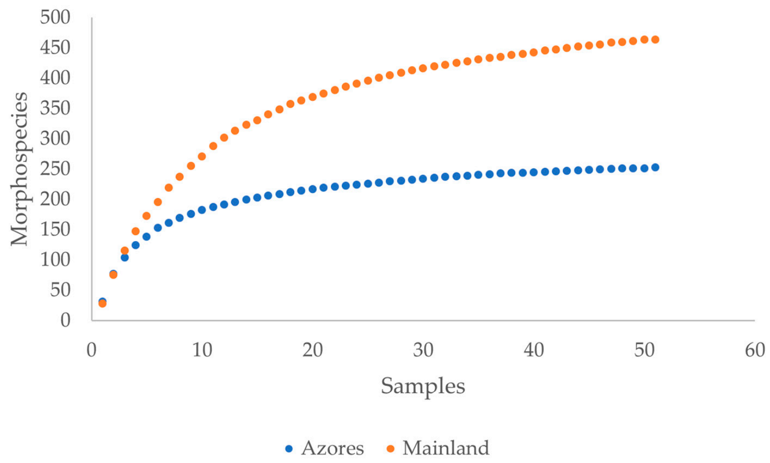

Figure 3. Species accumulation curves for species and morphospecies recorded on the Azores and mainland coastal grasslands based on 100 randomized curves.

However, Uniques (species found in just one sample) and Singletons (species represented by one individual) are superior to Duplicates (species found in two samples) and Doubletons (species represented by two individuals) [46] in both locations (Table 3). This means that additional species are expected if more effort is applied in future surveys.

Table 3. Diversity metrics for the Azores and Mainland: *N*—number of individuals; *S*—number of species.

	Azores	**Mainland**
N	7861	5654
S	210	392
Chao 1	245.06	464.18
Jackknife1	252.16	491.56
Completeness Chao1	0.86	0.84
Completeness Jackknife1	0.83	0.80
Singletons	34	82
Doubletons	15	45
Uniques	43	101
Duplicates	45	79

Concerning the total abundance of arthropods for communities of both locations, we found out that it was significantly higher in the Azores coastal grasslands (154.14 ± 18.34) than in the mainland (80.77 ± 11.33) (Kruskal–Wallis-test: K-W = 17.635; df = 1; $p \leq 0.001$) (Figure 4).

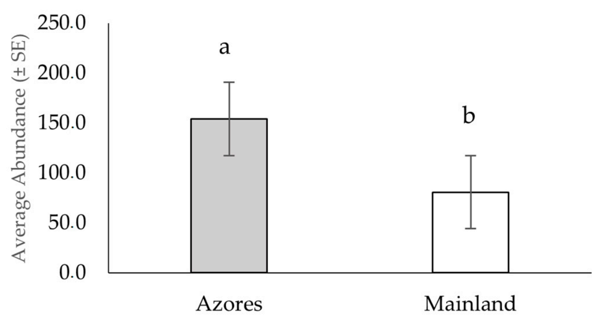

Figure 4. Abundance means for Azores and Mainland. Different letters indicate significant differences (Kruskal–Wallis-test; $p < 0.05$).

3.2. Diversity Metrics for the Arthropod Communities of the Azores and Mainland Coastal Grasslands (Hill Series)

When we analyze the differences between species richness (H_0) in coastal grasslands of the Azores (30.9 ± 1.96) and mainland (29.43 ± 2.05), we found no significant differences (Kruskal–Wallis-test: K-W = 0.322; df = 1; p = 0.571) (Figure 5). Concerning the Shannon–Wiener exponent (H_1) for the arthropod communities, also no significant statistical differences were observed between Azores (16.36 ± 0.87) and mainland (18.75 ± 1.17) coastal grasslands (GLM test: Z = 2.345; df = 1; p = 0.128). No significant differences were found in the inverse Simpson's index (H_2) between coastal grasslands of arthropod communities of the Azores (10.71 ± 0.63) and mainland (12.86 ± 0.82) (GLM test: Z = 3.803; df = 1; p = 0.054). When the inverse of the Berger–Parker index (H_3) was analyzed between the Azores (5.07 ± 0.29) and mainland (5.74 ± 0.34) coastal grasslands, no significant differences were observed either (GLM test: Z = 8.018; df = 1; p = 0.153).

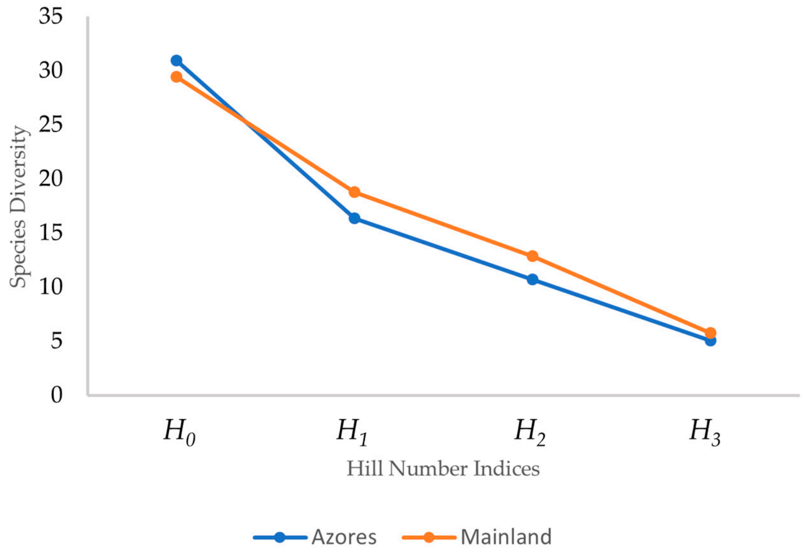

Figure 5. Differences between mean Specific Richness (H_0), mean Shannon–Wiener exponent (H_1), mean Simpson's inverse (H_2), and mean Berger–Parker's inverse (H_3) in the Azores and mainland coastal grasslands communities.

When the Evenness was analyzed, significant differences were observed between the Azores (0.82 ± 0.010) and mainland (0.88 ± 0.011) coastal grasslands (Kruskal–Wallis test: K-W = 18.080; df = 1; $p \leq 0.001$) (Figure 6).

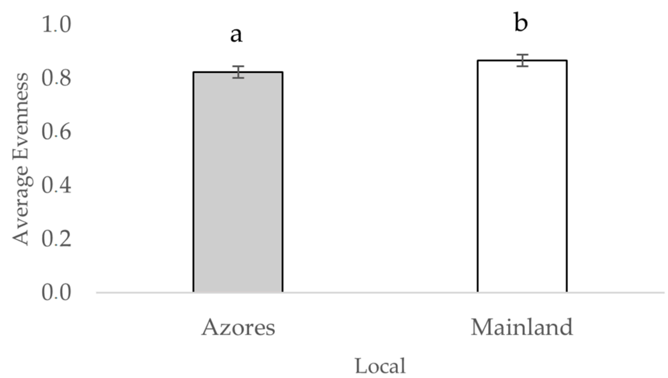

Figure 6. Evenness means for Azores and mainland coastal grasslands. Different letters indicate significant differences (Kruskal–Wallis test; $p < 0.05$).

When the Fisher's Alpha index in each region was analyzed, we found significant differences between the Azores (13.98 ± 0.71) and mainland (24.07 ± 1.78) coastal grasslands (Kruskal–Wallis-test: K-W = 20.783; df = 1; $p \leq 0.001$) (Figure 7).

