COMPOSITION AND STRUCTURE OF HETEROPTERA COMMUNITIES (HEMIPTERA) IN HIGH ALTITUDE HABITATS OF A NATIONAL PROTECTED AREA IN ARGENTINA

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ABSTRACT: Composition and structure of Heteroptera communities (Insecta: Hemiptera) in high altitude habitats of a national protected area in Argentina. One of the basic strategies to protect biodiversity is the establishment of National Parks and other protected areas. Los Cardones National Park (Salta, Argentina) is of great importance because it attempts to preserve a representative sample of Andean biomes above 2700masl, such as Monte Occidental , the Puna-Prepuna and upper reaches of the Yungas. We describe the composition and structure of an inventory of true bugs sampled over a 1-year period in the three ecoregions represented in this protected area. Twenty-nine species of Heteroptera were recorded, including five new records for the Province of Salta. All species are first records to the park. The inventory obtained represents 85.29% of the total estimated by non-parametric estimator (Chao1), with Miridae as the best represented family. The results contribute to knowledge of the Heteroptera of the protected area and provide a basis for comparisons with other studies conducted in other high altitude habitats.

KEY WORDS: Biodiversity, true bugs, ecoregions, Northwest of Argentina, mountain environments, Miridae.

One of the basic strategies for protecting biodiversity is the establishment of National Parks and other protected areas (Cernea & Schmidt-Soltau, 2006). A National Park is a natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude activities inimical to the purpose of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of wich must be environmentally and culturally compatible (Glowka et al., 1994). In Argentina, there are 28 National Parks covering about 3 million of hectares, and protect almost the 4% of the national territory, that (APN, 2011).

Local or regional richness is one of the most important parameters for making decisions about which areas to prioritize for conservation (Torp Petersen & Meier, 2003). Therefore, to determine what areas should be preserved or protected, one should ideally have access to a complete list of species for each area. However this is impractical or even impossible, since species richness within a habitat is dependent on sample size (Ugland et al., 2003). Local richness can be estimated by extrapolating species accumulation curves, using non-parametric techniques based on the distribution of individuals among species or of species among samples (Colwell & Coddington, 1994). Martin-Lopez et al. (2011) suggest that the scientific effort should be expended on lower taxa (fungi, vegetation, and

invertebrates) and Red lists should assess the lesser known taxonomic groups (Butchart et al., 2007; Baillie et al., 2008).

It is not easy to identify at species level all collected specimens, for this purpose the use of the morphospecies concept may be used in some enviroenmental monitoring andconservation practice, in particular where decisions are guided by estimates of richness and the comparison of communities (Oliver & Beatti, 1996).

Biodiversity conservation is closely related to other global environment changes and globalization issues, such as climate change, land use and land cover change, and sustainable development (Vitousek, 1994; Thuiller et al., 2005; Gude et al., 2007). Although international organizations and countries have made significant efforts to conserve biodiversity, such as the "Convention on Biological Diversity", the "Census of Marine Life, and "DIVERSITAS" (Glowka et al., 1994, Cropper, 1993, Costello et al., 2010), these efforts have not been sufficient, and biodiversity loss has continued (Tisdell, 2003; Burns et al., 2009).

Heteroptera or "true bugs" are good indicators of insect diversity in general, for several reasons: 1) first because they are an ecologically diverse group, with including among them phytophagous, predacious and parasitic species (Dolling, 1991), may occur as flying and non-flying forms, can live in very diverse environments including water, and also some species are closely associated with humans, 2) some species are generalists while others are specialists, 3) both the immature and adult Heteroptera live in similar habitats and respond sensitively to environmental changes (Otto, 1996), 4) further studies have shown that the richness of true bugs is strongly correlated with insect diversity (Duelli & Obrist, 1998; Duelli et al., 1999; Di Giulio et al., 2001).

