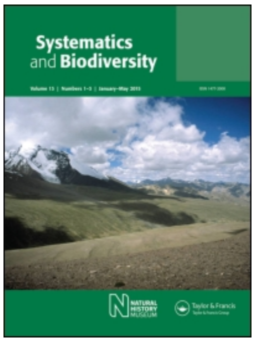

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Research Article

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Community assembly and inventory efficiency at a regional scale: the case of terrestrial Heteroptera (Insecta) in northern Patagonia, Argentina

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The first step to understanding the species present in a particular area is to perform inventory and assemblage studies. To obtain a species inventory, it is important to determine parameters such as species richness and relative abundance. This information can be useful for future studies and decision-making purposes in the conservation area. Despite the fundamental role of the terrestrial Heteroptera in ecosystems, they remain poorly known. We expected that the terrestrial Heteroptera species assemblage would be strongly associated with plant communities. Presently, 840 samples were collected in northern Argentine Patagonia during two years, 2013 and 2014. A total of 1950 adults of terrestrial Heteroptera belonging to 12 families, 32 species, and 8 morphospecies were found. Various statistical techniques were applied to correct the observed data for undersampling bias. These suggested that the lower boundary of the summer Heteroptera species richness in northern Patagonia was about 44–54 species. We concluded that the high regional habitat heterogeneity along the west-to-east and south-to-north gradients was paralleled by the turnover of Heteroptera. However, the Patagonian steppe shared a high number of species with the Monte and Subantarctic provinces. The suction sampling technique is an efficient technique to collect Heteroptera in environments with different plant structure and should thus be used in a complementary way with the sweeping technique.

Keywords: Argentina, assemblage, inventory, Patagonia, sampling technique, terrestrial Heteroptera

Introduction

One of the main objectives of ecology researchers is the measurement and assessment of biodiversity (Gotelli & Colwell, 2011). Understanding biodiversity patterns at local and regional scales is thus becoming increasingly important (Knop, 2016). The development and implementation of measures targeted at increasing the diversity of specialist species in their respective biogeographic regions could help to stop the worldwide decline of biodiversity (Knop, 2016). However, to do this, the first step is to know the richness and species composition of each biogeographic region.

Unlike other biodiversity parameters, species richness (i.e. the number of species in a certain region) is very difficult to estimate and the richness of observed species is highly sensitive to the sample size. Because most species in an assemblage are rare, biodiversity samples are usually incomplete, and some species are not detected (Chao et al., 2014).

The Heteroptera (true bugs) represent the largest and most diverse group of hemimetabolous insects (Schuh & Slater, 1995), with 42,000 species described worldwide (Henry, 2009) and 2,030 species recorded for Argentina (Coscarón, 2017). The importance of Heteroptera species in ecosystems makes them useful in conservation biology (Henry, 2009). Some are economically important, either negatively as vectors of *Trypanosoma cruzi* (Chagas), the aetiological agent of Chagas disease, one of the most important diseases in South America (Nattero et al., 2016), or economically positive as biological control agents, such as *Orius insidiosus* (Say) (Gholami & Sadeghi, 2016).

Patagonia is located in both Argentina and Chile, two South American countries that usually lack sufficient economic resources and researchers devoted to the analysis

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of biodiversity. Under these circumstances, it is essential to implement adequate protocols to objectively evaluate the efficiency and completeness of rapid diversity assessments.

Patagonia can be defined as a temperate or cool-temperate region, in which the Andes play a crucial role in determining the climate, generating a temperature gradient ranging from 14 to 6°C and a precipitation gradient ranging from 200 to 1500 mm from east to west (Paruelo, Beltran, Jobbagy, Sala, & Golluscio, 1998). Human activities such as deforestation, erosion, and domestic sewage disposal have impacted this region over the past few decades, mostly due to the increasing immigration from other parts of Argentina (Massaferro, Ribeiro Guevara, Rizzo, & Arribere, 2005). Biogeographically, northern Argentine Patagonia includes three phytogeographic provinces: the Monte (north-east), the Patagonian steppe (central) and the Subantarctic (north-west) provinces (Cabrera & Willink, 1980). Nine National Parks are located in northern Argentine Patagonia, whereas only four (Alerces, Nahuel Huapi, Lanín, and Lago Puelo National Parks) are located in the Subantarctic province (Administración de Parques Nacionales Argentina, 2017).

Since the north-west Argentine Patagonia is part of the Southern Volcanic Zone (Stern, 2004), numerous volcanic eruptions have also impacted this area during the last millennium. Consequently, numerous aquatic environments in the Nahuel Huapi National Park have been adversely affected by volcanic events (Massaferro et al., 2005).

The aim of this study was to improve the knowledge of the biodiversity of terrestrial Heteroptera in northern Argentine Patagonia. To this end, we used quantitative measures of inventory completion and statistical analyses to analyse our results and to elucidate the effects of inventory design parameters, with a view towards increasing the efficiency and effectiveness of biological inventory. Also, based on the association of Heteroptera species to plants and their response to floristic composition and vegetation structure, we expected that the alpha and beta diversities of true bug assemblages were different when studying different vegetation types. To assess this hypothesis, the alpha and beta diversities of the Heteroptera assemblages collected in the Monte, Patagonian steppe, and Subantarctic provinces, the three plant communities characterizing the north of Argentine Patagonia, were described and compared.