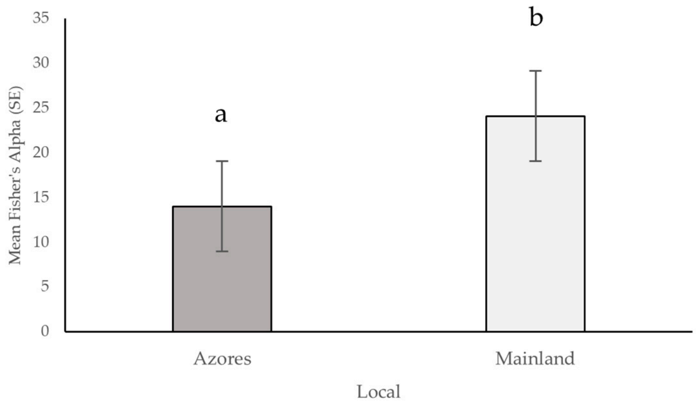

Figure 7. Fisher's Alpha means for Azores and mainland coastal grasslands. Different letters indicate significant differences (Kruskal–Wallis test; $p < 0.05$).

3.3. Dissimilarity Index (Jaccard)

Analyzing the beta partition between sites in each region with the Jaccard index for the global beta diversity, we found significant dissimilarity between the Azores (0.897 ± 0.06) and mainland (0.923 ± 0.06) coastal grasslands (GLM test: Z = 38.615; df = 1; $p \leq 0.001$). We also observed differences for the Beta Replacement between Azores (0.41 ± 0.26) and mainland (0.36 ± 0.23 (GLM test: Z = 8.794; df = 1; p= 0.003)), and for Beta Richness in both locals: Azores (0.49 ± 0.24) and mainland (0.56 ± 0.22) (GLM test: Z = 21.587; df = 1; $p \leq 0.001$) (Figure 8).

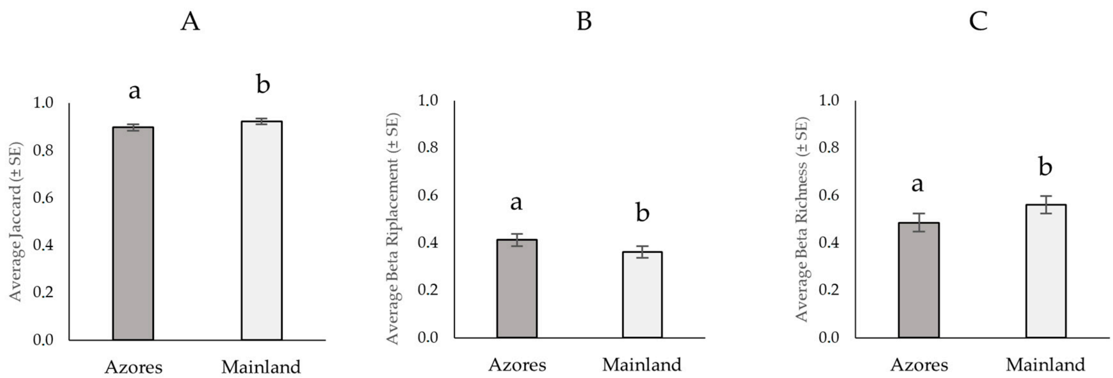

Figure 8. Comparison between Azores and mainland coastal grasslands of the between sites mean Jaccard dissimilarity index (**A**), mean Beta Replacement (**B**), and mean Beta Richness (**C**) indexes between sites. Different letters indicate significant differences (GLM test; $p < 0.05$).

4. Discussion

Our results indicate that there is a high difference in arthropod regional species richness (gamma diversity, sensu Magurran, 2004) [47] between the Azores and Portugal mainland coastal grasslands. Indeed, the total number of species and morphospecies in the Azorean coastal grasslands is almost half the number of the collected species in the mainland's coastal grasslands (cf. Table 1). In certain taxonomic groups, this difference is particularly noteworthy; for instance, the proportion of beetles (Coleoptera) compared to other insect groups is particularly higher on the mainland than in the Azores. Other examples are the species richness of the Arachnida and Hemiptera Orders, with almost twice as many morphospecies in mainland coastal grasslands at the regional level. Nevertheless, other groups have very similar numbers of morphospecies collected in both areas (e.g., Diptera and Lepidoptera). This result partially confirms our first prediction that lower diversity would be expected on the island-modified coastal grassland when compared to the mainland grassland since insular systems tend to be species poor and disharmonic [32,33].

However, when we analyze the alpha diversity (local diversity), the results are mixed. On the one hand, there is no statistical difference in the diversity profiles measured by the Hill numbers (mean species richness, rarity, and dominance), but such differences were observed when computing Fisher's alpha (Figure 7). Higher Fisher's alpha values on the mainland indicate greater specific richness. The results also suggest that we are in the presence of a stable ecosystem. Those values also corroborate the evenness results (higher in the mainland coastal grasslands). Conversely, the low values in the Azores might suggest some environmental degradation, habitat loss, or other stressors that lead to ecosystem homogenization (e.g., similar resource availability, habitat types, or levels of competition), affecting biodiversity. Despite a large regional difference in species richness, both communities support similar effective species numbers at a local scale as measured by the Hill numbers. This is against our initial prediction in terms of diversity profiles in both grassland ecosystems. In a recent critique of the Hill numbers approach, Ricotta and Feoli [48] suggested that in some situations in which there is a non-linear response of diversity measures, the conversion of classical diversity measures to Hill numbers is not useful. At this stage, we have no evidence that our two investigated communities differ in the rate of uncertainty associated with species additions, and consequently, we assume that the patterns observed are similar in the two communities.

Nevertheless, despite this apparent similarity of local diversity profiles in both regions, when analyzing the results obtained through the beta diversity partition using the Jaccard dissimilarity index, we observe significant differences in arthropod community structure between the mainland and the Azorean coastal grasslands. In the Azores, sample sites are more similar in species composition when compared to the mainland (Figure 8A). In both cases, arthropod species compositional differences are mostly due to beta richness differences between sites within each region (Figure 8B,C). The anthropogenic replacement of specialist native species by generalist non-native ones can lead to "biotic homogenization" [49], which can cause a similarity in the composition of the various communities over time [50,51]. In the Azores, human action during the last five centuries has likely contributed to this process since most of the islands' coastal areas are visibly altered in relation to their original ecosystems [52]. In contrast, some of the areas remain relatively little disturbed, which could further contribute to this differentiation.

We know that species spatial replacement refers to the well-known fact that species tend to replace each other along ecological gradients that are sufficiently long (i.e., turnover) [53,54]. Interestingly, species spatial replacement is higher across the Azorean sites than across mainland sites, and beta richness differences are higher on the mainland than in the Azores. One factor that may be responsible for these differences is the type of surrounding landscape. For example, the island of São Miguel is characterized by naturalized vegetation and semi-natural pastures with relatively high human activity, which increases habitat patchiness and might contribute to the observed higher turnover [55]. At the same time, many adjacent areas to the coastal grasslands in the Azores are heavily used for agriculture and pasture, particularly in spring, which may further contribute to the observed differences across locations. On the mainland, on the other hand, there might be greater regional stability on niche availability, allowing plant species to maintain their populations [56]. Some work on islands demonstrates that turnover decreases when naturalized vegetation, together with existing native forests, forms a layer of continuous vegetation [55].