To date, no studies had been carried out on the heteroptera diversity, or arthropod diversity in general in Los Cardones National Park (Salta, Argentina). Therefore, a baseline study was undertaken in order to investigate the insect fauna in different habitats.This paper describes the composition and structure of the heteroptera true bugs community at Los Cardones National Park, and compares the species richness and temporal changes in different habitats of the three ecorregions represented in this protected area. We thus provide ecological data that will make possible to compare in future studies in other altitude habitats.

MATERIAL AND METHODS

Data Analysis:

Species list: the heteroptera true bugs were identified to family and species using available taxonomic keys. We generated a database of digital images of the collected species/morphospecies using the software Taxis ver.3.5 (Meyke, 1999) to facilitate the separation and to quantify the material. Identifications were confirmed by comparisons with the literature and with the database generated using the type specimens and other specimens deposited at the Museo de La Plata, Argentina. Locality information for the new records was provided by the senior authors observations (Coscarón, submited) wich was gathered from publications cited in Zoological Record, along with a vast bibliographic revision. Vouchers of the studied material are deposited in the Museo de La Plata (Argentina).

Study area: The Los Cardones National Park aims to preserve a representative sample of the Andean biomes, such as the Puna, and the Prepuna, in the more septentrional portion, the Monte Occidental. The park covers an area of 65.000ha

(Fig. 1), and is located at the departments of Cachi and San Carlos, in the Center-West of Salta Province. Plans for its creation began in 1986, but only ten years later was it declared a National Park. Heights from 2.700masl (at the bottom of the Tin-Tin Valley) to the Malacante Hill at 5.000masl located on the northwestern edge of the Cajoncillo ravine, are represented in this protected area. The climate is arid (dry and warm) with rainfall not exceeding 200mm per year, and the median temperatures in winter is 11ºC, and 18°C in summer. Three areas where chosen in the different ecoregions of Los Cardones National Park (Fig. 1) corresponding to the top floor of the Yungas (TFY) (Encantado Valley); the Prepuna-Puna (PP) (Recta de Tin-Tin), and the Monte Occidental (MW) (Cajoncillo ravine), were chosen to obtain the samples of the Heteroptera true bugs fauna of this protected area (Bertonatti & Corcuera, 2000; Chebez, 2005). The first ecoregion (TFY) is represented by different combinations of grasses, legumes and several species of mushrooms; the Prepuna-Puna is preponderant in the park, up to about 2200masl, where the churqui (*Prosopis ferox* Griseb) is dominant forming small forest in the lower areas, the tola (*Baccharis incarum* Wedd), the tolilla (*Fabiana densa* J. Rémy) and collumnar cactus [*Trichocereus atacamensis* (Phil.) Backed] are important in this ecoregion. The Monte Occidental (Cajoncillo ravine) is characterized by cactus, jarillas (*Larrea divaricata* Cav) and amancay (*Alstroemeria aurea* L.), and in the open desert areas grow the breas [*Cercidium praecox* (Ruiz & Pav.) Burkart & Carter] and retama (*Bulnesia retama* Gillies ex Hook & Arn) Griseb) (SIB, 2008) (Fig. 2).

Laboratory and field activities: Sampling were carried out in different seasons (May, September and December-2007, and March-2008). Three sampling sites separated by more than one kilometer where chosen in each ecoregion. At each geo-referenced sites (Table 1) 10 random samples were taken from the vegetation with a G-VAC (Garden-Vacuum); a sample consisted of the insects obtained durin the suction of the vegetation in an area of one square meter for one minute. Each collected sample was placed in polyethylene bags with 70% ethyl alcohol, properly labeled and treated as independent. In the laboratory, the material was cleaned, the true bugs were separated from the other arthropods, and prepared for study.

Species richness: We generated an species accumulation curve based on individuals using the EstimateS 7.0 software (Colwell, 2004). Non-parametric estimators of species richness was obtained to assess how complete was the obtained inventory. Ecologists and other biologists have long recognized that there are undiscovered species in almost every survey or species inventory (Chao et al., 2000). Our dataset was analyzed using SPADE (Chao & Shen, 2003) to obtain estimated shared-species richness and to generate a prediction of the number of species remaining to be discovered in the studied communities if we increased the number of individuals collected. This prediction provides an objective measure on which to assess the effectiveness of further surveys so that sampling efforts and funding can be allocated among sites for effective and timely management of biological communities.It can also be used to estimate the minimum effort needed to reach a certain level of completeness (Chao & Shen, 2004).