Materials and methods

Study areas

The study area is located in the north of Argentine Patagonia, between 38°57′S–43°53′S and 64°6′W–71°42′W (Table S1, see online supplemental material, which is available from the article's Taylor & Francis Online page at https://doi.org/10.1080/14772000.2018.1465485), (Fig. 1.1). For the construction of the map, we used the programme QUANTUM-GIS 2.8.2 (QGIS Development Team, 2016). This area is characterized by the three phytogeographic provinces mentioned above: the Monte, the Patagonian steppe, and the Subantarctic province (Cabrera & Willink, 1980).

The Monte province (Table S1, see supplemental material online; Fig. 1.2) is characterized by a shrub stratum reaching two metres in height, dominated by *Larrea divaricata* Cav. or *Larrea cuneifolia* Cav., accompanied by *Larrea nitida* Cav. and *Monttea aphylla* (Miers) Benth. & Hook. The herbaceous stratum is dominated by *Trichloris crinita* (Lag.) Parodi, *Pappophorum caespitosum* R.E. Fr., and *Aristida mendocina* Phil.

The Patagonian steppe province (Table S1, see supplemental material online; Fig. 1.3) is characterized by stunted shrubs and cushioned wood species. Amongst the species of scrub habit are: *Mulinum spinosum* (Cav.) Pers, *Nassauvia glomerulosa* (Lag. Ex Lindl.) D. Don, *Junellia tridens* (Lag.) Moldenke and *Lepidophyllum cupressiforme* (Lam.) Cass. There are also herbaceous steppes of *Stipa speciosa* Trin. & Rupr, *Poa ligularis* Nees ex Steud, *Festuca gracillima* Hook, and *Festuca pallescens* (St.-Yves) Parod (Cabrera & Willink, 1980; Reuter & Bertolami, 2010).

The Subantarctic province (Table S1, see supplemental material online; Fig. 1.4) is characterized by forests of *Nothofagus obliqua* (Mirb.) Oerst., *Nothofagus dombeyi* (Mirb.) Oerst., and *Nothofagus alessandri* Espinosa. There are also specimens of *Eucryphia cordifolia* Cav., *Persea lingue* (Ruiz & Pav.) Nees, *Laurelia sempervirens* (Ruiz & Pav.) Tul., *Peumus boldus* Molina, *Cryptocaria alba* (Molina) Looser, *Gevuina avellana* Molina, *Aextoxicum punctatum* Ruiz & Pav., and *Podocarpus nubigena* Lindl. Also, in the understorey, there are specimens of the genus *Chusquea* Kunth. Between 37°30′S and 40°10′S, the vegetation is characterized by *Araucaria araucana* (Molina) K. Koch forests associated with *Nothofagus pumilio* (Poepp. & Endl.) Krasser. Three National Parks were sampled in this phytogeographic province: Nahuel Huapi, Lanín and Los Alerces National Parks, which are characterized by presenting many endemisms (Morrone, 2015).

Collection sites and methodology

Seven sites in each phytogeographic province were sampled in to search for Heteroptera specimens. Ten samples per year and per technique were collected in the summer (2013 and 2014) by means of each of the following capture techniques:

Sweeping: This technique consisted in sampling the low vegetation with a 40-cm diameter sweep net. After a few

