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Seasonal dynamics of arthropods in the humid native forests of Terceira Island (Azores)

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This work aims to provide a first detailed description of the results obtained in a seasonal abundance study of arthropods in the native pristine humid forest from Terceira Island (Azores). Ten sites were sampled during four years with SLAM (Sea, Land, and Air Malaise) traps targeting several arthropod taxa with good dispersal abilities as well as epigean species crawling into the trap. Samples were taken every three months in nine sites between 2012 and 2016 and monthly in one of the sites between 2014 and 2015. A total of 147 arthropod species and morphospecies were sampled mostly belonging to Hemiptera, Araneae and Coleoptera. Four endemic species, the tree lace-hopper *Cixius azoterceirae*, the capsid bug *Pinalitus oromii*, the bristletail *Trigoniophthalmus borgesi* and a morphospecies of Aleyrodidae accounted for 50% of all adult specimens. Most species peak in abundance in summer, but monthly data allowed the identification of other seasonal patterns.

Key words: Arthropods, Azores, native forest, temporal dynamics, peaks of activity

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INTRODUCTION

Arthropods are the most diverse animal group in Azores and elsewhere (Borges et al. 2010). They represent about 40% of total species and subspecies present in the Azorean archipelago with 2,346 species (Borges et al. 2010 and unpublished updates) from which 272 are endemic to the archipelago. Despite the fact that some species are causing severe problems for Azorean economy (e.g. termites, Guerreiro et al. 2014), most of the species provide relevant ecological services (e.g. pollinators, Picanço et al. 2017). In the last twenty years, there was a huge investment in the study of native communities of Azorean arthropods (reviewed in Borges et al 2011). These studies targeted the last remnants of native forest covering seven of the Azorean islands (Gaspar et al. 2008), but other three habitats were also extensively investigated, namely exotic forest, semi-natural pasture and intensive pasture (see Borges et al. 2008; Cardoso et al. 2009; Meijer et al. 2011; Florencio et al. 2016). These and other studies were relevant for the improvement of the knowledge concerning the distribution and abundance of Azorean arthropod species (e.g. Gaston et al. 2006; Rigal et al. 2013; Borges et al. 2016) but lack information on the temporal and seasonal dynamics of arthropod communities and individual species in Azorean native forests.

Seasonal abundance of arthropods is normally triggered by macroclimatic and microclimatic changes and by biotic factors such as food availability, host tree phenology, predation, parasitism, and interspecific resource competition (Wolda 1988; Thomas et al. 1992; Didham & Springate 2003; Beltrán & Wunderle 2014). Studies about the seasonal patterns of arthropods in temperate regions, show that abundance increases normally from early, mid-spring, reaching its annual maximum at the end of summer (MacLean & Pitelka 1971; Cardoso et al. 2007; Sanford & Huntly 2010). Some exceptions to this general seasonal pattern are for example species of arthropods considered agricultural pests which are also related to host plant physiological response (kairomones diffusion) (Gold et al. 2004; Quilici et al. 2014) and phenology state (fruit availability) (Hedström 1993; Katsoyannos et al. 1998; Lopes et al. 2006, 2011; Vayssières et al. 2015; Pimentel et al. 2017).

Monitoring the quality of island habitats is crucial for understanding key ecological processes on islands (Patiño et al. 2017). Every seasonality study offers unique perspectives on how targeted communities abundance changes overtime, relate to each other and what drives its fluctuation. At the conservation perspective level, or even from the invasion control perspective, these studies are very useful to unveil the most fragile periods, and therefore allowing a better support for decision making processes for its preservation or control/management (Williamson 1999; Vargas et al. 2001; Nestel et al. 2004; Olden 2006; Hendrichs et al. 2007; Aluja et al. 2012).

The main goal of this study is to provide a first detailed description of the seasonal abundance of arthropods in pristine humid forests from Azores. We targeted Terceira Island, the Azorean island with the best-preserved areas of native forest in the archipelago (Gaston et al. 2006; Gaspar et al. 2008, 2011; Borges et al. 2008, 2011). According to the latest list of terrestrial and marine biota on the Azores, there are about 1,245 species and subspecies of arthropods in Terceira Island (Borges et al. 2010 and unpublished updates), meaning that over 53% of total arthropod species in the Azores can be found just in Terceira. Many of those species are endemic (132 species and subspecies) and occur mostly in the remnants of pristine humid forest (Borges et al. 2008, 2016).

MATERIAL AND METHODS

STUDY SITES

The Azores archipelago is composed by nine islands located in North Atlantic, roughly between 37º to 40º N latitude and 25º to 3º W longitude: Corvo, Flores, Faial, Pico, São Jorge, Graciosa, Terceira, São Miguel and Santa Maria (Fig. 1). The target island, Terceira is the third largest island in the archipelago with 400,6 km^2. The samples were collected within the Natural Park of Terceira Island (38°43'54.09"N and 27°12'14.07"W) (Fig. 1). The climate is very mild, with regular and abundant rainfall, with high levels of relative humidity and persistent winds, mainly during the winter and autumn seasons (Azevedo 1996). The topography of the islands has great influence in precipitation regimes and air temperatures, which at sea level range between an annual average minimum of 13°C and a maximum of 24°C (Azevedo 1996).

The Natural Park of Terceira has a total area of 95.78 km^2 of which 88.35 km^2 and 7.43 km^2 are terrestrial and marine areas, respectively. This Natural Park represents about 22% of Terceira's terrestrial land area. All pristine native forests still remaining in the island are within the boundaries of the network of protected areas. Due to historical human clearance these native forests are now restricted to areas above 500m, and are characterized as montane cloud forests, i.e., high humidity and evergreen short sized stature trees with a dominance of two types of forests: "*Juniperus-Ilex* Montane Forests" and "*Juniperus* Montane Woodlands" (Elias et al. 2016). The dominant trees and shrubs are the endemic *Juniperus brevifolia*, *Erica azorica*, *Laurus azorica* and *Ilex perado* subsp. *azorica*. In the most exposed and wet conditions, the Azorean cedar (*J. brevifolia*) is the most abundant tree and in some circumstances, this species shares its dominance with the *I. perado* subsp. *azorica*