RESULTS

In this study, twenty nine species of true bugs were collected (Table 2) belonging to six families, of which Miridae represented the largest proportion of the total catch (51%), followed by Anthocoridae (24%), and Lygaeidae (19%) (Fig.

3). The first two families were represented in all the ecoregions sampled. Miridae was most abundant in summer (77%). However Anthocoridae (50%) in fall and Lygaeidae were more abundant in winter and spring (Fig. 4). Singletons represented 37.9% of the true bugs collected (Table 3). The species accumulation curve did not reach an asymptote (Fig. 5). Despite this, according to the non-parametric estimators the inventory obtained represented the 85.29% of the total estimates species by Chao1 (Fig. 6, Table 4). If we doubled the sampling effort the number of undiscovered species expected in the inventory would be 6±3.9 species (95% confidence interval: 0-13.7) in accordance with predictions made using the SPADE software. The top floor of the Yungas ecoregion was the most diverse studied area (Table 2).

The list below details the 12 species identified to date: new records are noted for the province of Salta.

FAMILY ANTHOCORIDAE

***Orius insidiosus* (Say, 1832)**

Known distribution in Argentina: Buenos Aires: Ascasubi, Balcarce, Cerro Cura Malal, La Plata, Mar del Plata, Pedro Luro, Pradere, Villarino; Catamarca; Chaco; Córdoba; Corrientes; Entre Ríos; Formosa; Jujuy; La Pampa; Mendoza: Guaymallén, Las Carreras, Las Heras, Luján, San Rafael; Misiones; Neuquén: San Martín de los Andes; San Juan; Río Negro; San Luis; Santa Fé; Santiago del Estero; Salta, and Tucumán.

New record: Argentina: Salta: Los Cardones National Park: Site 1TFY, 1 male, 12/03/2008, Cava & collab. Cols.; Site 2TFY, 3 males, 1 female, 07/05/2007, Cava & collab. Cols., 2 males, 1 female, 12/03/2008, Cava & collab. Cols.; Site 3TFY, 5 males, 2 females, 07/05/2007, Cava & collab. Cols.; Site 1MW, 1 female, 12/03/2008, Cava & collab. Cols.

FAMILY LYGAEIDAE

***Lygaeus alboornatus* Blanchard, 1852**

Known distribution in Argentina: Buenos Aires: Cerro Cura Malal; Corrientes: Capital Department, Lavalle Department, San Cosme; Chubut; Córdoba; Entre Ríos: Paraná; South Patagonia, and Tucumán.

New record: Argentina: Salta: Los Cardones National Park: Site 3TFW, 1 male, 07/05/2007, Cava & collab. Cols.

***Nysius simulans* Stål, 1859**

Known distribution in Argentina: Buenos Aires: Cerro Cura Malal; Corrientes: Bella Vista Department, Monte Caseros, Paso de los Libres; Entre Ríos: Colón, Paraná, Tala, Villaguay; Mendoza: Guaymallén, Las Heras, San Rafael, and Misiones: Cainguás Department, Eldorado, San Luis del Palmar.

New record: Argentina: Salta: Los Cardones National Park: Site 1TFY, 1 female, 12/03/2008, Cava & collab. Cols.; Site 3TFY, 2 males, 1 female, 07/05/2007, Cava & collab. Cols.; Site 1PP, 1 male, 12/03/2008, Cava & collab. Cols.