However, when we observed the gamma richness in both regions, we observed a significant difference. That difference could be explained by the geographic distance between some collection sites, such as, for example, Sines and Setúbal, whose distances between both locations exceeded a few tens of kilometers. This distance may also have contributed to the increase in the collection area, which became bigger than in the Azores. Despite being in similar conditions (maritime influence, type of substrate, altitude), environmental conditions (type of vegetation) and/or climatic conditions (temperature, wind, or exposure to the sun) may contribute to the difference in species fixed in some locations, generating the high total beta diversity (Figure 8A).

Concerning the abundance, we found a significant difference between the two coastal grassland systems, with a significantly higher abundance in the Azores compared to the mainland. Indeed, most of the commonly identified species are more abundant in the insular than in the mainland coastal grasslands. The species *Lasius grandis*, *Mecinus pascuorum,* or *Taylorilygus apicalis*, for example, showed a great difference in their abundance. Other Hemiptera, like *Nabis capsiformis*, *Kleidocerys ericae,* or *Sogatella nigeriensis,* also show a high difference in their abundance in the Azores coastal grasslands when compared to the mainland. This discrepancy could be explained by an apparent abundance compensation in some arthropods [27]. These results are in line with our initial prediction that some abundance compensation could occur in the Azores' coastal grasslands.

Lastly, when we analyzed the species composition of both areas, we found that many arthropod species in the Azorean coastal grassland are common to those found in the mainland, which suggests that the Portuguese mainland may have been an important source of arthropods for the colonization of the islands, what was expected for both geographic (proximity) and political reasons. Although the islands' biodiversity depends on several well-known factors (e.g., migration and extinction rate, habitat diversity, and others [32,57,58]), anthropogenic factors, like commerce and tourism, could contribute to the species' introduction and are thus an important determinant of biodiversity. Indeed, exotic species are continuously introduced in the Azores and found mostly in coastal areas [59,60].

5. Conclusions

This comparison of the coastal grasslands of the Azores and mainland Portugal allowed us to gain a deeper understanding of the composition and diversity profiles of the arthropod communities in both regions and the main differences between island and continental environments. As arthropod communities belong to numerous types of ecosystem services, the loss of many of these organisms could have devastating consequences. For example, as the Azores is an agricultural region, many organisms could play an important role in adjacent agricultural areas, whether through pollination, recycling of materials, or pest control (e.g., [61,62]). Even on the mainland, in some coastal areas, this could also occur, considering that some of the areas are also located in rural regions. Thus, losses in arthropod communities could greatly affect the productivity of these agricultural regions. Furthermore, some of these organisms may also be closely linked to the host plants they share. Although situations may occur in which some organisms can functionally replace others in some of the ecological services provided, they may not be able to achieve the same performance as the former [63,64]. Moreover, as these coastal communities host many exotic species, they could be the reservoirs of potential agricultural pests or invasive species.

Lastly, comparative studies are important tools for conservation and restoration programs, and thus, they should be continued and monitored over longer time scales [65]. This knowledge will allow us to develop better strategies to mitigate the anthropogenic changes suffered over the years in these areas, trying, if possible, to reverse their effects. Work carried out in the Azores and elsewhere shows that it is possible to restore part of some of these lost ecosystems, as well as some of the characteristics they had, through the repopulation of native species [35,66,67]. More work must be done to understand which factors could influence the arthropod communities in the Azores and mainland coastal grasslands.

Author Contributions: Conceptualization, H.R.M.G.C., P.A.V.B., R.H. and A.O.S.; methodology, H.R.M.G.C. and P.A.V.B.; formal analysis, H.R.M.G.C. and P.A.V.B.; investigation, H.R.M.G.C., P.A.V.B., R.H. and A.O.S.; resources, A.O.S.; data curation, H.R.M.G.C. and P.A.V.B.; writing—original draft preparation, H.R.M.G.C.; writing—review and editing, H.R.M.G.C., P.A.V.B., R.H. and A.O.S.; supervision, P.A.V.B., R.H. and A.O.S.; project administration, A.O.S.; funding acquisition, P.A.V.B. and A.O.S. All authors have read and agreed to the published version of the manuscript.

Funding: H.R.M.G.C. was funded by the Regional FRCT Ph.D. Grant M3.1.a/F/012/2021: Phenotypic Plasticity of Pest and Biological Control Agents: Contrasting Mainland and Insular Coastal Ecosystems. A.O.S. and P.A.V.B. were also funded by the projects Pluriannual Funding FCT-UIDB/00329/2020-2024—DOI 10.54499/UIDB/00329/2020 (Thematic Line 1—integrated ecological assessment of environmental change on biodiversity), Azores DRCT Pluriannual Funding (M1.1.A/FUNC.UI&D/010/2021-2024) and PAVB by the project AZORESBIOPORTAL—PORBIOTA (ACORES-01-0145-FEDER-000072).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Data will be available soon in GBIF and in a Data Paper to be published in a Data Journal. Please contact the Correspondence Author for details in due course.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Location, coordinates, and verbatim locality of plots in São Miguel Island, Setubal Peninsula, and Sines.

Location ID	Coordinates	Locality
AZ_01	37°44′48″ N 25°42′46″ W	Relva
AZ_02	37°51′40″ N 25°51′12″ W	Ferraria
AZ_03	37°53′57″ N 25°49′04″ W	Mosteiros
AZ_04	37°49′53″ N 25°39′30″ W	São Vicente
AZ_05	37°49′26″ N 25°36′15″ W	Calhetas
AZ_06	37°50′05″ N 25°30′40″ W	Ribeira Grande
AZ_07	37°50′31″ N 25°30′01″ W	Ribeirinha
AZ_08	37°46′43″ N 25°37′25″ W	Ponta Delgada
AZ_09	37°45′34″ N 25°39′31″ W	Ponta Delgada
AZ_10	37°45′00″ N 25°37′17″ W	Ponta Delgada
AZ_11	37°45′05″ N 25°34′58″ W	Lagoa
AZ_12	37°43′07″ N 25°27′04″ W	Vila Franca do Campo
AZ_13	37°47′37″ N 25°11′34″ W	Fajã do Araújo
ML_01	38°25′01″ N 9°12′43″ W	Cabo Espichel
ML_02	38°25′11″ N 9°12′42″ W	Cabo Espichel
ML_03	38°25′12″ N 9°12′04″ W	Cabo Espichel
ML_04	38°25′56″ N 9°10′25″ W	Azoia
ML_05	38°26′32″ N 9°08′42″ W	Azoia
ML_06	38°26′47″ N 9°09′17″ W	Azoia
ML_07	38°26′58″ N 9°12′01″ W	Meco
ML_08	38°27′16″ N 9°11′51″ W	Meco
ML_09	38°27′43″ N 9°11′34″ W	Meco
ML_10	37°50′59″ N 8°47′41″ W	Porto Covo
ML_11	37°51′42″ N 8°47′36″ W	Porto Covo
ML_12	37°53′27″ N 8°47′45″ W	Porto Covo
ML_13	37°53′57″ N 8°47′52″ W	Sines
ML_14	37°54′30″ N 8°47′58″ W	Sines
ML_15	37°54′57″ N 8°48′08″ W	Sines
ML_16	38°27′08″ N 9°11′27″ W	Meco
ML_17	38°26′13″ N 9°11′52″ W	Azoia
ML_18	38°26′38″ N 9°11′50″ W	Azoia

Table A2. List of morphospecies of arthropods identified for the Azores and Mainland. Legend: MS ID—morphospecies identification; E—endemic from the Azores; N—native non-endemic; I—introduced; NA—not attributed.

