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Arthropod Assemblages from La Chimba National Reserve (Antofagasta Region, Chile): Biodiversity, Threats and Conservation

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ABSTRACT

We provide the first inventory of terrestrial arthropods from La Chimba National Reserve (Antofagasta Region, Chile), a protected area whose purpose is to preserve the biota of the Coastal desert of Tocopilla embedded in the larger transitional coastal desert. The study was conducted during spring of 2019. A total of 2,852 specimens were recorded, distributed across 188 species. Among the collected specimens, 5 new species were identified: two species of scorpions, *Brachistosternus chimba* Ojanguren-Affilastro, Alfaro & Pizarro-Araya, 2021 and *Rumikiru* sp. nov. (Scorpiones: Bothriuridae); a solpugid (Solifugae: Ammotrechidae); a spider (Araneae: Filistatidae), and a centipede (Scutigeromorpha: Scutigeridae). The richness estimations showed large values for most arthropod groups, which is evidence of an incomplete inventory of species richness. The article also discusses the current threats faced by these communities of endemic arthropods and suggests immediate actions to preserve these groups in extremely fragile semiarid ecosystems.

Keywords: Atacama Desert, conservation, coastal desert, endemism, richness estimation.

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INTRODUCTION

The longitudinal coastal strips of northern Chile are composed of a wide variety of geomorphological, ecological, and climatic zones (Hartley, Chong, Houston, & Mather, 2005; Rundel, Villagra, Dillon, Roig-Juñent, & Debandi, 2007). This wide variety of habitats has favored the evolution of a biota specifically adapted to dry conditions, changes in sea level, as well as humidity and dryness oscillations that are characteristic of the coastal desert (Ceccarelli, Pizarro-Araya, & Ojanguren-Affilastro, 2017), with biodiversity hotspots, endemic species, and relictual distributions in different sections of its geography (Roig-Juñent & Flores, 2001; Cepeda-Pizarro, Pizarro-Araya, & Vásquez, 2005a; Rundel et al, 2007).

The transitional coastal desert of Chile (25° to 32° S) is an important strip in terms of flora diversity, species endemism, desert bloom, and biological conservation (Muñoz, 1991; Vidiella, Armesto, & Gutiérrez, 1999). This region constitutes the northernmost limit of the vegetation biodiversity hotspot recognized for central Chile (Gaston, 2000). Additionally, due to its latitudinal location, the area is subject to the effects of ENOS events (Jaksic, 1998; Cepeda-Pizarro et al, 2005a, Cepeda-Pizarro, Pizarro-Araya, & Vásquez, 2005b) as well as the potential effects of global climate change (Mooney et al, 2001). An important landscape element in the geomorphological diversity of the transitional coastal desert of Chile are interior ravines (Paskoff & Manríquez, 1999). These ravines are attractive for tourism or real estate development, and once they become accessible, they are subject to strong anthropic pressures (Paskoff & Manríquez, 1999).

Terrestrial arthropods are one of the most diverse and abundant biological components of the transitional coastal desert (Cepeda-Pizarro et al, 2005a, 2005b; Pizarro-Araya, Pizarro-Araya, Alfaro, Ojanguren-Affilastro, Perez-Schultheiss, & Thiel, 2023). They play different ecological roles, such as increasing the primary and secondary production of their ecosystems (Ayal, 2007) either due to their ability to pollinate or their ability to dynamize the flow of energy or the nutrient cycle, while at the same time being abundant, high-quality trophic resources (Vidal, Pizarro-Araya, Jerez, & Ortiz, 2011). During the dry season, they function as important macrodecomposers and are significant trophic resources both for invertebrates (Pizarro-Araya, 2010; Cruz-Jofré & Vilina, 2014) and vertebrates (Vidal et al, 2011; Tirado, Trujillo, Pizarro-Araya, Alfaro, González, & Carretero, 2018).

Recent expeditions conducted by an Argentinean-Chilean team have provided relevant biological information regarding the ecology (Ceccarelli, Ojanguren-Affilastro, Mattoni, Ochoa, Ramírez, & Prendini, 2016; Ceccarelli et al, 2017; Alfaro, Pizarro-Araya, & Flores, 2016; Alfaro, Pizarro-Araya & Flores, 2009; Pizarro-Araya & Alfaro, 2018), conservation (Pizarro-Araya, Vergara, & Flores, 2012; Pizarro-Araya, Alfaro, Flores, & Letelier, 2017; Pizarro-Araya & Ojanguren-Affilastro, 2018), biology (Pizarro-Araya, 2010; Ojanguren-Affilastro, Botero-Trujillo, Castex, & Pizarro-Araya, 2016), and taxonomy and systematics of the Arthropoda found in this coastal desert. As a result, several taxonomic groups have been described, e.g.,