FAMILY MIRIDAE

***Chileria pamparum* (Berg, 1883)**

Known distribution in Argentina: Buenos Aires: Cerro Cura Malal, Chascomús, Chacabuco,; Catamarca: Arroyo El Pintado; Chaco: Pampa Del Infierno; Chubut: Parque Nacional Lago Puelo (Lago Puelo); Córdoba; Corrientes; Entre Ríos; La Rioja: Guandacol, 42 km SW of Villa Unión, Los Robles, San Blas, Santa Clara; Mendoza: Guandacol, 42 km SW of Villa Unión, Los Robles, San Blas, Santa Clara; Misiones: La Colina; Neuquén; Salta; San Luis; San Juan: El Huaco; Santa Cruz; Santiago del Estero: Beltrán, and Tucumán: Cadillal, 35 km SE of Quilmes.

New record: Argentina: Salta: Los Cardones National Park: Site 3PP, 3 males, 1 female, 12/03/2008, Cava & collab. Cols.

***Megaloceroea costicollis* (Berg, 1878)**

Known distribution in Argentina: Buenos Aires: Baradero; Córdoba; Entre Ríos; La Rioja,

and Misiones.
New record: Argentina: Salta: Los Cardones National Park: Site 1PFY, 1 male, 12/03/2008, Cava & collab. Cols.; Site 2PFW, 1 female, 12/03/2008, Cava & collab. Cols.

***Prepops catamarcanus* Carvalho, 1988**
Known distribution in Argentina: Catamarca: El Manchado; La Pampa, and Salta.
New record: Argentina: Salta: Los Cardones National Park: Site 1MW, 2 males, 12/03/2008, Cava & collab. Cols.

***Araucanocoris nigricallosus* Carvalho, 1983**
Known distribution in Argentina: Neuquén: Collón Curá.
New record: Argentina: Salta: Los Cardones National Park: Site 1MW, 3 males, 2 females, 12/03/2008, Cava & collab. Cols.

***Rhinacloa dimorphica* Carvalho & Carpintero, 1990**
Known distribution in Argentina: Jujuy.
New record: Argentina: Salta: Los Cardones National Park: Site 1MW, 3 males, 12/03/2008, Cava & collab. Cols.; Site 2MW, 1 male, 12/03/2008, Cava & collab. Cols.

***Stenodema fritzi* Carvalho & Carpintero, 1990**
Known distribution in Argentina: Jujuy; Salta, and Tucumán.
New record: Argentina: Salta: Los Cardones National Park: Site 2TFY, 1 female, 12/03/2008, Cava & collab. Cols.

***Orthotylus platensis* Carvalho & Fontes, 1973**
Known distribution in Argentina: Buenos Aires; Chaco, and Salta.
New record: Argentina: Salta: Los Cardones National Park: Site 2MW, 2 males, 12/03/2008, Cava & collab. Cols.

***Tytthus parviceps* (Reuter, 1890)**
Known distribution in Argentina: Buenos Aires; Córdoba; Entre Ríos; Misiones, and Salta.
New record: Argentina: Salta: Los Cardones National Park: Site 2PP, 2 males, 2 females, 12/03/2008, Cava & collab. Cols.

FAMILY RHOPALIDAE
***Harmostes procerus* Berg, 1878**
Known distribution in Argentina: Buenos Aires: Baradero, Chacabuco, Cerro Cura Malal; Chaco; Corrientes; Entre Ríos: Gualeguay Department; Formosa; Jujuy; La Pampa; Misiones; Salta; San Luis; Santa Cruz: Río Santa Cruz; Santa Fe; Santiago del Estero; Tierra del Fuego, and Tucumán.
New record: Argentina: Salta: Los Cardones National Park: Site 1PFY, 1 male, 12/03/2008, Cava & collab. Cols.; Site 1MW, 1 male, 12/03/2008, Cava & collab. Cols.

DISCUSSION

This study represent the first approach to understanding the Heteroptera diversity to the Los Cardones National Park. Prior to this no systematic studies and biodiversity estimation have been conducted on arthropods in this protected area. The few records of arthropods available in the Biodiversity Database of the National Parks Administration (SIB, 2008) for this protected area involve a few species of Coleoptera, Hymenoptera and Lepidoptera. Five species of true bugs (*A. nigricallosus, R. dimorphica, M. costicollis, L. alboornatus and N. simulans*) recorded in the Los Cardones National Park represent new records for the Province of Salta. This enlarges the known geographical distributional of these species.