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
73	Arachnida	Araneae	Araneidae	42	66	I
102	Arachnida	Araneae	Araneidae	16	117	NA
138	Arachnida	Araneae	Araneidae	8	1	I
279	Arachnida	Araneae	Araneidae	0	5	NA
282	Arachnida	Araneae	Araneidae	0	13	NA
284	Arachnida	Araneae	Araneidae	0	22	NA
306	Arachnida	Araneae	Araneidae	0	13	NA
307	Arachnida	Araneae	Araneidae	0	11	NA
308	Arachnida	Araneae	Araneidae	0	6	NA
316	Arachnida	Araneae	Araneidae	0	12	NA
318	Arachnida	Araneae	Araneidae	0	3	NA
347	Arachnida	Araneae	Araneidae	0	8	NA
447	Arachnida	Araneae	Araneidae	0	1	NA
477	Arachnida	Araneae	Araneidae	0	2	NA
519	Arachnida	Araneae	Araneidae	0	2	NA
530	Arachnida	Araneae	Araneidae	0	4	NA
722	Arachnida	Araneae	Araneidae	1	0	NA
723	Arachnida	Araneae	Araneidae	1	0	NA
725	Arachnida	Araneae	Araneidae	8	0	NA
728	Arachnida	Araneae	Araneidae	1	0	NA
374	Arachnida	Araneae	Cheiracanthiidae	0	6	NA
446	Arachnida	Araneae	Dictynidae	0	1	NA
349	Arachnida	Araneae	Gnaphosidae	0	5	NA
375	Arachnida	Araneae	Gnaphosidae	0	1	NA
605	Arachnida	Araneae	Gnaphosidae	0	1	NA
32	Arachnida	Araneae	Linyphiidae	25	0	I
33	Arachnida	Araneae	Linyphiidae	52	15	I
130	Arachnida	Araneae	Linyphiidae	18	0	N
131	Arachnida	Araneae	Linyphiidae	11	4	I
312	Arachnida	Araneae	Linyphiidae	0	13	NA
350	Arachnida	Araneae	Linyphiidae	0	29	NA
370	Arachnida	Araneae	Linyphiidae	0	41	NA
371	Arachnida	Araneae	Linyphiidae	0	7	NA
596	Arachnida	Araneae	Linyphiidae	1	0	NA
597	Arachnida	Araneae	Linyphiidae	0	16	NA
310	Arachnida	Araneae	Lycosidae	0	1	NA
407	Arachnida	Araneae	Lycosidae	0	2	NA
529	Arachnida	Araneae	Lycosidae	0	8	NA
317	Arachnida	Araneae	Philodromidae	0	12	NA
329	Arachnida	Araneae	Philodromidae	0	23	NA
445	Arachnida	Araneae	Philodromidae	0	9	NA
553	Arachnida	Araneae	Pisauridae	0	1	NA
18	Arachnida	Araneae	Salticidae	73	13	I
45	Arachnida	Araneae	Salticidae	31	28	I
85	Arachnida	Araneae	Salticidae	61	7	I
104	Arachnida	Araneae	Salticidae	16	6	N
313	Arachnida	Araneae	Salticidae	0	5	NA
551	Arachnida	Araneae	Salticidae	0	1	NA
552	Arachnida	Araneae	Salticidae	0	2	NA
563	Arachnida	Araneae	Salticidae	3	0	NA
724	Arachnida	Araneae	Salticidae	1	0	NA
729	Arachnida	Araneae	Salticidae	0	1	NA
265	Arachnida	Araneae	Tetragnathidae	0	52	NA
437	Arachnida	Araneae	Tetragnathidae	52	0	NA
726	Arachnida	Araneae	Tetragnathidae	0	3	NA
278	Arachnida	Araneae	Theridiidae	0	3	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
311	Arachnida	Araneae	Theridiidae	0	18	NA
368	Arachnida	Araneae	Theridiidae	0	11	NA
518	Arachnida	Araneae	Theridiidae	0	3	NA
606	Arachnida	Araneae	Theridiidae	0	1	NA
17	Arachnida	Araneae	Thomisidae	90	97	I
315	Arachnida	Araneae	Thomisidae	0	32	NA
373	Arachnida	Araneae	Thomisidae	0	13	NA
440	Arachnida	Araneae	Thomisidae	0	59	NA
727	Arachnida	Araneae	Thomisidae	4	0	NA
76	Arachnida	Opiliones	Leiobunidae	32	0	N
548	Arachnida	Opiliones	Phalangiidae	0	2	NA
143	Diplopoda	Julida	Julidae	1	0	I
61	Insecta	Coleoptera	Apionidae	72	3	I
478	Insecta	Coleoptera	Cantharidae	0	1	NA
488	Insecta	Coleoptera	Cantharidae	0	6	NA
354	Insecta	Coleoptera	Carabidae	0	65	NA
539	Insecta	Coleoptera	Carabidae	0	2	NA
542	Insecta	Coleoptera	Carabidae	0	1	NA
591	Insecta	Coleoptera	Carabidae	0	2	NA
421	Insecta	Coleoptera	Cerambycidae	0	49	NA
429	Insecta	Coleoptera	Cerambycidae	0	5	NA
23	Insecta	Coleoptera	Chrysomelidae	11	49	N
71	Insecta	Coleoptera	Chrysomelidae	12	0	I
106	Insecta	Coleoptera	Chrysomelidae	30	0	I
208	Insecta	Coleoptera	Chrysomelidae	2	0	I
215	Insecta	Coleoptera	Chrysomelidae	8	0	N
239	Insecta	Coleoptera	Chrysomelidae	20	0	I
280	Insecta	Coleoptera	Chrysomelidae	0	20	NA
289	Insecta	Coleoptera	Chrysomelidae	0	15	NA
327	Insecta	Coleoptera	Chrysomelidae	0	32	NA
366	Insecta	Coleoptera	Chrysomelidae	0	7	NA
367	Insecta	Coleoptera	Chrysomelidae	0	72	NA
381	Insecta	Coleoptera	Chrysomelidae	0	24	NA
401	Insecta	Coleoptera	Chrysomelidae	0	16	NA
417	Insecta	Coleoptera	Chrysomelidae	0	18	NA
435	Insecta	Coleoptera	Chrysomelidae	0	10	NA
450	Insecta	Coleoptera	Chrysomelidae	0	25	NA
455	Insecta	Coleoptera	Chrysomelidae	0	51	NA
459	Insecta	Coleoptera	Chrysomelidae	0	15	NA
462	Insecta	Coleoptera	Chrysomelidae	0	1	NA
469	Insecta	Coleoptera	Chrysomelidae	0	3	NA
476	Insecta	Coleoptera	Chrysomelidae	0	5	NA
480	Insecta	Coleoptera	Chrysomelidae	0	4	NA
491	Insecta	Coleoptera	Chrysomelidae	0	44	NA
525	Insecta	Coleoptera	Chrysomelidae	0	62	NA
544	Insecta	Coleoptera	Chrysomelidae	0	1	NA
545	Insecta	Coleoptera	Chrysomelidae	0	2	NA
547	Insecta	Coleoptera	Chrysomelidae	0	2	NA
574	Insecta	Coleoptera	Chrysomelidae	0	1	NA
585	Insecta	Coleoptera	Chrysomelidae	0	1	NA
587	Insecta	Coleoptera	Chrysomelidae	0	2	NA
592	Insecta	Coleoptera	Chrysomelidae	0	1	NA
598	Insecta	Coleoptera	Chrysomelidae	0	28	NA
600	Insecta	Coleoptera	Chrysomelidae	0	13	NA
602	Insecta	Coleoptera	Chrysomelidae	0	9	NA
604	Insecta	Coleoptera	Chrysomelidae	0	14	NA
40	Insecta	Coleoptera	Coccinellidae	37	0	I
111	Insecta	Coleoptera	Coccinellidae	129	2	I
135	Insecta	Coleoptera	Coccinellidae	38	5	N