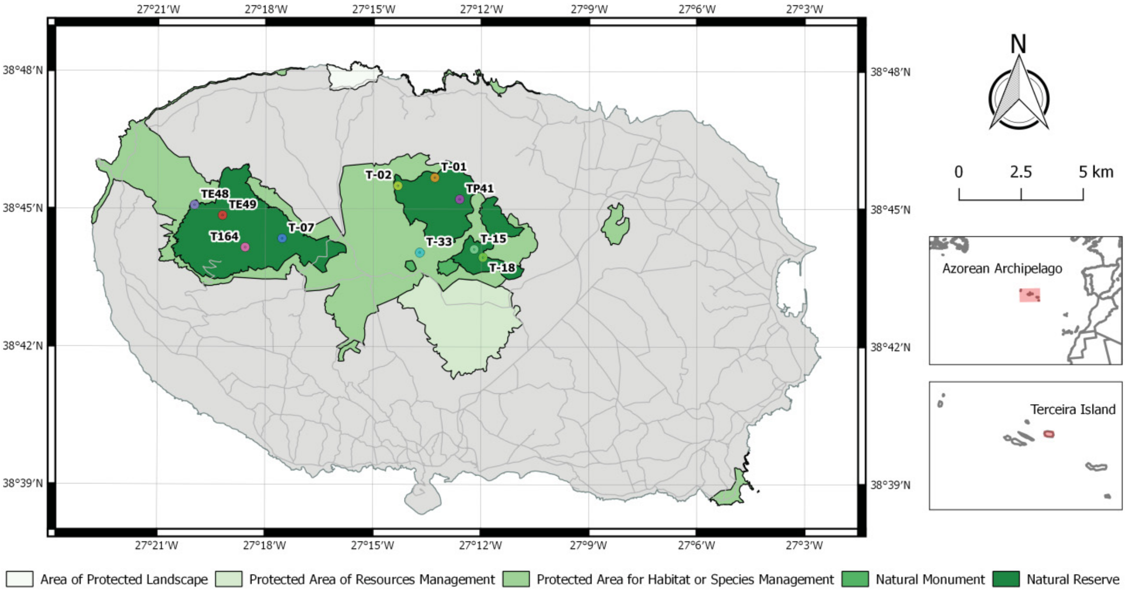

Fig. 1. Localization of Azores and Terceira Island in Azores, respectively (right maps). Map of Terceira Island with the distribution of the 10 studied plots. T-18 is the plot from Terra-Brava in which a monthly study was performed. Green areas represent the Terceira network of protected areas, i.e. Terceira Natural Park.

(Elias et al. 2011, 2016). These pristine forests are luxuriant and include bryophyte communities at all substrates (Gabriel & Bates 2005).

A total of ten sites were selected using 50m x 50m plots located in four fragments of native forest in Terceira: Serra de Santa Bárbara (Plots T07, T48, T49, T164), Biscoito da Ferraria (Plots T01, T02, T41), Terra-Brava (Plot T15, T18) and Galhardo (Plot T33) (Fig. 1). These plots were setup in 2012 within a comparative study of island native forests between Terceira island in the Azores, Tenerife in the Canary Islands and La Réunion in the Mascarene Islands (see Cicconardi et al. 2017). In each island we selected native wet forest areas with few signals of human disturbance to compare biodiversity in what can be considered well-preserved patches of native forest.

SAMPLING

Passive flight interception traps named SLAM (Sea, Land, and Air Malaise trap) (see Fig. 2) were setup in 2012, one in each plot. The sampling recipients were filled with propylene glycol (pure 1,2-PROPANODIOL) to kill and conserve the samples between periodic collections, safeguarding DNA preservation for genetic analysis also. The SLAM traps are approximately 110 x 110 x 110 cm (see Fig. 2), intercepting flying arthropods on an area of black mesh. The trapped arthropods subsequently crawls up the mesh, falling into a sampling bottle.

Fig. 2. A passive flight interception trap SLAM (Sea, Land, and Air Malaise trap), placed in a pristine forest area of Terceira Island.

Although directed to sample flying arthropods, additionally it also captures several non-flying species, sometimes in extremely high abundances (Collembola, Acari, Diplopoda, Chilopoda). The SLAM also works as an extension of the tree, and animals can also walk into it from the trees instead of flying. Therefore, its monitoring range goes beyond the initially predicted high dispersive flying insect groups (Diptera, Hymenoptera, Lepidoptera).

Sampling started from June 13 of 2012 to December 22 of 2016. In all sites, except Terra-Brava T18, arthropods were collected every three months (roughly in mid March, mid June, mid September and mid December) to sample the four seasons. In Terra-Brava T18, arthropods were collected on a monthly basis covering two years (2014 and 2015). Terra-Brava is considered to be one of the most pristine natural areas of Terceira Island (Gaspar et al. 2011) and therefore was elected to perform a more detailed study with monthly samples.

DATA ANALYSES

A rapid biodiversity assessment was performed following three steps: 1) specimens were sorted into all arthropod orders by students (see acknowledgments); 2) for arthropod orders for which there was taxonomic expertise, using a parataxonomy approach sensu Oliver & Beattie (1993) trained students performed morphospecies sorting using a reference collection (see Gaspar et al. 2008); and 3) a trained taxonomist (PAVB) corrected all the splitting and lumping errors identifying species always as possible.

Targeted taxa for species identification belonged to Diplopoda, Chilopoda, Arachnida (excluding Acari) and Hexapoda (excluding Collembola, Lepidoptera, Diptera and Hymenoptera). The reasons for not considering Acari, Collembola, Lepidoptera, Diptera and Hymenoptera were twofold; 1) applying the parataxonomy approach sorting Acari, Collembola, Diptera and Hymenoptera morphospecies is a daunting task due to difficulties in using adequate morphological traits for fast specimens sorting; 2) for Lepidoptera we successfully applied this strategy in BALA project (reviewed in Borges et al. 2011), but the large amount of specimens in SLAM traps made this process unpractical. All specimens were catalogued, conserved in 96% ethanol and stored in the University of Azores insect Collection Dalberto Teixeira Pombo. All data were introduced into an arthropod database for later analysis.

The taxonomic nomenclature followed Borges et al (2010). Species were classified in three colonization status:

E – Azorean endemic species, i.e. species (or subspecies) occurring only in the Azores, as a result of either speciation events (neo-endemics) or extinction of the mainland populations (palaeo-endemics);

N – native species, i.e. species which arrived by long-distance dispersal in the Azores and which also occur in other archipelagos and/or on continents. The native or introduced status of a taxon is still debatable; however we tried a consensus among all the authors, based on the available information;

I - introduced species, i.e., species believed to occur in the archipelago as a result of human activities.

In case of any doubt between to be an Endemic or Native, the Native colonization status was always applied.

For each species we also indicate their trophic status classifying them in the following categories: H – herbivore; S - saprophagous; P - predator and F – fungivore. For the current study we quantified species abundance for adult and juvenile stages.

RESULTS

ALL SITES STUDY

A total of 15,733 specimens were collected in the ten sampling sites belonging to 147 arthropod species and morphospecies. The most abundant species belonging to the first quartile (37 species) when ranking species abundances accounted for 15,292 specimens (Table 1), i.e. 97% of all adult sampled specimens. Four species (*Cixius azoterceirae* Remane & Asche; *Pinalitus oromii* J. Ribes; *Trigoniophthalmus borgesi* Mendes et al. and a morphospecies of Aleyrodidae), three of them belonging to Hemiptera, accounted for 50% of all adult sampled specimens (Table 1).