Miridae was the most diverse (18 species). These results reinforce those obtained by Coscarón et al. (2009) in collections made in Carlos Pellegrini,

Corrientes (Argentina), which suggests that this family is a very good candidate as an indicator group of environmental quality in studies of long-term monitoring in natural and disturbed environments. The Miridae is one of the most diverse families within the Heteroptera (Coscarón & Carpintero, 1996; Wheeler, 2001). While in the Los Cardones National Park this family was dominant and diverse, we only reported a little over 11% of the total species recorded for the province of Salta (74 genera and 161 spp). Possibly, this can be explained, on the one hand because we only considered a single collecting method in this study. On the other hand it may be owing to the fact that the typical environments that dominate the national park really have a low diversity compared with more humid environments present in the rest of the provincial territory.

Our results indicate that the mirids were dominant in summer. This period is the rainy season for these altitude habitats of the park, when there is a greater abundance and diversity of vegetation that tends to be markedly reduced in other seasons. These findings are agree with Fauvel (1999) who proposed a positive correlation between the presence of Miridae and the plants. There is a positive correlation between the density of mirids and vegetation cover (Otto, 1996). In addition, our results show that fall is also a suitable period for collecting Heteroptera. Coscarón et al. (2009) in a study of other areas of our country found a similar result and suggest this is a good time of year to achieve greater representation of Heteroptera and obtained the most complete inventories.

Heteroptera occupy many different habitats, microhabitats and trophic niches, and therefore requires the use of several collecting techniques (Marrero et al., 2008). We could only use a single collecting method for the specimens on the vegetation, taking into account the accessibility to the sites and the vegetation type. Nevertheless the inventory obtained in this study achieved the 85,29% of the total species estimated by a non-parametric calculation (Chao1). If it had been possible to use more complementary methods like those proposed by Coscarón et al. (2009) (sweeping + beating + light trapping), probably the inventory, species richness and relative abundance of taxa, would have been higher. An increase in sampling effort might not have made a dramatic increase in the registration of undiscovered species in this inventory, according to the results obtained with the SPADE software. Therefore future studies in this national park should assess whether is better to increase the sampling effort or add other collecting methods.

In conclusion this inventory was a good first estimation of species richness and true bugs diversity in Los Cardones National Park, despite of the small number of individuals collected. This allows us a good approximation of the true bugs diversity in this protected area. The results the basis for future studies in similar ecoregions and deepen our understanding of the relationship between the Heteroptera diversity and the vegetation in these high altitude environments with extreme climate.

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Table 1. Coordinates and altitude (masl) of sampling sites of Los Cardones National Park, Salta (Argentina).

	TFY	MW	PP
Site 1	-25°11'51.9714''	-25°13'57''	-25° 8' 33.2154"
	-65°50'30.9834''	-65°57'10.476''	-65° 59' 44.916"
	3109masl	2968masl	2954masl
Site 2	-25°11'25.5474''	-25° 13' 57.3234"	-25° 10' 19.2"
	-65°50'33.0714''	-65° 56' 31.7394"	-65° 59' 7.0794"
	3145masl	2959masl	2959masl
Site 3	-25° 11' 26.1954"	-25°13'52.32''	-25° 11' 45.0954"
	-65° 50' 48.516"	-65°56'1.14''	-65° 58' 36.1554"
	3183masl	2953masl	2954masl

Table 2. Species/morphospecies of true bugs recorded at different ecoregions of Los Cardones National Park, Salta (Argenina).