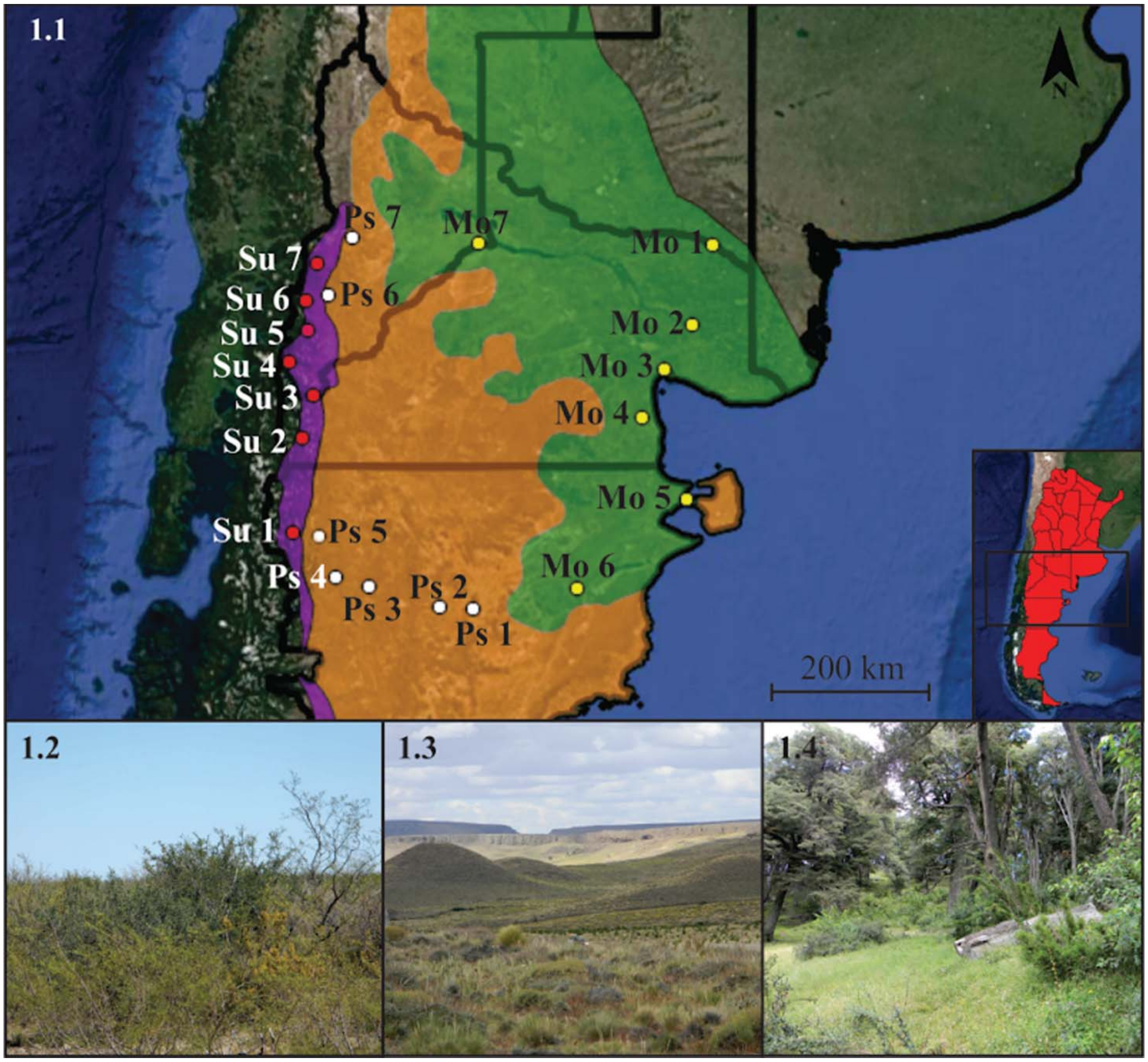

Fig. 1. Vegetation characteristics and sampling sites in each phytogeographic province studied **1.1 -1.4**. **1.1** position of the sampling sites: Mo, Monte sites; Ps, Patagonian steppe sites; Su, Subantarctic sites; green area, Monte; orange area, Patagonian steppe; violet area, Subantarctic. **1.2** Monte province. **1.3** Patagonian steppe. **1.4** Subantarctic province.

sweeps, the net was emptied to prevent damaging the specimens.

Suction (garden vacuum): This technique consisted in passing a garden vacuum over the vegetation to extract Heteroptera specimens. The garden vacuum has a tube length of 1.10 m and 0.12 m in diameter, divided in the middle by a mesh that collects arthropods. Each sampling with this technique was performed in an area of 25 m^2. Each sampling unit lasted for 1.5 minutes and a total of 840 sampling units were carried out (420 sampling units per technique).

Light trap: A mercury vapour light trap was used from 2–9 January in 2013 and from 4–10 February in 2014. Each sample consisted of all the Heteroptera trapped every half hour from 20:30 to 00:30 h.

Each sample was preserved in a vial containing 75% ethanol and labelled with the locality, date, collector, and capture method. The material was first separated and identified to family and genus levels in the laboratory and then identified to species level by using scientific literature specific for each family or genus (e.g. Acanthosomatidae: Carvajal & Faúndez, 2014; Faúndez & Osorio, 2010; Kumar, 1974. Coreidae: Allen, 1969; Brailovsky, 2014; O'Shea, 1980; Pall & Coscarón, 2013. Nabidae: Cornelis & Coscarón, 2013; Cornelis, Diez, & Coscarón, 2016; Harris, 1939. Rhopalidae: Chopra, 1967; Diez & Coscarón, 2015; Göllner-Scheiding, 1976, 1978, 1980). Also, the specimens were compared with collection material deposited at the Museo de La Plata, La Plata, Buenos Aires, Argentina (MLP). In uncertain cases, specialists were consulted. After we finish future morphological studies, voucher specimens will be deposited at the collection of the Museo de La Plata, Buenos Aires, Argentina (MLP).

Statistics

Non-parametric estimators (mostly the Chao) perform better than other estimators such as curve models or fitting species-abundance distributions (Walther & Moore, 2005). Thus, to evaluate the effectiveness of our approach with regard to attaining a thorough representation of the assemblage, we used EstimateS 9.1.0 (Colwell, 2013) to calculate random accumulation curves of observed species richness, singletons, doubletons, and several different estimators (Chao 1, Chao 2, first and second order Jackknife and Michaelis–Menten).

Inventory completeness, defined as observed species richness in relation to estimated richness, was calculated using the Chao 1 estimate, so that completeness values could be comparable with previous studies (Sørensen, Coddington, & Scharff, 2002). The Chao estimators are especially appropriate for such statistics because they perform well (Colwell & Coddington, 1994; Walther & Martin, 2001), especially when the coefficient of variation (CV) <0.65 (Rajakaruna, Drake, Chan, & Bailey, 2016). Since the value of Chao estimated CV for abundance distribution was >0.5, we re-computed Chao 1 by using the Classic instead of the Bias-Corrected option of the EstimateS program (Chao, 2004).

To evaluate and compare the different techniques employed in the three phytogeographic provinces, we performed a non-asymptotic analysis comparing the estimated and observed diversities based on the statistical estimation of Hill numbers of order $q = 0$, 1, and 2 with the R-project program (R Development Core Team, 2005) in the package iNEXT (Hsieh, Ma, & Chao, 2016) and graphics were made with the ggplot2 package.