Hemiptera, Araneae, Coleoptera and Psocoptera were the most diverse orders in the first quartile

Table 1. List of species in the first quartile ranked according to abundance of adults (data from ten sites between 2012 and 2016). Colonization status (E- endemic, N – native, I – introduced). Trophic groups (P – predators; H – herbivores; S – saprophages; F – fungivores).

Class	Order	Family	Species	Coloniz.	Trophic	Abundance
Insecta	**Hemiptera**	Cixiidae	*Cixius azoterceirae* Remane & Asche	E	H	5105
Insecta	**Hemiptera**	Miridae	*Pinalitus oromii* J. Ribes	E	H	1330
Insecta	**Microcoryphia**	Machilidae	*Trigoniophthalmus borgesi* Mendes et al.	E	S	761
Insecta	**Hemiptera**	Aleyrodidae	Gen. sp.	E	H	742
Arachnida	**Araneae**	Theridiidae	*Rugathodes acoreensis* Wunderlich	E	P	723
Arachnida	**Araneae**	Linyphiidae	*Savigniorrhipis acoreensis* Wunderlich	E	P	621
Insecta	**Hemiptera**	Triozidae	*Trioza laurisilvae* Hodkinson	N	H	586
Insecta	**Psocoptera**	Elipsocidae	*Elipsocus brincki* Badonnel	E	S	542
Insecta	**Hemiptera**	Delphacidae	*Kelisia ribauti* Wagner	N	H	451
Arachnida	**Opiliones**	Phalangiidae	*Leiobunum blackwalli* Meade	N	P	429
Insecta	**Neuroptera**	Hemerobiidae	*Hemerobius azoricus* Tjeder	E	P	407
Arachnida	**Araneae**	Linyphiidae	*Acorigone acoreensis* (Wunderlich)	E	P	356
Insecta	**Coleoptera**	Curculionidae	*Calacalles subcarinatus* (Israelson)	E	H	318
Insecta	**Psocoptera**	Caeciliusidae	*Valenzuela flavidus* (Stephens)	N	S	279
Arachnida	**Araneae**	Araneidae	*Gibbaranea occidentalis* Wunderlich	E	P	242
Chilopoda	**Lithobiomorpha**	Lithobiidae	*Lithobius pilicornis pilicornis*	N	P	217

			Newport			
Insecta	**Coleoptera**	Curculionidae	*Drouetius borgesi borgesi* Machado	E	H	186
Insecta	**Hemiptera**	Aphididae	Gen. sp.	N	H	174
Insecta	**Blattaria**	Polyphagidae	*Zetha vestita* (Brullé)	N	S	173
Insecta	**Coleoptera**	Scraptiidae	*Anaspis proteus* (Wollaston)	N	H	164
Arachnida	**Araneae**	Tetragnathidae	*Sancus acoreensis* (Wunderlich)	E	P	151
Arachnida	**Araneae**	Dictynidae	*Lathys dentichelis* (Simon)	N	P	140
Insecta	**Coleoptera**	Curculionidae	*Pseudophloeophagus tenax* (Wollaston)	N	H	139
Insecta	**Hemiptera**	Lachnidae	*Cinara juniperi* (De Geer)	N	H	134
Insecta	**Hemiptera**	Flatidae	*Cyphopterum adcendens* (Herr.-Schaff.)	N	H	125
Insecta	**Psocoptera**	Ectopsocidae	*Ectopsocus briggsi* McLachlan	I	S	118
Arachnida	**Araneae**	Salticidae	*Macaroeris cata* (Blackwall)	N	P	118
Insecta	**Coleoptera**	Leiodidae	*Catops coracinus* Kellner	N	S	82
Insecta	**Coleoptera**	Staphylinidae	*Atheta dryochares* Israelson	E	P	67
Insecta	**Hemiptera**	Psyllidae	*Strophingia harteni* Hodkinson	E	H	67
Insecta	**Psocoptera**	Elipsocidae	*Elipsocus azoricus* Meinander	E	S	66
Insecta	**Psocoptera**	Trichopsocidae	*Trichopsocus clarus* (Banks)	N	S	59
Arachnida	**Araneae**	Pisauridae	*Pisaura acoreensis* Wunderlich	E	P	54
Insecta	**Hemiptera**	Lygaeidae	*Kleidocerys ericae* (Horváth)	N	H	48
Arachnida	**Araneae**	Linyphiidae	*Microlinyphia johnsoni* (Blackwall)	N	P	43
Diplopoda	**Julida**	Julidae	*Ommatoiulus moreletii* (Lucas)	I	H	38
Insecta	**Thysanoptera**	Phlaeothripidae	*Hoplothrips corticis* (De Geer)	N	F	33

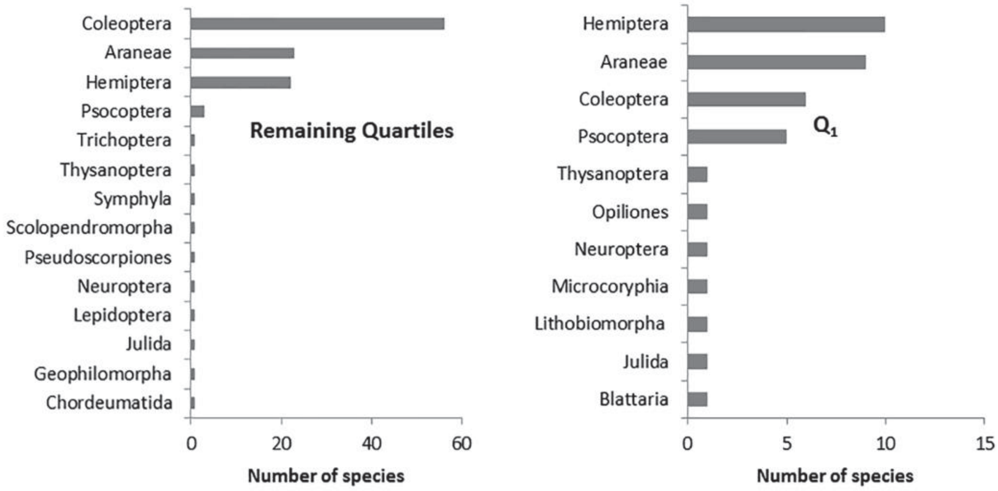

Fig. 3. Number of species for each order at first quartile (see also Table 1) and in the remaining quartiles.