	Ecoregion		
Species	TFY	MW	PP
Anthocoridae			
Orius sp.	1		7
Orius insidiosus	15	1	
Sp.1	2		
Lygaeidae			
Sp.1	1		
Sp.2	11	1	
Sp.3	1		
Lygaeus alboornatus	1		
Nysius simulans	4		1
Miridae			
Chilleria pamparum			4
Megaloceroea costicollis	2		
Sp.1	7		1
Sp.2		1	1
Sp.3		1	1
Sp.4			1
Prepops catamarcanus		2	
Auracanocoris nigricallosus		5	
Rhinacloa dimorphica		4	
Sp.5		1	
Sp.6			1
Stenodema fritzi	1		
Sp.7			1
Orthotylus platensis		2	
Sp.8	2		
Sp.9	1		
Sp.10			11
Tytthus parviceps			4
Nabidae			
Nabis sp.	1		
Rhopalidae			
Harmostes procerus	1	1	
Tingidae			
Sp.1			3
S Total	15	10	12

Table 3. Observed and estimated species richness of the Heteroptera families collected in Los Cardones National Park, Salta, Argentina.

Family	Anthocoridae	Lygaeidae	Miridae	Nabidae	Rhopalidae	Tingidae
Individuals (N)	26	20	54	1	2	3
Richness (S)	3	5	18	1	1	1
Singletons	0	3	6	1	0	0
Doubletons	1	0	6	0	1	0
Uniques	0	3	8	1	0	0
Duplicates	2	0	5	0	1	0
Chao1	3	8	21,14	1	1	1
Completion (%)	100	63	90	100	100	100

Table 4. Species richness observed and best species richness estimates from non-parametric estimators.

Observed species richness	
S_{obs}	29
Estimated species richness	
ACE	38,87
Chao1	34 ± 4,31
Chao2	36 ± 5,66

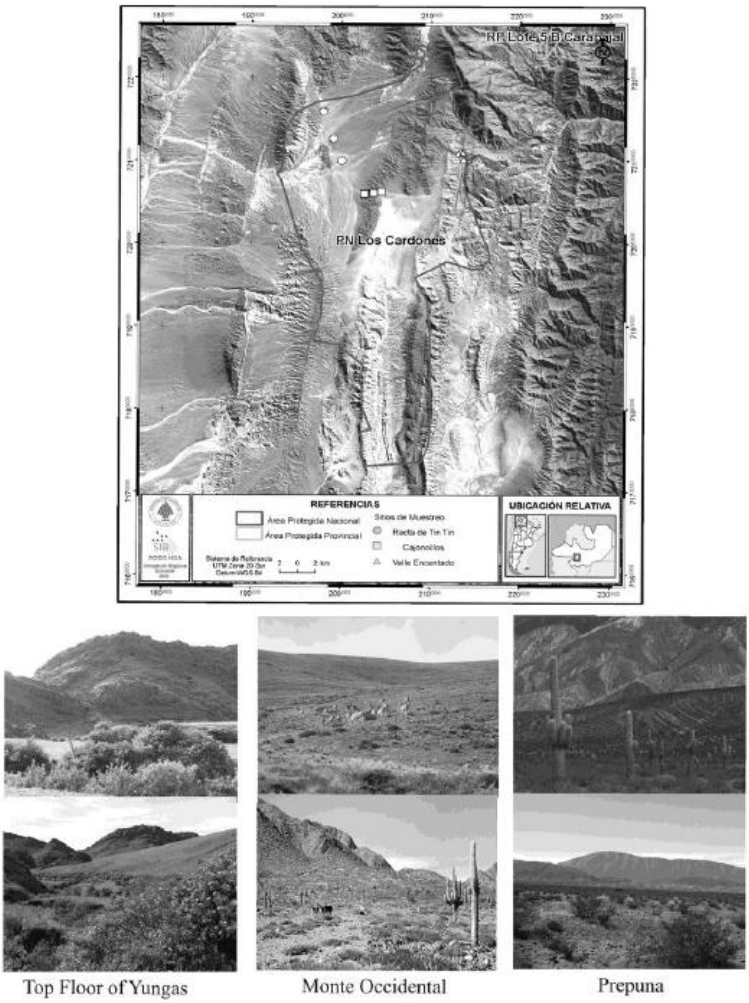
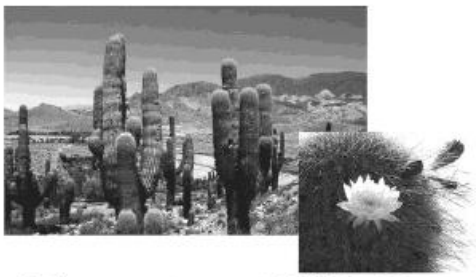


Figure 1. Locations of the collected sites in the Los Cardones National Park, Salta (Argentina).