Non-metric multidimensional scaling (NMDS) based on the Bray–Curtis similarity distances was used to compare the similarity of the true bug species composition in the three phytogeographic provinces by using the R statistical program (R Development Core Team, 2005) with Vegan packages (Oksanen et al., 2009). Stress <0.1 corresponds to a good ordination with no real risk of drawing false inferences, whereas Stress <0.2 can still lead to a usable picture (Clarke, 1993). The PAST 3.11 program (Hammer, Harper, & Ryan, 2001) was used to run an analysis of similarities (ANOSIM) with Bonferroni corrected *P* values to test for statistically significant differences between Heteroptera assemblages at the three phytogeographic provinces. ANOSIM returns R values that can vary from 0 (similar communities between groups) to 1 (large differences between communities) and *P* values that are the significance levels.

Species turnover between phytogeographic provinces was assessed through complementarity values (C_AB). The value of species complementarity varies from 0, when both sites are identical in species composition, to 1, when both sites are entirely different (Colwell & Coddington, 1994).

Results

A total of 840 samplings were conducted over two sampling years, capturing 2007 specimens, 1890 of which were identified to species level (Table S2, see supplemental material online), resulting in 32 species distributed in 12 families. Sixty of the total specimens captured were identified to genus level, differentiated in eight morphospecies and 57 immature-stage specimens could not be identified due to their unknown morphology and biology. Both the Monte and the Patagonian steppe provinces presented low abundance and richness ($S = 20$, $N = 340$ and $S = 20$, $N = 1257$ respectively). The Subantarctic province showed intermediate abundance and lower richness than the other two phytogeographic provinces ($S = 17$, $N = 353$). In addition, the distributional range of a high proportion of the species captured was extended with these records (see details in Discussion).

Although *Nisyus simulans* (Stål) (1127 individuals) greatly exceeded the abundance of all other species, it accounted for more than 50% of the total inventory. However, this species was not dominant in the three phytogeographic provinces, since in the Subantarctic province, the dominant species was *Nabis punctipennis* Blanchard, represented by less than 9% of the total inventory. The Heteroptera families with the highest richness were Miridae ($S = 10$) and Rhopalidae ($S = 7$), whereas the most abundant family was Orsillidae ($N = 1187$).

The performance of the non-parametric estimator of species richness found that the inventory reached 93.2% of the value estimated by Chao 1. Despite our effort, the nonparametric species richness estimators suggested that a few species of Heteroptera were not collected (between 3 and 14 estimated species) in northern Patagonia in summer (Fig. 2).

The mean inventory completeness by the suction sampling technique was 79.7%, whereas by the sweeping technique it was 82.4%. In 2013–2014, a total of 29 species were recorded with the suction technique and 32 species were recorded with the sweeping technique, obtaining an inventory completeness of 80% and 86.1% respectively. The suction technique was less complete than the sweeping method, despite the equal sampling time effort. The sweeping technique allowed for the capturing of greater richness in the three phytogeographic provinces (Table 1; Fig. 3). Overall, sample intensity (specimens: species) was 28.5 by the suction technique and 34.9 by the sweeping technique. The sample intensity per phytogeographic province and per technique showed that, unlike that of the Patagonian steppe, the sample intensity of the Monte and Subantarctic provinces with the sweeping technique was higher than that with the suction technique (Table 2).

The completeness values in the three phytogeographic provinces sampled were equal to or higher than 70% with both sampling techniques together (Table 1).

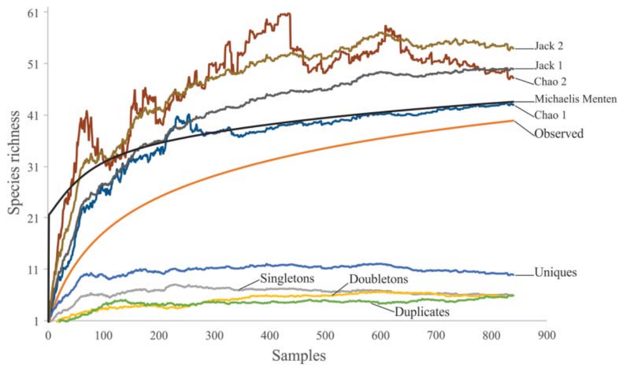

Fig. 2. Performance of the richness estimators in relation to the observed species of Heteroptera recorded in North Patagonia, Argentina, during 2013–2014.

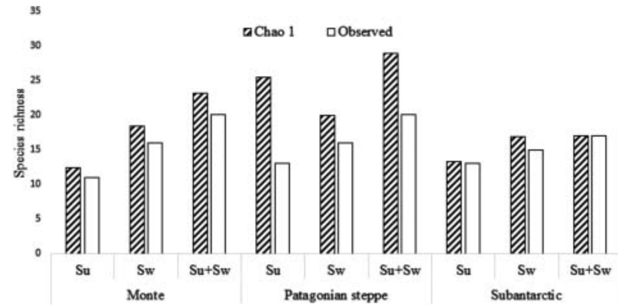

Fig. 3. Inventory completion by each sampling technique used in each phytogeographic province studied. Su, Suction sampling technique; Sw, Sweeping sampling technique. Su+Sw, Sum of the suction and sweeping sampling techniques.