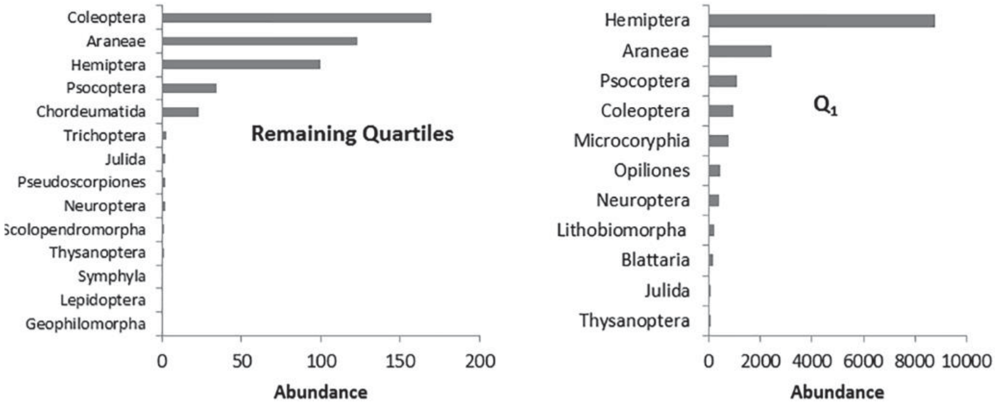

Fig. 4. Number of individuals for each order at first quartile (see also Table 1) and in the remaining quartiles.

(Fig. 3), with ten, nine, six and five species, respectively. The most diverse order in the remaining quartiles was Coleoptera with 56 species whereas the same order was ranked as third in the first quartile (Fig.3).

The most abundant orders at the first quartile (Table 1 and Fig. 4) were Hemiptera and Araneae with 57% and 16% of the total specimens captured, respectively (Fig. 4). However, according to figure 4, the dominant order in the remaining quartiles is Coleoptera with about 36% of relative abundance followed by the Araneae with 26% of the specimens.

Herbivores and predators were the most diverse an abundant feeding groups in the first quartile of species abundances (Fig. 5). Saprophages were not particularly diverse, but were almost as abundant as predators. Only 33 of the sampled specimens, representing 0.3% of the total abundance, were fungivores.

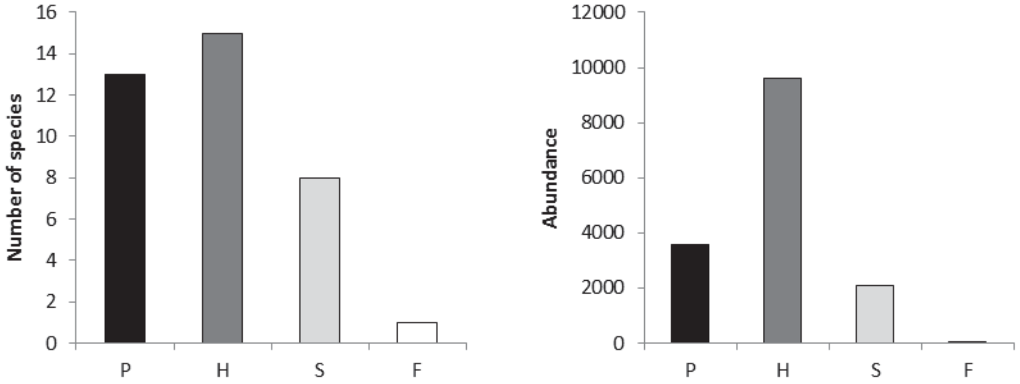

Fig. 5. Number of species and sampled individuals per different feeding groups at first quartile of species abundances (see Table 1). P – predators; H – herbivores; S – saprophages; F – fungivores.

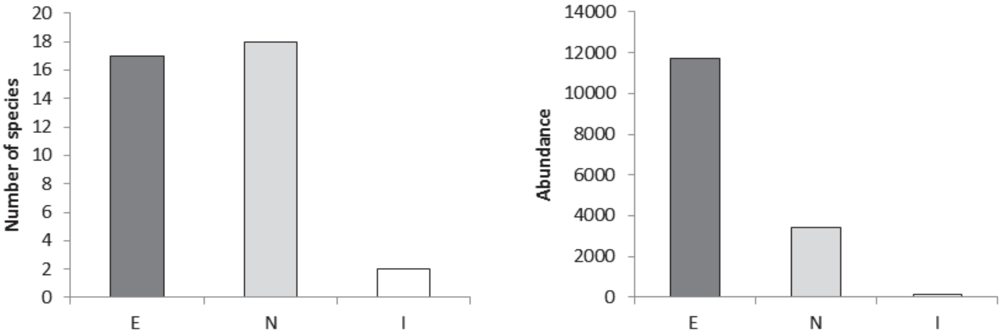

Fig. 6. Number of species and of sampled individuals per colonization status at first quartile of species abundances (Table 1). E- endemic, N – native, I - introduced.

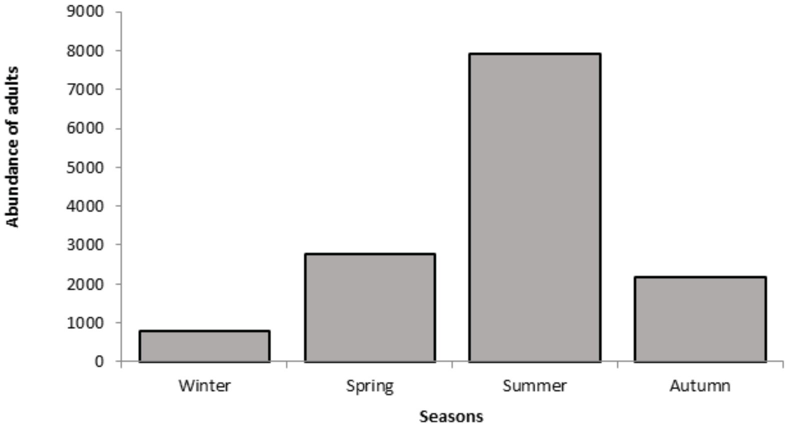

Fig. 7. Abundance of adults on each season between 2012 and 2016 in all study sites.