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
154	Insecta	Coleoptera	Coccinellidae	22	0	I
155	Insecta	Coleoptera	Coccinellidae	2	0	N
156	Insecta	Coleoptera	Coccinellidae	2	1	I
231	Insecta	Coleoptera	Coccinellidae	0	24	NA
233	Insecta	Coleoptera	Coccinellidae	1	0	NA
361	Insecta	Coleoptera	Coccinellidae	0	3	NA
426	Insecta	Coleoptera	Coccinellidae	0	16	NA
466	Insecta	Coleoptera	Coccinellidae	0	5	NA
573	Insecta	Coleoptera	Coccinellidae	0	1	NA
603	Insecta	Coleoptera	Coccinellidae	0	11	NA
67	Insecta	Coleoptera	Cryptophagidae	1	0	I
599	Insecta	Coleoptera	Cryptophagidae	0	8	NA
81	Insecta	Coleoptera	Curculionidae	10	0	I
101	Insecta	Coleoptera	Curculionidae	6	0	I
136	Insecta	Coleoptera	Curculionidae	286	18	I
243	Insecta	Coleoptera	Curculionidae	0	2	I
274	Insecta	Coleoptera	Curculionidae	0	4	NA
277	Insecta	Coleoptera	Curculionidae	0	5	NA
299	Insecta	Coleoptera	Curculionidae	0	9	NA
321	Insecta	Coleoptera	Curculionidae	0	15	NA
332	Insecta	Coleoptera	Curculionidae	0	5	NA
357	Insecta	Coleoptera	Curculionidae	0	6	NA
358	Insecta	Coleoptera	Curculionidae	0	6	NA
359	Insecta	Coleoptera	Curculionidae	0	5	NA
360	Insecta	Coleoptera	Curculionidae	0	12	NA
427	Insecta	Coleoptera	Curculionidae	0	2	NA
448	Insecta	Coleoptera	Curculionidae	0	2	NA
473	Insecta	Coleoptera	Curculionidae	0	3	NA
486	Insecta	Coleoptera	Curculionidae	0	1	NA
508	Insecta	Coleoptera	Curculionidae	0	11	NA
579	Insecta	Coleoptera	Curculionidae	0	1	NA
580	Insecta	Coleoptera	Curculionidae	0	1	NA
581	Insecta	Coleoptera	Curculionidae	0	1	NA
594	Insecta	Coleoptera	Curculionidae	0	1	NA
336	Insecta	Coleoptera	Dasytidae	0	202	NA
495	Insecta	Coleoptera	Dermestidae	0	107	NA
496	Insecta	Coleoptera	Dryophthoridae	0	1	NA
234	Insecta	Coleoptera	Elateridae	2	0	E
353	Insecta	Coleoptera	Elateridae	0	4	NA
414	Insecta	Coleoptera	Elateridae	0	1	NA
556	Insecta	Coleoptera	Elateridae	0	6	NA
576	Insecta	Coleoptera	Elateridae	0	2	NA
339	Insecta	Coleoptera	Malachiidae	0	21	NA
419	Insecta	Coleoptera	Malachiidae	0	3	NA
513	Insecta	Coleoptera	Malachiidae	0	42	NA
422	Insecta	Coleoptera	Melyridae	0	14	NA
460	Insecta	Coleoptera	Melyridae	0	25	NA
528	Insecta	Coleoptera	Melyridae	0	4	NA
451	Insecta	Coleoptera	Mordellidae	0	130	NA
52	Insecta	Coleoptera	Nitidulidae	54	8	I
75	Insecta	Coleoptera	Nitidulidae	26	0	I
192	Insecta	Coleoptera	Nitidulidae	10	0	NA
301	Insecta	Coleoptera	Nitidulidae	0	47	NA
356	Insecta	Coleoptera	Nitidulidae	0	9	NA
402	Insecta	Coleoptera	Nitidulidae	0	4	NA
601	Insecta	Coleoptera	Nitidulidae	0	2	NA
720	Insecta	Coleoptera	Nitidulidae	0	1	NA
461	Insecta	Coleoptera	Oedemeridae	0	20	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
489	Insecta	Coleoptera	Oedemeridae	0	7	NA
41	Insecta	Coleoptera	Phalacridae	14	10	N
340	Insecta	Coleoptera	Phalacridae	0	10	NA
501	Insecta	Coleoptera	Phalacridae	0	1	NA
566	Insecta	Coleoptera	Phalacridae	0	2	NA
567	Insecta	Coleoptera	Phalacridae	0	8	NA
535	Insecta	Coleoptera	Rutelidae	0	4	NA
540	Insecta	Coleoptera	Rutelidae	0	7	NA
394	Insecta	Coleoptera	Scarabaeidae	0	17	NA
22	Insecta	Coleoptera	Staphylinidae	1	0	NA
115	Insecta	Coleoptera	Staphylinidae	1	1	NA
134	Insecta	Coleoptera	Staphylinidae	8	0	I
213	Insecta	Coleoptera	Staphylinidae	0	1	NA
291	Insecta	Coleoptera	Staphylinidae	0	1	NA
351	Insecta	Coleoptera	Staphylinidae	0	1	NA
352	Insecta	Coleoptera	Staphylinidae	0	1	NA
543	Insecta	Coleoptera	Staphylinidae	0	3	NA
487	Insecta	Coleoptera	Tenebrionidae	0	1	NA
507	Insecta	Coleoptera	Tenebrionidae	0	24	NA
520	Insecta	Coleoptera	Tenebrionidae	0	13	NA
593	Insecta	Coleoptera	Tenebrionidae	0	2	NA
26	Insecta	Diptera	Agromyzidae	64	0	NA
126	Insecta	Diptera	Agromyzidae	10	1	NA
616	Insecta	Diptera	Agromyzidae	0	26	NA
53	Insecta	Diptera	Calliphoridae	16	3	NA
194	Insecta	Diptera	Calliphoridae	1	0	NA
560	Insecta	Diptera	Calliphoridae	0	1	NA
453	Insecta	Diptera	Carnidae	0	7	NA
7	Insecta	Diptera	Cecidomyiidae	44	0	NA
624	Insecta	Diptera	Cecidomyiidae	0	20	NA
8	Insecta	Diptera	Chloropidae	32	35	NA
150	Insecta	Diptera	Chloropidae	4	0	NA
15	Insecta	Diptera	Drosophilidae	102	0	NA
27	Insecta	Diptera	Drosophilidae	79	0	NA
615	Insecta	Diptera	Drosophilidae	0	6	NA
617	Insecta	Diptera	Drosophilidae	0	4	NA
43	Insecta	Diptera	Hybotidae	5	0	NA
159	Insecta	Diptera	Hybotidae	1	0	NA
619	Insecta	Diptera	Hybotidae	0	7	NA
622	Insecta	Diptera	Hybotidae	0	2	NA
34	Insecta	Diptera	Lauxaniidae	7	0	NA
618	Insecta	Diptera	Lauxaniidae	0	7	NA
46	Insecta	Diptera	Lonchopteridae	67	69	NA
3	Insecta	Diptera	Muscidae	123	71	NA
14	Insecta	Diptera	Muscidae	69	0	NA