The light trap technique allowed the capture of only 10 specimens of *N. simulans* in the Patagonian steppe, and one of *Nezara viridula* (Linnaeus) and one of *Lygaeus alboornatus* Blanchard in the Monte province, distributed in 48 samples. Thus, we did not consider the light trap technique in the analyses of completeness and rarefaction.

When we extrapolated the results with the double 'number of sampling units' used in the field by each technique, we found that, in all cases, the sweeping technique allowed capture of more species than the suction technique in the three provinces, although there was almost complete overlap between the two confidence intervals (Fig. 4). Moreover, the extrapolation showed that richness values will be higher if only the sweeping technique is

Table 1. Richness estimators and completeness for each technique, phytogeographic province and year.

		2013			2014			2013+2014		
		Su	Sw	Su+Sw	Su	Sw	Su+Sw	Su	Sw	Su+Sw
Monte	Chao1	11.3	13.4	15.7	6.4	9.4	10.4	12.4	18.4	23.1
	% inventory completeness	61.9	89.5	95.5	93.7	85.1	86.5	88.7	86.9	86.5
	Singletons	3	3	3	1	3	3	3	5	5
	Unique	5	4	5	1	4	4	4	7	8
	Doubletons	1	3	3	1	3	1	1	5	4
	Duplicate	1	4	3	1	2	_	1	5	3
Patagonian steppe	Chao1	13.9	11.4	16.3	7.48	10.2	12.6	25.4	19.9	28.9
	% inventory completeness	57.5	87.7	79.7	93.5	98	95.2	51.1	80.4	69.2
	singletons	4	3	5	1	1	2	5	4	6
	Unique	4	4	6	1	3	4	5	5	7
	Doubletons	_	3	2	1	3	3	1	2	2
	Duplicate	2	3	2	2	3	2	2	3	3
Subantarctic	Chao1	4	9.9	12.2	10.9	9.3	13.6	13.3	16.9	17
	% inventory completeness	100	90.9	81.9	91.7	96.7	95.5	97.7	88.7	100
	Singletons	_	3	3	2	2	2	2	4	1
	Unique	2	4	5	3	2	3	5	5	2
	Doubletons	2	2	2		2	3	2	4	2
	Duplicate	_	2	1	1	2	4	1	4	5
Total	Chao1	20.1	30.1	36.9	19.3	20.1	25.1	35.9	38.3	42.9
	% inventory completeness	79.6	79.7	78.5	98.4	99.5	99.6	80	86.1	93.2
	Singletons	5	7	8	2	2	2	7	8	6
	Unique	8	9	12	2	5	4	8	11	10
	Doubletons	3	4	4	2	6	4	2	6	6
	Duplicate	3	5	3	4	4	6	4	6	6

Table 2. Sample intensity for each technique and phytogeographic province.

	Su	Sw	Su+Sw
Monte	9.4	15.2	17
Patagonian steppe	47.2	40.1	62.8
Subantarctic	8.3	15.5	20.7

used. As proven by rarefaction curves and extremely high sample coverage, the sampling of Heteroptera communities was almost complete (Fig. 5).

We used each fixed value of q (q = 1 and 2), with 95% confidence intervals (parentheses) at the reference sample size (number of individual specimens) and graphically extrapolated up to double the reference sample size (Fig. 4). The Monte and Subantarctic provinces had high values of diversity for q = 1 and q = 2 of Hill numbers compared with the Patagonian steppe, with the suction technique, whereas the Patagonian steppe had higher values of diversity for q = 1 and q = 2 than the Monte and Subantarctic provinces with the sweeping technique (Fig. 4).

The species compositions of the assemblages recorded in the Monte and Subantarctic provinces were highly significantly different for both phytogeographic provinces, based on the R and *P* values (Table 3; Fig. 6). Although the three phytogeographic provinces can be significantly differentiated according to their species composition, these analyses revealed that there were also fewer differences between the Heteroptera assemblage from the Patagonian steppe and the assemblage from the Monte and Subantarctic provinces (Table 3; Fig. 6). The stress value obtained in the present study (Fig. 6) indicates a reliable result.

The species complementarity (turnover) between phytogeographic provinces was highest between the Monte and Subantarctic provinces, with a value of 0.94. The lowest complementarity was between both the Monte or Subantarctic provinces and the Patagonian steppe, with values of 0.78 and 0.67 respectively (Fig. 7).