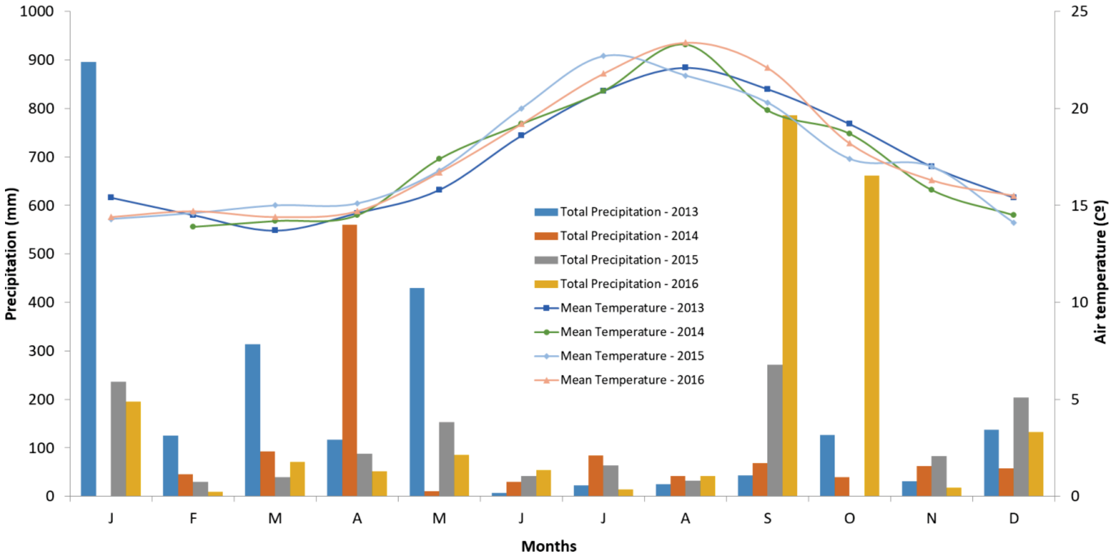

Fig. 8. Precipitation and mean air temperature during 2013–2016 measured at the Lages Azores weather station (station code: 08509) (Value 2016).

Concerning the colonization status (Fig. 6), endemics and natives non-endemic are represented by a similar number of species. However, 77% of the sampled specimens were endemic, while only 22% were native non-endemic.

Performing a seasonal abundance analysis at island level (Fig. 7) the number of specimens sampled from winter to spring tripled and the same pattern happened from spring to the end of the summer, with a peak in this season. This increase in general abundance seems to be correlated with air temperature variation (Fig. 8).

Case study of Terra-Brava (Site T18)

In Terra-Brava T18 site, 894 specimens belonging to 33 species were sampled over a period of two years (2014-2015). The most dominant species at the first quartile (Table 2) was also *C. azoterceirae* (see also Table 1) whereas the less dominant at first quartile was *Anaspis proteus* (Wollaston).

Despite the most abundant species being *C. azoterceirae*, there were species with much less abundance, but with also high percentage of incidence (at least one specimen sampled in a given month) in the samples (Fig. 9). For instance, only fifteen adult specimens of the spider *Savigniorrhipis acoreensis* (Wunderlich) were captured, but this species was found in about 38% of samples.

Concerning the abundance of juveniles in samples (Fig. 10), the most abundant species was the spider *Rugathodes acoreensis* (Wunderlich) with 158 specimens and around 92% of presence in the 24 studied months. In the first quartile there were three species during these two years of monthly sampling that were never detected as juveniles. These were *C. azoterceirae*, Gen. sp. (Hemiptera) and *Trioza laurisilvae* Hodkinson.

The most species rich orders in samples at the first quartile (Table 2) were Hemiptera (four species) and Araneae (three species) accounting for 58% of the species (Fig. 11).

The Araneae at first quartile was ranked second both in number of species and in abundance (Fig. 11 e 12). Moreover, the Araneae was ranked first with higher abundance of sampled specimens over Coleoptera in the remaining quartiles (Fig. 12).

Concerning the distribution of species according to each trophic level, herbivores and predators shared the same number of species (5) (Fig. 13). Despite having the same diversity as predators, herbivores were the dominant functional group with a relative abundance of about 66% whereas predators and saprophages had only about 18% and 16%, respectively (Fig. 13).

Concerning the colonization status, there were no records of introduced species at the first quartile (Fig. 14). The abundance of endemic species was around 92% against only 8% of native non-endemic species.

The monthly patterns of abundance in Terra-Brava T18 showed that, most species follow the same seasonal trends as in the pool data from the remaining sites, presenting their abundance peak in summer (Fig. 15). However, for three species their seasonal abundance in Terra-Brava T18 seem to be desynchronized from the remaining

Table 2. List of species in first quartile according to total adult abundance at Terra-Brava (T18) site between 2014-2015. Colonization status (E- endemic, N – native, I – introduced). Trophic groups (P – predators; H – herbivores; S – saprophages; F – fungivores).

Class	Order	Family	Species	Coloniz.	Trophic	Abundance
Insecta	**Hemiptera**	Cixiidae	*Cixius azoterceirae* Remane & Asche	E	H	305
Insecta	**Hemiptera**	Aleyrodidae	Gen. sp.	E	H	101
Insecta	**Hemiptera**	Miridae	*Pinalitus oromii* J. Ribes	E	H	94
Insecta	**Microcoryphia**	Machilidae	*Trigoniophthalmus borgesi* Mendes et al.	E	S	82
Arachnida	**Araneae**	Linyphiidae	*Acorigone acoreensis* (Wunderlich)	E	P	51
Insecta	**Psocoptera**	Elipsocidae	*Elipsocus brincki* Badonnel	E	S	48
Arachnida	**Araneae**	Theridiidae	*Rugathodes acoreensis* Wunderlich	E	P	46
Insecta	**Hemiptera**	Triozidae	*Trioza* (*Lauritrioza*) *laurisilvae* Hodkinson	N	H	32
Arachnida	**Opiliones**	Phalangiidae	*Leiobunum blackwalli* Meade	N	P	24
Arachnida	**Araneae**	Linyphiidae	*Savigniorrhipis acoreensis* Wunderlich	E	P	15
Insecta	**Neuroptera**	Hemerobiidae	*Hemerobius azoricus* Tjeder	E	P	14
Insecta	**Coleoptera**	Scraptiidae	*Anaspis proteus* (Wollaston)	N	H	12