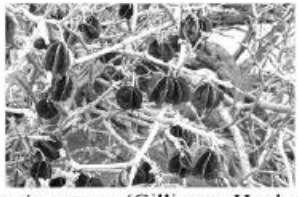
Trichocereus atacamensis (Phil.) Backeb

Alstroemenia aurea L.

Baccharis incarum Wedd

Cercidiun praecox (Ruiz & Pav.) Burkart & Carter

Larrea divaricata Cav.



Bulnesia retama (Gillies ex Hook & Arn) Griseb

Prosopis ferox Griseb

Figure 2. Main species plants dominant in different ecoregions of Los Cardones National Park, Salta (Argentina).

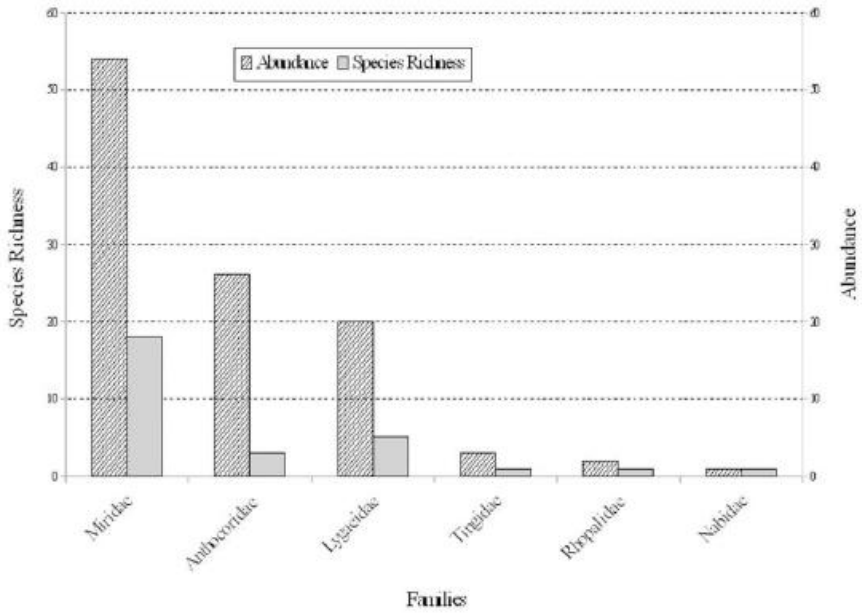


Figure 3. Richness and abundance of Heteroptera families present in Los Cardones National Park.