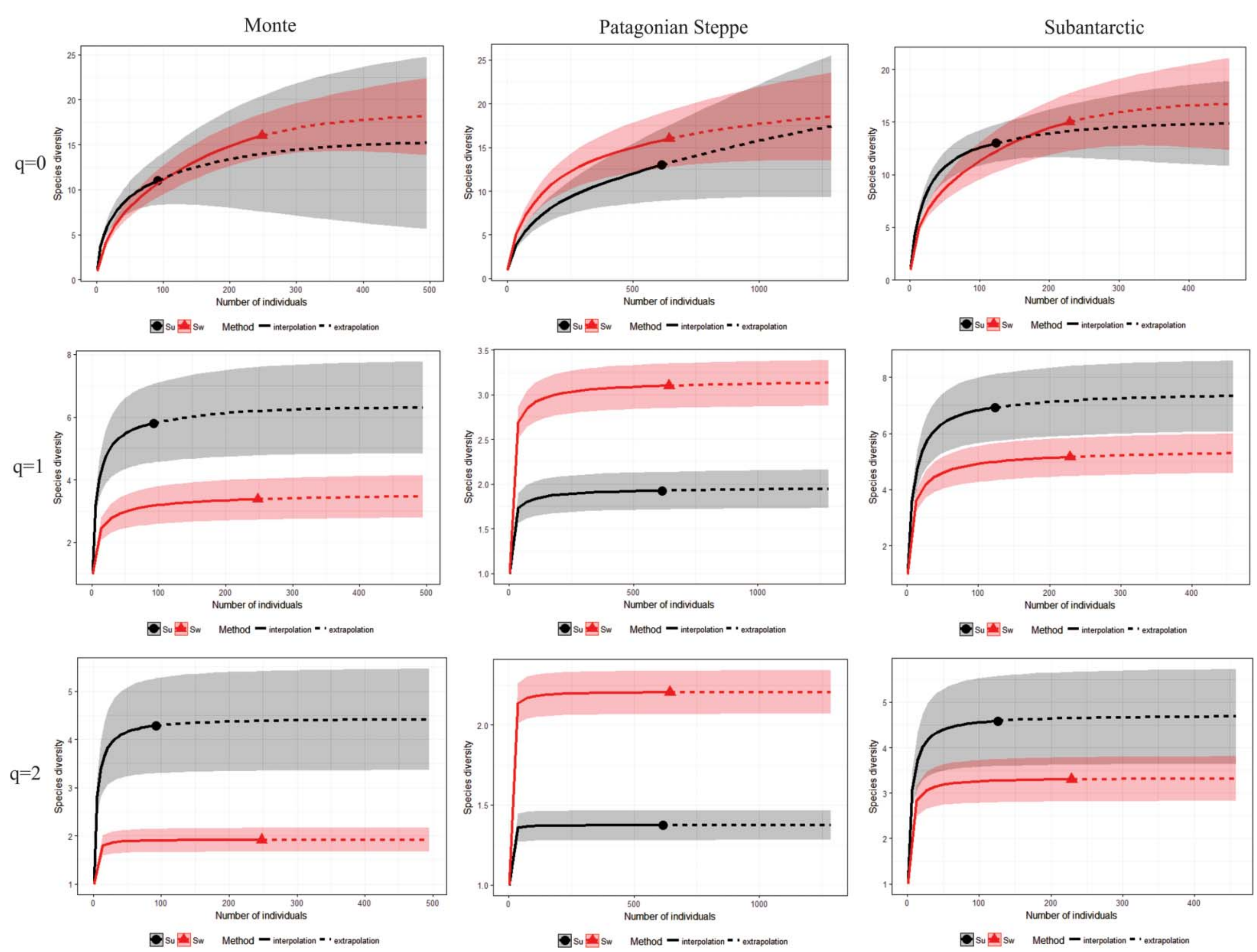

Fig. 4. Plot of species richness for rarefied samples (solid line) and extrapolated samples (dashed line) as a function of sample size for the Heteroptera samples collected by the sweeping and suction techniques in each phytogeographic province studied.