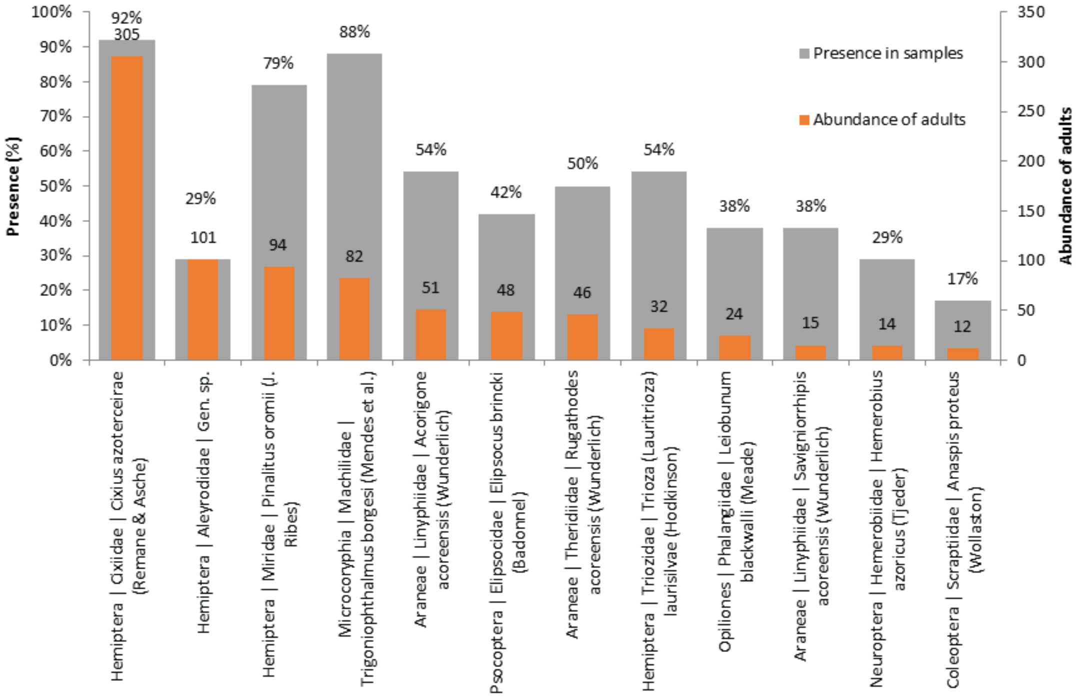

Fig. 9. Abundance (inside bars) and percentage of presence in samples (outside bars) of adults of each species in first quartile of species abundances at Terra-Brava (T18) site between 2014-2015 (see Table 2).

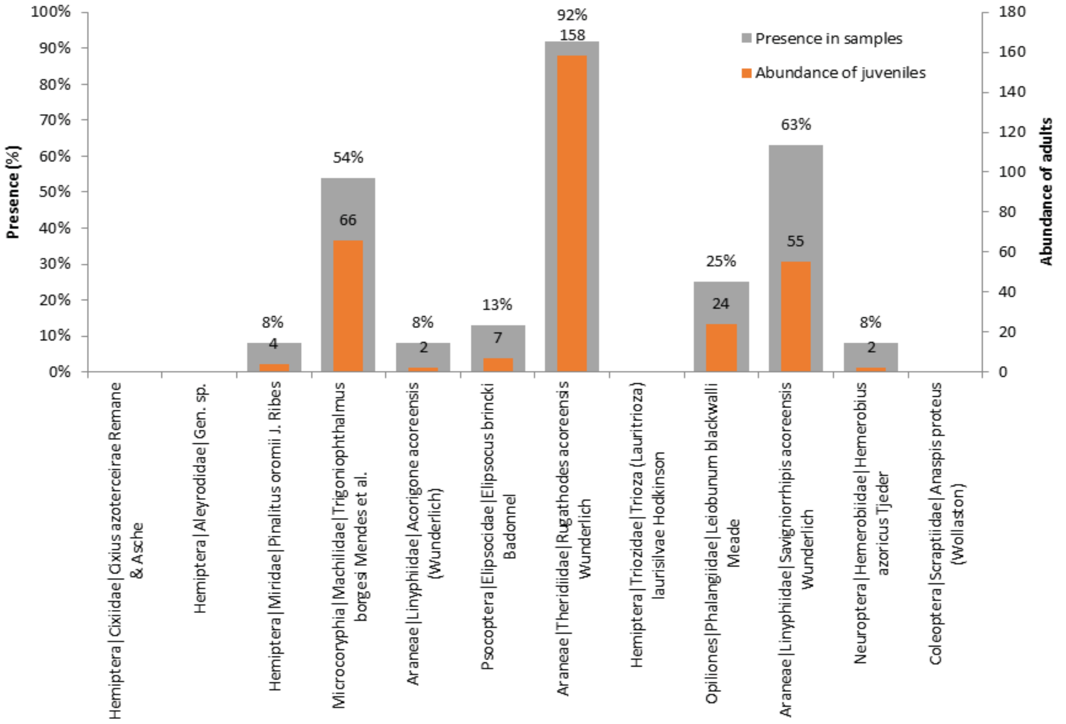

Fig. 10. Abundance (inside bars) and percentage of presence in samples (outside bars) of juveniles of each species in first quartile of species abundances at Terra-Brava (T18) site between 2014-2015.

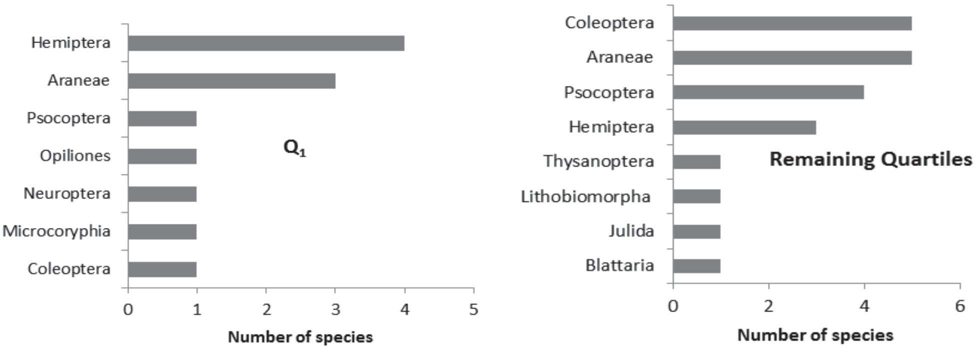

Fig. 11. Number of species for each order at first and at the remaining quartiles of species adult abundances at Terra-Brava (T18) site between 2014-2015 (see Table 2).

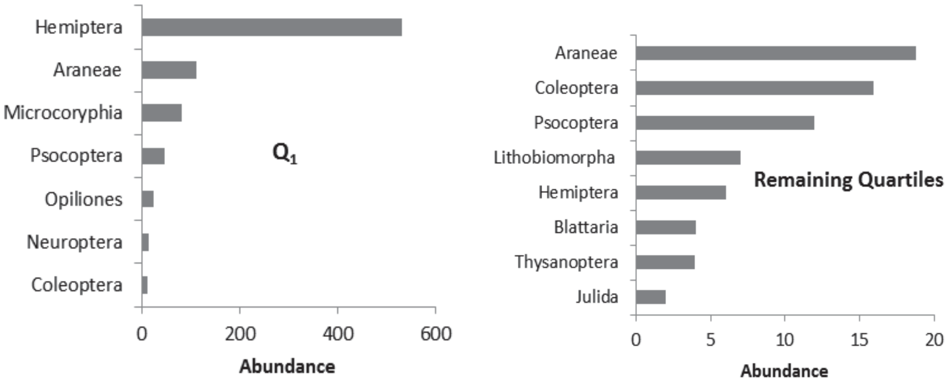

Fig. 12. Abundance charts according to each order at first and at the remaining quartiles of species abundances at Terra-Brava (T18) site between 2014-2015 (see Table 2).