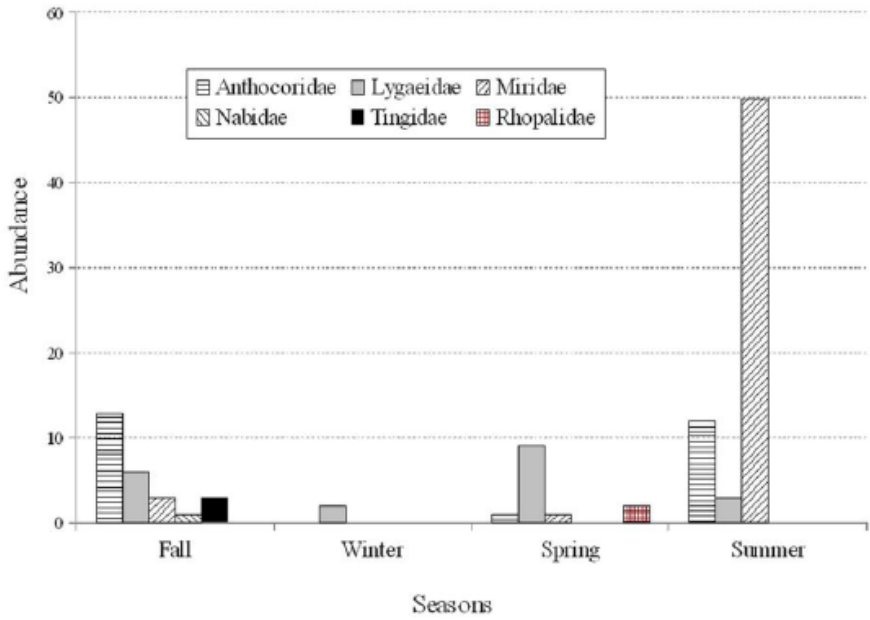


Figure 4. True bugs abundance by seasons.

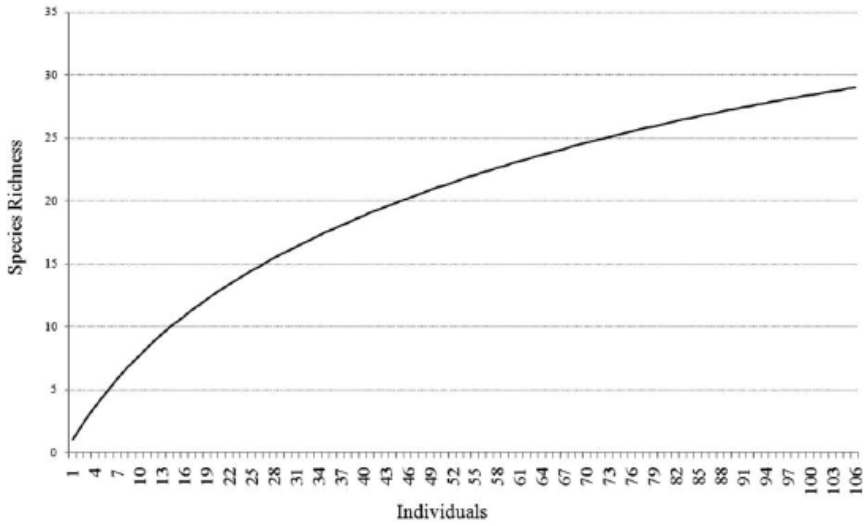


Figure 5. Species accumulation curve based on individuals at Los Cardones National Park.

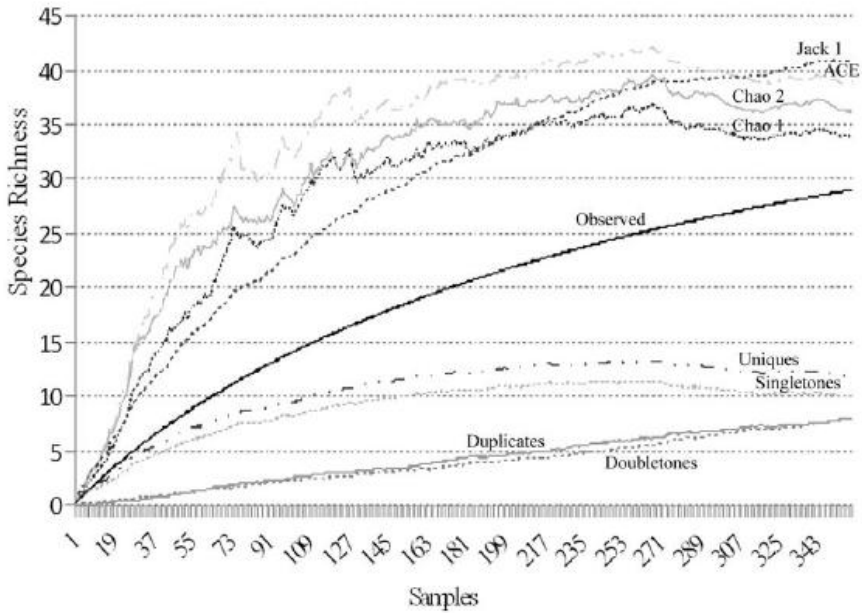


Figure 6. Nonparametric estimators of species richness of Heteroptera in Los Cardones National Park, Salta, Argentina.