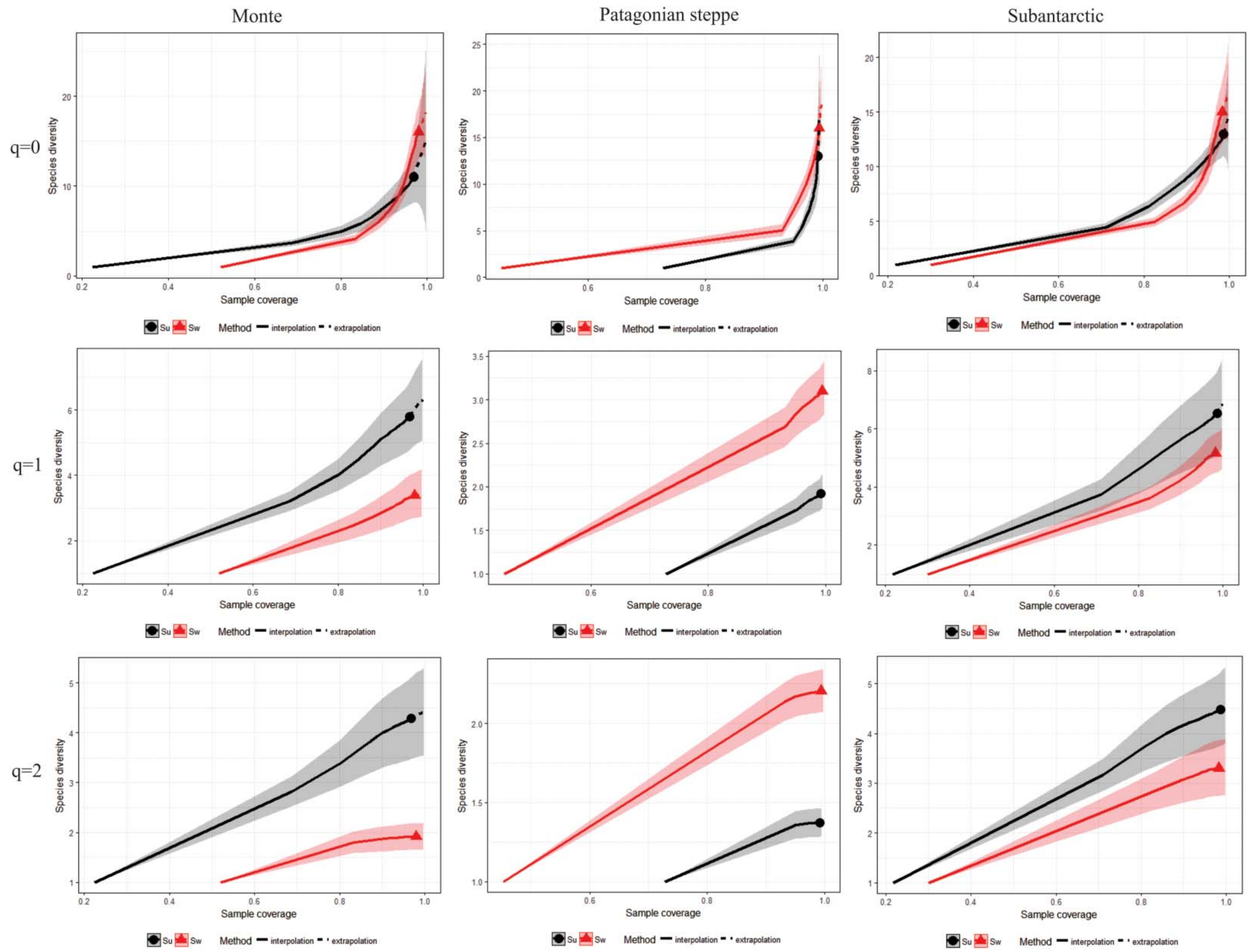

Fig. 5. Plot of sample coverage for rarefied samples (solid line) and extrapolated samples (dashed line) as a function of sample size for the Heteroptera samples collected by the sweeping and suction techniques in each phytogeographic province studied.

Discussion

The present study provides useful information to evaluate the efficiency of different strategies, i.e. how to apportion the sampling effort amongst habitat types by using the sweeping and suction sampling techniques, to capture Heteroptera species in rapid diversity assessments within northern Patagonia. This may be of primary importance in regions in which the Heteroptera fauna is poorly known, such as the one mentioned earlier (northern Patagonia). This is the first inventory of terrestrial Heteroptera from Patagonia. Cheli et al. (2010) studied the ground-dwelling arthropod community of Península Valdés in Patagonia using the pit-fall trap technique, but found that Heteroptera showed low abundance and identified only 23 specimens at species level and 85 at morphospecies level. Our results agreed with the idea that the abundance of Heteroptera in Patagonia is low.

Table 3. ANOSIM between phytogeographic provinces. Upper half *P*-values, lower half R values.

	Monte	Patagonian steppe	Subantarctic
Monte		0.3217	0.8105
Patagonian steppe	0.0039		0.38
Subantarctic	0.0007	0.0006	

In tropical rain forests of Sulawesi, Indonesia, Hodkinson and Casson (1991) found 465 species of terrestrial Heteroptera, whereas in Carlos Pellegrini, a system with subtropical and temperate regions, Coscarón, Melo, Coddington, and Corronca (2009) captured 225 species and estimated about 250–300 species. Dellapé, Colpo, Melo, Montemayor, and Dellapé (2017) collected 1,027 specimens which belonged to 73 species, a partial result due to the fact that these authors had previously published 17 families (Dellapé, Melo, Montemayor, Dellapé, & Brailovsky, 2015). This number of specimens was low, but with a very high richness. This suggests the need for unifying the collection methodologies to be able to make a comparison between different habitats and regions. The

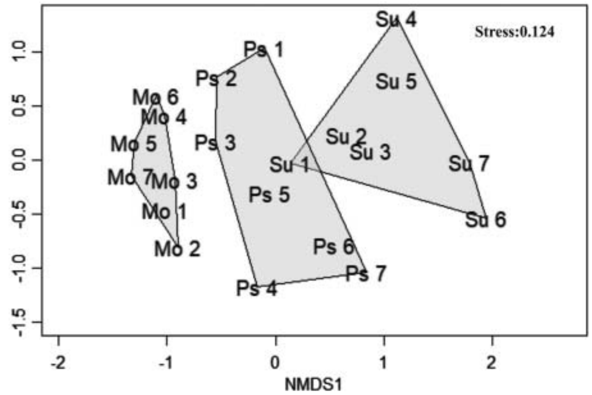

Fig. 6. Non-metric multidimensional scaling (NMDS) ordination of sites according to the composition and abundance of Heteroptera assemblages recorded in North Patagonia, Argentina. Mo, Monte province; Ps, Patagonian steppe; Su, Subantarctic province.

difference in the number of species recorded in the present study (32 species and 8 morphospecies), and thus the probability that many microclimates were not sampled, are probably due to the large area studied. The seasonal variation in species composition was not evaluated. In addition, in some species, adults are limited to only one season (Coscarón et al., 2009) and probably they were present as eggs or hidden in places that were inaccessible to the collecting methods we used. Thus, more studies are needed to elucidate all Heteroptera species present in Argentine Patagonia.