30	Insecta	Diptera	Muscidae	65	8	NA
142	Insecta	Diptera	Muscidae	70	6	NA
151	Insecta	Diptera	Muscidae	4	0	NA
166	Insecta	Diptera	Muscidae	5	0	NA
177	Insecta	Diptera	Muscidae	4	0	NA
214	Insecta	Diptera	Muscidae	1	0	NA
225	Insecta	Diptera	Muscidae	95	0	NA
230	Insecta	Diptera	Muscidae	1	0	NA
263	Insecta	Diptera	Muscidae	0	13	NA
614	Insecta	Diptera	Muscidae	0	57	NA
621	Insecta	Diptera	Muscidae	0	1	NA
623	Insecta	Diptera	Muscidae	0	112	NA
625	Insecta	Diptera	Muscidae	0	1	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
626	Insecta	Diptera	Muscidae	0	7	NA
721	Insecta	Diptera	Muscidae	0	4	NA
127	Insecta	Diptera	Opomyzidae	4	3	NA
28	Insecta	Diptera	Rhinophoridae	82	15	NA
2	Insecta	Diptera	Scathophagidae	52	0	NA
181	Insecta	Diptera	Sciaridae	23	0	NA
627	Insecta	Diptera	Sciaridae	0	1	NA
10	Insecta	Diptera	Sepsidae	352	0	NA
144	Insecta	Diptera	Sepsidae	82	0	NA
161	Insecta	Diptera	Sepsidae	59	0	NA
193	Insecta	Diptera	Sepsidae	6	0	NA
613	Insecta	Diptera	Sepsidae	0	2	NA
575	Insecta	Diptera	Stratiomyidae	0	7	NA
4	Insecta	Diptera	Syrphidae	15	7	NA
5	Insecta	Diptera	Syrphidae	34	12	NA
56	Insecta	Diptera	Syrphidae	4	3	NA
205	Insecta	Diptera	Syrphidae	2	0	NA
254	Insecta	Diptera	Syrphidae	1	0	NA
258	Insecta	Diptera	Syrphidae	1	0	NA
288	Insecta	Diptera	Syrphidae	3	0	NA
294	Insecta	Diptera	Syrphidae	0	2	NA
383	Insecta	Diptera	Syrphidae	0	9	NA
550	Insecta	Diptera	Syrphidae	0	2	NA
628	Insecta	Diptera	Syrphidae	0	15	NA
629	Insecta	Diptera	Syrphidae	0	1	NA
55	Insecta	Diptera	Tephritidae	77	0	NA
210	Insecta	Diptera	Tephritidae	220	1	NA
335	Insecta	Diptera	Tephritidae	0	4	NA
386	Insecta	Diptera	Tephritidae	0	2	NA
514	Insecta	Diptera	Tephritidae	0	2	NA
620	Insecta	Diptera	Tephritidae	0	31	NA
29	Insecta	Diptera	Tipulidae	2	0	NA
204	Insecta	Diptera	Tipulidae	1	0	NA
490	Insecta	Diptera	Ulidiidae	0	1	NA
433	Insecta	Hemiptera	Alydidae	0	6	NA
125	Insecta	Hemiptera	Anthocoridae	44	3	I
140	Insecta	Hemiptera	Anthocoridae	16	0	NA
203	Insecta	Hemiptera	Anthocoridae	2	0	NA
293	Insecta	Hemiptera	Anthocoridae	0	5	NA
314	Insecta	Hemiptera	Anthocoridae	1	0	NA
380	Insecta	Hemiptera	Anthocoridae	0	4	NA
410	Insecta	Hemiptera	Anthocoridae	0	1	NA
523	Insecta	Hemiptera	Anthocoridae	0	1	NA
6	Insecta	Hemiptera	Aphididae	257	48	N
16	Insecta	Hemiptera	Aphididae	42	2	NA
24	Insecta	Hemiptera	Aphididae	58	2	NA
88	Insecta	Hemiptera	Aphididae	127	45	N
89	Insecta	Hemiptera	Aphididae	31	0	N
108	Insecta	Hemiptera	Aphididae	13	0	N
112	Insecta	Hemiptera	Aphididae	1	0	N
124	Insecta	Hemiptera	Aphididae	19	10	N
376	Insecta	Hemiptera	Aphididae	13	0	NA
474	Insecta	Hemiptera	Aphididae	0	1	NA
50	Insecta	Hemiptera	Aphrophoridae	285	241	I
319	Insecta	Hemiptera	Aphrophoridae	0	2	NA
387	Insecta	Hemiptera	Aphrophoridae	0	3	NA
467	Insecta	Hemiptera	Aphrophoridae	0	1	NA
465	Insecta	Hemiptera	Blissidae	0	43	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
31	Insecta	Hemiptera	Cicadellidae	185	0	NA
113	Insecta	Hemiptera	Cicadellidae	57	0	I
133	Insecta	Hemiptera	Cicadellidae	301	14	NA
189	Insecta	Hemiptera	Cicadellidae	35	0	N
236	Insecta	Hemiptera	Cicadellidae	8	0	NA
244	Insecta	Hemiptera	Cicadellidae	1	0	I
245	Insecta	Hemiptera	Cicadellidae	17	0	N
253	Insecta	Hemiptera	Cicadellidae	1	0	N
257	Insecta	Hemiptera	Cicadellidae	3	0	NA
342	Insecta	Hemiptera	Cicadellidae	1	0	N
369	Insecta	Hemiptera	Cicadellidae	0	1	NA
378	Insecta	Hemiptera	Cicadellidae	0	25	NA
393	Insecta	Hemiptera	Cicadellidae	0	4	NA
470	Insecta	Hemiptera	Cicadellidae	0	3	NA
483	Insecta	Hemiptera	Cicadellidae	0	1	NA
522	Insecta	Hemiptera	Cicadellidae	0	3	NA
48	Insecta	Hemiptera	Cixiidae	0	13	NA
272	Insecta	Hemiptera	Cixiidae	0	14	NA
409	Insecta	Hemiptera	Cixiidae	0	8	NA
423	Insecta	Hemiptera	Cixiidae	0	15	NA
418	Insecta	Hemiptera	Coreidae	0	13	NA
479	Insecta	Hemiptera	Coreidae	0	4	NA
412	Insecta	Hemiptera	Cydnidae	0	2	NA
12	Insecta	Hemiptera	Delphacidae	243	0	N
49	Insecta	Hemiptera	Delphacidae	252	45	N
77	Insecta	Hemiptera	Delphacidae	44	3	N
271	Insecta	Hemiptera	Delphacidae	0	5	NA
331	Insecta	Hemiptera	Delphacidae	0	5	NA
428	Insecta	Hemiptera	Delphacidae	0	3	NA
557	Insecta	Hemiptera	Delphacidae	0	20	NA
153	Insecta	Hemiptera	Flatidae	3	0	N
328	Insecta	Hemiptera	Flatidae	0	1	NA
114	Insecta	Hemiptera	Liviidae	1	0	E
20	Insecta	Hemiptera	Lygaeidae	49	6	N
51	Insecta	Hemiptera	Lygaeidae	40	0	NA
141	Insecta	Hemiptera	Lygaeidae	14	15	N
338	Insecta	Hemiptera	Lygaeidae	0	19	NA
341	Insecta	Hemiptera	Lygaeidae	0	12	NA
355	Insecta	Hemiptera	Lygaeidae	0	4	NA
87	Insecta	Hemiptera	Miridae	433	26	N