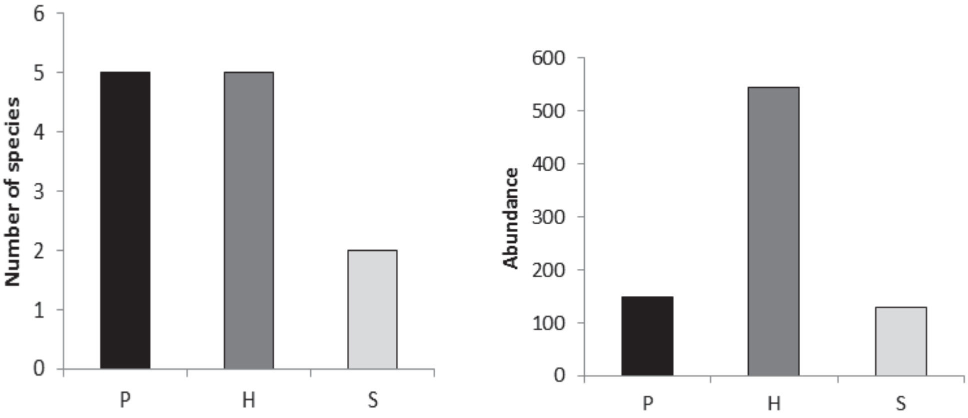

Fig. 13. Number of species and sampled individuals per different feeding groups at first quartile of species abundances at Terra-Brava (T18) site between 2014-2015 (see Table 2). P- predators; H – herbivores, S-saprophages.

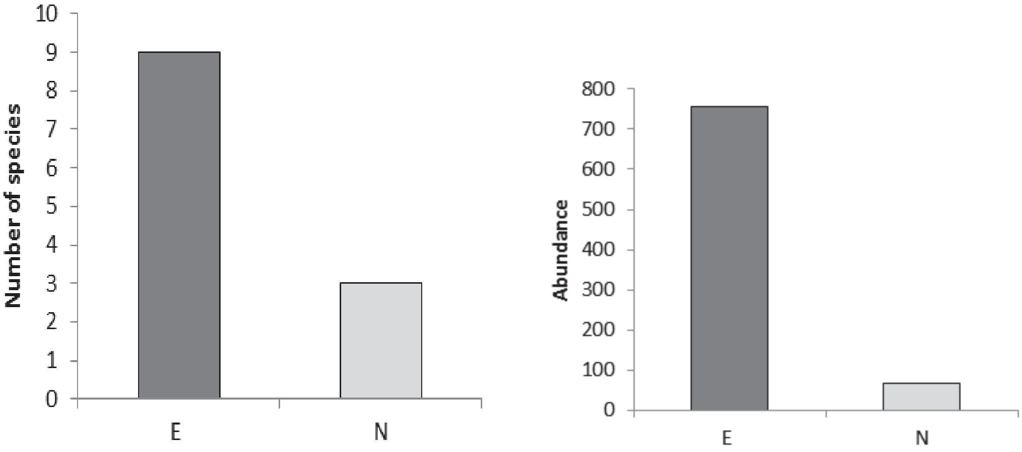

Fig. 14. Number of species and of sampled individuals per colonization status at the first quartile of species abundance at Terra-Brava (T18) site between 2014-2015 (Table 2). E- endemics; N – native non-endemic species.

sites at island scale: the Hemiptera *P. oromii*, the Microcoryphia *T. borgesi* and the Neuroptera *Hemerobius azoricus* (Tjeder) (Fig. 15). In addition to the previous species with undefined peak of abundance, two spiders, *R. acoreensis* and *S. acoreensis*, peak in abundance in the spring and autumn, respectively. The psocoptera *Elipsocus brinckii* Badonnel presents also a peak in spring.

DISCUSSION

SLAM traps are a sampling method that mainly targets flying insects. As stated above in the current study, we were not interested in the most dispersive airborne insect orders, i.e. Lepidoptera, Diptera and Hymenoptera. However, the orders Araneae, Hemiptera and Coleoptera also include species with high dispersal ability, which were investigated in detail. Species of those orders from Azorean native forest were used successfully to investigate the impact of dispersal ability (low vs high) on species abundance distributions (SADs) (see Borda-de-Água et al. 2017), which gives us confidence in the importance of SLAM traps to investigate community structure patterns.

According to studies already carried out on Azores, but using pitfall traping and direct canopy beating (Gaspar et al. 2008) or only canopy beating (Nunes et al. 2015), it has been reported a much higher relative abundance of spiders (Araneae) over other orders than in the present study (even with the addition of Lepidoptera in previous studies). However, spiders were still quite abundant in the SLAM traps as a consequence of the fact that many spider species use actively ballooning as a dispersal method, either as juveniles as well as in the adult stage. In fact, the second most abundant family of spiders is Linyphiidae, which have been reported of having the highest dispersal capabilities due to the mentioned strategy (Thomas et al. 2003; Borges and Wunderlich 2008; Cardoso et al. 2010; Blandenier et al. 2013). In Terra-Brava T18, as well as at island scale, the most dominant airborne species is the phytophagous tree lace-hopper *C. azoterceirae*. This species is also widespread and frequent, occurring in all sites and almost every sample. Concerning the feeding functional groups, even not considering Lepidoptera in our study, herbivores are slightly more diverse and abundant than predators and this is in accordance with previous studies that used data from tree canopies (Gaspar et al. 2008; Nunes et al. 2015).