Most of the species captured, such as *Leptoglossus impictus* (Stål) (Diez, Ruiz Espindola, Cornelis, & Coscarón, 2016), *Xenogenus picturatum* (Berg), *Xenogenus gracilis* (Reed) (Diez & Coscarón, 2015), and *N. simulans* (Pall, Kihn, Diez, & Coscarón, 2016), were new records for provinces of the north of Argentine Patagonia,

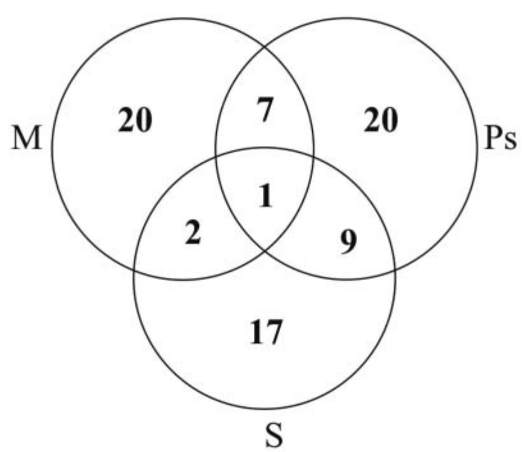

Fig. 7. Venn diagram of species overlap in the three phytogeographic provinces studied. M, Monte province; PS, Patagonian steppe; S, Subantarctic province.

whereas others such as *Nysius irroratus* (Spinola) (Pall et al., 2016) and *Nabis ashworthi* Faúndez & Carvajal (Cornelis et al., 2016) were new records in the country. The predators found in all environments were specimens that belong to the family Nabidae, the most abundant predators. However, this family has not been cited in the Monte phytogeographic province, but in the central region of Argentina (Pall & Coscarón, 2016). Some specimens need more distributional and morphological studies, because they are possibly new species and new records for Argentina. To avoid confusion, they will be published in a separate article. Amongst these species, some, such as *N. simulans*, *Athaumastus haematicus* (Stål), and *Piezodorus guildinii* (Westwood), have recognized economic importance as pest species of important crops (e.g., soybean and sunflower). Thus, this study also represents a new geographic distribution record for these species.

The sweeping technique used showed >80% inventory completeness (Coscarón et al., 2009; Firmino, Mendonça, Lima, & Grazia, 2017). Although differences in species richness captured by the sweeping and suction sampling techniques were not statistically significant and presented complete overlap of confidence intervals (Fig. 4), both techniques had a high completeness. This suggests that the suction technique is efficient to collect Heteroptera in environments with different plant structure. Moreover, both techniques captured specimens with large size such as *L. impictus* and smaller ones such as *O. insidiosus*. In contrast, the sweeping technique captured some species that the suction technique failed to capture and vice-versa. Therefore, to perform inventory and species composition studies in environments located at different ecoregions or phytogeographic provinces of northern Argentine Patagonia, we propose using the sweeping and suction collection techniques. Due to the high number of samples without Heteroptera specimens, we propose to double the time for each sampling.

The light trap is not recommended to be used in Patagonia due to the low capture of Heteroptera. This is probably because Heteroptera species have a low flying activity in temperatures lower than 19°C (Holloway, 1977; Southwood, 1960), a temperature not reached at night in this area. In addition, Miridae, Lygaeidae, and Pentatomidae were the most amenable to the light trap technique (Coscarón et al., 2009) and our results suggest that Orsillidae and Pentatomidae were the only families captured with this technique. With a standardized measure of species richness, i.e. one that considers inventory efficacy and completeness, it should be possible to compare species inventories from different places or different times. Then, this collection technique will be used for future studies of Heteroptera in Argentine Patagonia.

Argentine Patagonia presents an environmental gradient that influences the species composition. The Subantarctic and Patagonian Steppe transition in north-western

Patagonia is known to be a strong ecological barrier for ant species (Fergnani, Sackmann, & Ruggiero, 2013). In the present study, based on a sampling protocol with high completeness, we found that Heteroptera assemblages from the Subantarctic and the Monte provinces could be intrinsically related to the plant community in which they live. These assemblages are characterized by the large number of species exclusively found in each plant community. As shown by the ordination analysis, each true bug community was set apart and reflected the different plant species composition of each biotope considered. However, when we included Heteroptera assemblages from the Patagonian steppe with other comparisons, it was not easy to find differences due to the high number of species shared with the Monte and Subantarctic provinces. Possibly, the spatial variation in the species composition of Heteroptera assemblages in northern Patagonian is associated with the variation of other environmental variables at regional scales and not only with the plant community. Environmental filtering might underlie the structuring of species assemblages near their distributional limits (Fergnani, Ruggiero, Ceccarelli, Menu, & Rabinovich, 2013).

There exists evidence that different factors can affect the assemblage of insects in Patagonia at a small scale. Temperature, for example, is known to be a primary determinant of ant species composition in Subantarctic forests and the high Andean Steppes (Werenkraut, Fergnani, & Ruggiero, 2015). Thus, further studies are needed to understand the modulator, at large scale, of the species composition of insects and more specifically of Heteroptera in the Argentine Patagonia, which will allow further comparisons in beta-diversity studies. The north-west region of Patagonia provides an additional opportunity to examine the relative importance of climate and vegetation on ecosystem processes. This study represents a first step towards the knowledge on assemblage structure and diversity patterns of Heteroptera in Argentine Patagonia.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Supplemental data

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