195	Insecta	Hemiptera	Miridae	3	0	N
211	Insecta	Hemiptera	Miridae	74	0	NA
413	Insecta	Hemiptera	Miridae	0	1	NA
438	Insecta	Hemiptera	Miridae	1	0	NA
569	Insecta	Hemiptera	Miridae	0	8	NA
571	Insecta	Hemiptera	Miridae	0	1	NA
58	Insecta	Hemiptera	Nabidae	27	0	N
72	Insecta	Hemiptera	Nabidae	180	3	N
377	Insecta	Hemiptera	Nabidae	0	100	NA
439	Insecta	Hemiptera	Oxycarenidae	1	0	I
117	Insecta	Hemiptera	Pentatomidae	53	13	I
408	Insecta	Hemiptera	Pentatomidae	0	1	NA
430	Insecta	Hemiptera	Pentatomidae	0	8	NA
463	Insecta	Hemiptera	Pentatomidae	0	9	NA
500	Insecta	Hemiptera	Pentatomidae	0	12	NA
68	Insecta	Hemiptera	Psyllidae	15	21	I
546	Insecta	Hemiptera	Psyllidae	0	2	NA
379	Insecta	Hemiptera	Reduviidae	0	2	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
396	Insecta	Hemiptera	Reduviidae	0	6	NA
406	Insecta	Hemiptera	Reduviidae	0	1	NA
524	Insecta	Hemiptera	Reduviidae	0	2	NA
531	Insecta	Hemiptera	Reduviidae	0	1	NA
554	Insecta	Hemiptera	Reduviidae	0	1	NA
443	Insecta	Hemiptera	Rhopalidae	0	1	NA
504	Insecta	Hemiptera	Rhopalidae	0	10	NA
532	Insecta	Hemiptera	Rhopalidae	0	1	NA
198	Insecta	Hemiptera	Rhyparochromidae	2	0	N
218	Insecta	Hemiptera	Rhyparochromidae	1	9	N
588	Insecta	Hemiptera	Rhyparochromidae	0	1	NA
19	Insecta	Hemiptera	Saldidae	4	1	N
589	Insecta	Hemiptera	Saldidae	0	1	NA
475	Insecta	Hemiptera	Scutelleridae	0	22	NA
568	Insecta	Hemiptera	Tettigometridae	0	1	NA
411	Insecta	Hemiptera	Tingidae	0	4	NA
492	Insecta	Hemiptera	Tingidae	0	10	NA
9	Insecta	Hymenoptera	Aphelinidae	96	0	NA
93	Insecta	Hymenoptera	Aphelinidae	10	0	NA
128	Insecta	Hymenoptera	Aphelinidae	9	2	NA
561	Insecta	Hymenoptera	Aphelinidae	0	13	NA
661	Insecta	Hymenoptera	Aphelinidae	0	587	NA
35	Insecta	Hymenoptera	Apidae	19	6	I
36	Insecta	Hymenoptera	Apidae	16	3	NA
345	Insecta	Hymenoptera	Apidae	0	11	NA
390	Insecta	Hymenoptera	Apidae	0	7	NA
399	Insecta	Hymenoptera	Apidae	0	3	NA
549	Insecta	Hymenoptera	Apidae	0	2	NA
559	Insecta	Hymenoptera	Apidae	0	1	NA
572	Insecta	Hymenoptera	Apidae	0	3	NA
578	Insecta	Hymenoptera	Apidae	0	1	NA
13	Insecta	Hymenoptera	Braconidae	16	0	NA
25	Insecta	Hymenoptera	Braconidae	55	0	NA
109	Insecta	Hymenoptera	Braconidae	3	0	NA
207	Insecta	Hymenoptera	Braconidae	3	0	NA
251	Insecta	Hymenoptera	Braconidae	0	2	NA
276	Insecta	Hymenoptera	Braconidae	0	6	NA
645	Insecta	Hymenoptera	Braconidae	0	12	NA
653	Insecta	Hymenoptera	Braconidae	0	1	NA
660	Insecta	Hymenoptera	Braconidae	1	0	NA
662	Insecta	Hymenoptera	Braconidae	0	6	NA
663	Insecta	Hymenoptera	Braconidae	0	22	NA
485	Insecta	Hymenoptera	Chalcididae	0	3	NA
389	Insecta	Hymenoptera	Colletidae	0	8	NA
502	Insecta	Hymenoptera	Colletidae	3	0	NA
674	Insecta	Hymenoptera	Colletidae	0	3	NA
47	Insecta	Hymenoptera	Encyrtidae	5	0	NA
91	Insecta	Hymenoptera	Encyrtidae	13	2	NA
121	Insecta	Hymenoptera	Encyrtidae	3	0	NA
123	Insecta	Hymenoptera	Encyrtidae	3	0	NA
646	Insecta	Hymenoptera	Encyrtidae	0	4	NA
665	Insecta	Hymenoptera	Encyrtidae	0	4	NA
100	Insecta	Hymenoptera	Eulophidae	6	4	NA
122	Insecta	Hymenoptera	Eulophidae	69	86	NA
536	Insecta	Hymenoptera	Eumenidae	0	3	NA
42	Insecta	Hymenoptera	Figitidae	7	0	NA
97	Insecta	Hymenoptera	Figitidae	2	0	NA
157	Insecta	Hymenoptera	Figitidae	7	0	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
343	Insecta	Hymenoptera	Figitidae	0	2	NA
595	Insecta	Hymenoptera	Figitidae	0	2	NA
643	Insecta	Hymenoptera	Figitidae	0	1	NA
644	Insecta	Hymenoptera	Figitidae	0	1	NA
648	Insecta	Hymenoptera	Figitidae	0	3	NA
21	Insecta	Hymenoptera	Formicidae	593	6	N
44	Insecta	Hymenoptera	Formicidae	5	5	N
137	Insecta	Hymenoptera	Formicidae	20	4	N
139	Insecta	Hymenoptera	Formicidae	30	0	N
219	Insecta	Hymenoptera	Formicidae	12	0	I
220	Insecta	Hymenoptera	Formicidae	2	0	N
241	Insecta	Hymenoptera	Formicidae	9	0	N
262	Insecta	Hymenoptera	Formicidae	0	177	NA
268	Insecta	Hymenoptera	Formicidae	0	50	NA
292	Insecta	Hymenoptera	Formicidae	0	18	NA
320	Insecta	Hymenoptera	Formicidae	0	13	NA
322	Insecta	Hymenoptera	Formicidae	0	20	NA
425	Insecta	Hymenoptera	Formicidae	0	3	NA
436	Insecta	Hymenoptera	Formicidae	0	1	NA
449	Insecta	Hymenoptera	Formicidae	0	9	NA
464	Insecta	Hymenoptera	Formicidae	0	8	NA
482	Insecta	Hymenoptera	Formicidae	0	5	NA
654	Insecta	Hymenoptera	Formicidae	0	2	NA
657	Insecta	Hymenoptera	Formicidae	0	5	NA
669	Insecta	Hymenoptera	Formicidae	0	6	NA
672	Insecta	Hymenoptera	Formicidae	0	4	NA
37	Insecta	Hymenoptera	Halictidae	113	0	NA
145	Insecta	Hymenoptera	Halictidae	30	0	NA
190	Insecta	Hymenoptera	Halictidae	5	0	NA
362	Insecta	Hymenoptera	Halictidae	0	11	NA