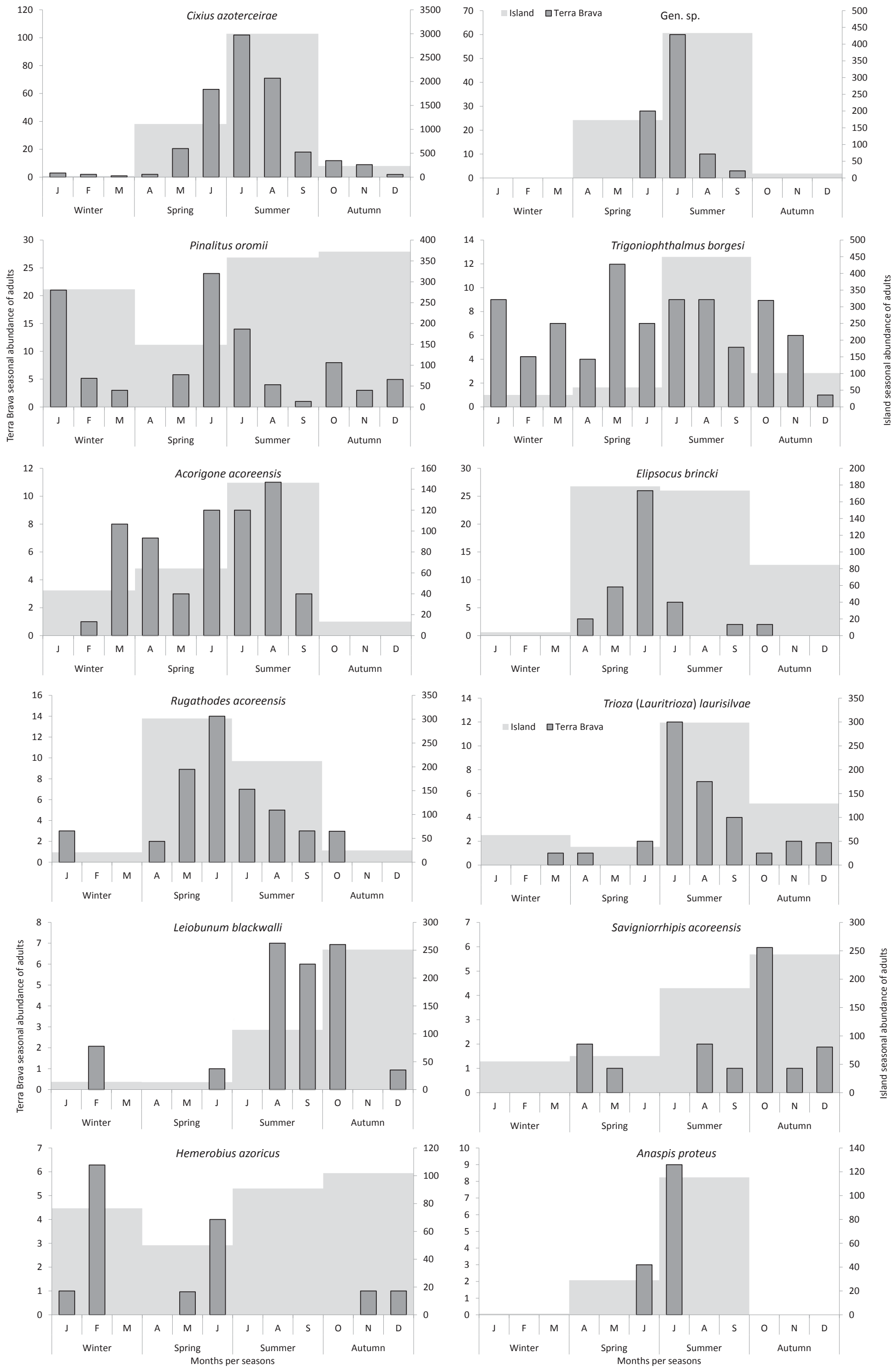

Fig. 15. Adult monthly abundance in Terra-Brava T18 and seasonal abundance in all the sites for the species in the first quartile in Terra-Brava T18 (see Table 2).

The high percentage of endemic specimens (77%) over any other type of colonization status is, from the conservation point of view, of great relevance especially when considering that the species richness of endemics and natives non-endemic are almost the same. This may be indicative of the good environmental and conservation conditions of the sampling areas, because the endemic species are being able to sustain much greater population abundance than native and introduced species. Introduced species account for only 1% of the overall abundance of first quartile most abundant species. Results from Gaspar et al. (2008) and Nunes et al. (2015) show even higher figures of introduced species. Also according to Borges et al. (2008) these introduced species as well as some native non-endemic species are more abundant in other habitats and behave as habitat-tourists in the native forest (see also Florencio et al. 2016). In Terra-Brava T18, the absence of introduced species in the first quartile is a really remarkable characteristic from the conservation point of view. In fact, this site is one of the most pristine locations in Azores (Gaspar et al. 2011).

However, the status of well-preserved conditions in Terceira native forest might be in danger due to the predicted impact of future climatic changes (Ferreira et al. 2016; Patiño et al. 2016). In addition, according to studies based on 30 years (1981-2010) average of meteorological data, Terra-Brava is characterized by the high levels of annual average air humidity (96% - 100%), high annual cumulative quantities of water from precipitation (2200 - 2600 mm) and by annual average air temperatures lesser than 14ºC (Azevedo 1996). Recent meteorological data collected shows that localities that used to have less than 1000 mm of annual precipitation (Azevedo 1996), are now reaching about 1700 mm (OGIMET 2016). Using the same analogy for the same places, but for annual mean of air temperature, it is possible to observe a drop of 1ºC. A 2013 report from the Institute for European Environmental Policy (IEEP) concludes that the European islands face very concrete risks as a result of a changing climate as a result of higher temperatures and changed rainfall regimes (Sauter et al. 2013). As a consequence these slight changes in climatic conditions may unbalance current ecological state by favouring the introduced species to disperse even more in future (Jaworski & Hilszczański 2013).

Comparing sampled species in Terra-Brava with their seasonal trend at island level, there are three species belonging to three different orders that seems to be desynchronized. This desynchronization can be a consequence to several specific local environmental factors. The seasonal evolution of the capsid bug *P. oromi* abundance at some point in summer starts to be desynchronized as the abundance decreases while at island scale it increases. This decrease can be due to high levels of local predation or even to resources depletion (Thomas et al. 1992; Didham & Springate 2003; Savopoulou-Soultani et al. 2012). Concerning the bristletail *T. borgesi* at Terra-Brava T18 it has similar densities throughout the year, whereas at the island regional scale the species peaks at summer. The explanation for this pattern is not easy to discern. On other hand, the brown lacewing *H. azoricus* seems to be rare at Terra-Brava than at regional scale.

In temperate climate zone conditions, the increase of average air temperature is followed by a more intensive and longer total diel activity, such as feeding and mating, as well as time spent on finding proper place for laying eggs (Jaworski & Hilszczański 2013). Moreover, the increase of temperature reduces the growth period from egg phase to pupa (Jaworski & Hilszczański 2013) and therefore an increase of abundance over time is expected. The general seasonal patterns of arthropod abundances at island level (i.e. regional scale) seems to be in concordance with other studies (e.g. MacLean Jr & Pitelka 1971; Cardoso et al. 2007; Sanford & Huntly 2010).

CONCLUSIONS

The SLAM trap device targets mainly airborne insects, and therefore within the investigated taxa a bias towards high dispersive flying species like Hemiptera was expected. Nevertheless the Araneae was the second most abundant order in samples most likely as a consequence of both the ballooning performed by some spider species as well as a consequence of their high densities in the several forest substrates around the traps.

Seasonal analysis showed that at regional scale there was a general increase of arthropod abundance starting in spring and ending at the end of summer, with some exceptions being found at local scale for some species. The low figures of airborne introduced species within the Natural Park was a fascinating result, showing that arthropod canopy communities are still pristine.

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