388	Insecta	Hymenoptera	Halictidae	0	1	NA
441	Insecta	Hymenoptera	Halictidae	0	9	NA
456	Insecta	Hymenoptera	Halictidae	0	6	NA
512	Insecta	Hymenoptera	Halictidae	0	2	NA
652	Insecta	Hymenoptera	Halictidae	0	2	NA
664	Insecta	Hymenoptera	Halictidae	0	19	NA
670	Insecta	Hymenoptera	Halictidae	0	15	NA
38	Insecta	Hymenoptera	Ichneumonidae	32	4	NA
148	Insecta	Hymenoptera	Ichneumonidae	20	0	NA
160	Insecta	Hymenoptera	Ichneumonidae	2	0	NA
175	Insecta	Hymenoptera	Ichneumonidae	8	0	NA
209	Insecta	Hymenoptera	Ichneumonidae	1	1	NA
235	Insecta	Hymenoptera	Ichneumonidae	2	0	NA
237	Insecta	Hymenoptera	Ichneumonidae	7	0	NA
249	Insecta	Hymenoptera	Ichneumonidae	1	0	NA
296	Insecta	Hymenoptera	Ichneumonidae	0	5	NA
326	Insecta	Hymenoptera	Ichneumonidae	0	3	NA
337	Insecta	Hymenoptera	Ichneumonidae	0	2	NA
363	Insecta	Hymenoptera	Ichneumonidae	0	3	NA
420	Insecta	Hymenoptera	Ichneumonidae	0	4	NA
472	Insecta	Hymenoptera	Ichneumonidae	0	3	NA
484	Insecta	Hymenoptera	Ichneumonidae	0	1	NA
647	Insecta	Hymenoptera	Ichneumonidae	0	3	NA
649	Insecta	Hymenoptera	Ichneumonidae	0	1	NA
650	Insecta	Hymenoptera	Ichneumonidae	0	3	NA
655	Insecta	Hymenoptera	Ichneumonidae	0	9	NA
656	Insecta	Hymenoptera	Ichneumonidae	0	1	NA
658	Insecta	Hymenoptera	Ichneumonidae	0	2	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
442	Insecta	Hymenoptera	Megachilidae	1	0	NA
673	Insecta	Hymenoptera	Megachilidae	0	2	NA
92	Insecta	Hymenoptera	Mymaridae	6	2	NA
252	Insecta	Hymenoptera	Mymaridae	6	0	NA
659	Insecta	Hymenoptera	Mymaridae	0	9	NA
516	Insecta	Hymenoptera	Pelecinidae	0	2	NA
65	Insecta	Hymenoptera	Pteromalidae	13	0	NA
96	Insecta	Hymenoptera	Pteromalidae	24	0	NA
212	Insecta	Hymenoptera	Pteromalidae	8	7	NA
666	Insecta	Hymenoptera	Pteromalidae	0	7	NA
667	Insecta	Hymenoptera	Pteromalidae	0	13	NA
199	Insecta	Hymenoptera	Sphecidae	4	0	NA
671	Insecta	Hymenoptera	Sphecidae	0	4	NA
11	Insecta	Hymenoptera	Tenthredinidae	12	0	NA
39	Insecta	Hymenoptera	Tenthredinidae	4	0	NA
165	Insecta	Hymenoptera	Tenthredinidae	0	5	NA
176	Insecta	Hymenoptera	Tenthredinidae	9	0	NA
642	Insecta	Hymenoptera	Tenthredinidae	0	1	NA
651	Insecta	Hymenoptera	Tenthredinidae	0	32	NA
98	Insecta	Hymenoptera	Trichogrammatidae	10	0	NA
668	Insecta	Hymenoptera	Trichogrammatidae	0	1	NA
191	Insecta	Hymenoptera	Vespidae	1	0	NA
333	Insecta	Hymenoptera	Vespidae	0	11	NA
404	Insecta	Hymenoptera	Vespidae	0	1	NA
458	Insecta	Hymenoptera	Vespidae	1	0	NA
184	Insecta	Lepidoptera	Choreutidae	20	0	N
692	Insecta	Lepidoptera	Choreutidae	0	8	NA
129	Insecta	Lepidoptera	Crambidae	19	0	NA
687	Insecta	Lepidoptera	Crambidae	0	9	NA
74	Insecta	Lepidoptera	Geometridae	8	0	NA
107	Insecta	Lepidoptera	Geometridae	2	0	E
186	Insecta	Lepidoptera	Geometridae	3	0	NA
686	Insecta	Lepidoptera	Geometridae	0	4	NA
689	Insecta	Lepidoptera	Geometridae	0	1	NA
232	Insecta	Lepidoptera	Lycaenidae	3	0	NA
690	Insecta	Lepidoptera	Lycaenidae	0	3	NA
1	Insecta	Lepidoptera	Noctuidae	24	0	NA
183	Insecta	Lepidoptera	Noctuidae	11	0	NA
185	Insecta	Lepidoptera	Noctuidae	2	0	NA
509	Insecta	Lepidoptera	Noctuidae	0	7	NA
685	Insecta	Lepidoptera	Noctuidae	0	4	NA
688	Insecta	Lepidoptera	Noctuidae	0	1	NA
171	Insecta	Lepidoptera	Pieridae	1	0	E
415	Insecta	Lepidoptera	Pieridae	4	1	N
691	Insecta	Lepidoptera	Pieridae	0	4	NA
382	Insecta	Lepidoptera	Pyralidae	0	27	NA
217	Insecta	Lepidoptera	Tortricidae	9	0	I
693	Insecta	Lepidoptera	Tortricidae	0	8	NA
444	Insecta	Mantodea	Empusidae	0	1	NA
240	Insecta	Neuroptera	Hemerobiidae	2	0	NA
255	Insecta	Orthoptera	Acrididae	3	1	N
267	Insecta	Orthoptera	Acrididae	0	42	NA
270	Insecta	Orthoptera	Acrididae	0	16	NA
493	Insecta	Orthoptera	Acrididae	0	5	NA
503	Insecta	Orthoptera	Acrididae	0	99	NA
511	Insecta	Orthoptera	Acrididae	0	10	NA
468	Insecta	Orthoptera	Prophalangopsidae	0	1	NA
63	Insecta	Orthoptera	Tetrigidae	7	0	NA

Table A2. *Cont.*

MS ID	Class	Order	Family	Azores	Mainland	Establishment Mean
64	Insecta	Orthoptera	Tetrigidae	4	0	NA
682	Insecta	Orthoptera	Tetrigidae	0	10	NA
202	Insecta	Orthoptera	Tettigoniidae	9	0	NA
229	Insecta	Orthoptera	Tettigoniidae	44	0	NA
309	Insecta	Orthoptera	Tettigoniidae	0	6	NA
416	Insecta	Orthoptera	Tettigoniidae	3	0	NA
683	Insecta	Orthoptera	Tettigoniidae	0	7	NA
82	Insecta	Orthoptera	Trigonidiidae	69	3	I
196	Insecta	Phasmida	Phasmatidae	1	0	I
94	Insecta	Psocodea	Caeciliusidae	48	3	N
120	Insecta	Psocodea	Ectopsocidae	21	0	I
206	Insecta	Psocodea	Trichopsocidae	7	0	N
200	Insecta	Thysanoptera	Thripidae	0	1	N
		Total		**7861**	**5654**	

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