Scorpiones (Ojanguren-Affilastro, Mattoni, & Prendini, 2007a, Ojanguren-Affilastro, Agusto, Pizarro-Araya, & Mattoni, 2007b, Ojanguren-Affilastro, Pizarro-Araya, & Ochoa-Cámara, 2018, Ojanguren-Affilastro, Alfaro, & Pizarro-Araya, 2021; Ojanguren-Affilastro & Pizarro-Araya, 2014), Araneae (Laborda, Ramírez, & Pizarro-Araya, 2013; Grismado & Pizarro-Araya, 2016; Izquierdo & Ramírez, 2017), and Coleoptera (Flores & Pizarro-Araya, 2012, 2014, 2022; Moore, 2017; Mondaca, Pizarro-Araya, & Alfaro, 2019). However, knowledge of the arthropods of the northern part of the Chilean coastal desert, represented by the plant formation known as Coastal Desert of Tocopilla (Gajardo, 1993), is virtually nonexistent. This formation is represented by protected areas such as the Morro Moreno National Park (23° S) and La Chimba National Reserve (23° S). Since these units are isolated from the coastal desert, they are expected to contain a unique endemic arthropod fauna, as documented for the Paposo priority area (25° S) (Pizarro-Araya & Jerez, 2004; Ojanguren-Affilastro & Pizarro-Araya, 2014; Ojanguren-Affilastro et al, 2018; Mondaca et al, 2019; Pizarro-Araya, Alfaro, Ojanguren-Affilastro, & Moreira-Muñoz, 2021). Due to the limited knowledge of the biodiversity from La Chimba National Reserve (Antofagasta Region, Chile), a FIC-R (Innovation Fund for Regional Competitiveness) project was developed during 2019 and 2020 to help recover and preserve its biota. The objectives of this research study were (a) to characterize the richness, abundance, and similarity of the terrestrial arthropod fauna from La Chimba National Reserve, (b) evaluate the level of endemism of the arthropod fauna and the significance of newly discovered species in this natural area, and (c) to identify existing threats to the local fauna and the challenges for its conservation.

MATERIAL AND METHODS

Study sites

La Chimba National Reserve is located in the coastal range of Antofagasta, 15 km north of the city of Antofagasta (Chile), and has a surface area of 2,583 ha (Fig. 1). The purpose of the reserve is to preserve the biota of the Coastal Desert of Tocopilla (Gajardo, 1993; CONAF, 1995). The reserve derives its name from La Chimba ravine (Fig. 2a), an arheic microbasin with a surface area of 1,455.2 ha and a drainage system composed of a third-order main ravine (La Chimba ravine) and the secondary ravines Guanaco (Fig. 2b) and Los Cactus (Fig. 2c). These ravines are important biological relicts of the coastal desert of northern Chile (CONAF, 1995). The vegetation in the area consists of an extremely xeromorphic, open coastal desert shrubland dominated by cacti and succulents, e.g., *Eulychnia iquiquensis* (K. Schum.) Britton & Rose 1920, *Atriplex clivicola* I.M. Johnst 1929, *Frankenia chilensis* C. Presl ex Schult. & Schult.f. 1830, *Nolana lachimbensis* Dillon, Arancio & Luebert 2007, *Ophryosporus triangularis* Meyen 1834, and *Tetragonia angustifolia* Barnéoud 1847 (Luebert & Pliscoff, 2006; Faúndez, 2022).

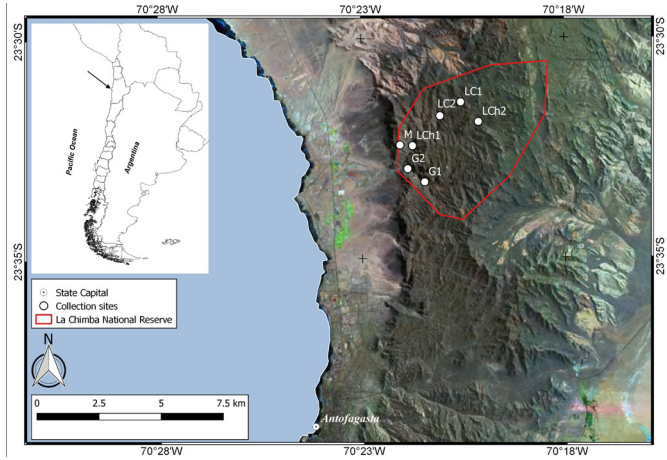

Figure 1. Geographic location of La Chimba National Reserve (Antofagasta Region, Chile) and study sites. Codes as in Table 1.

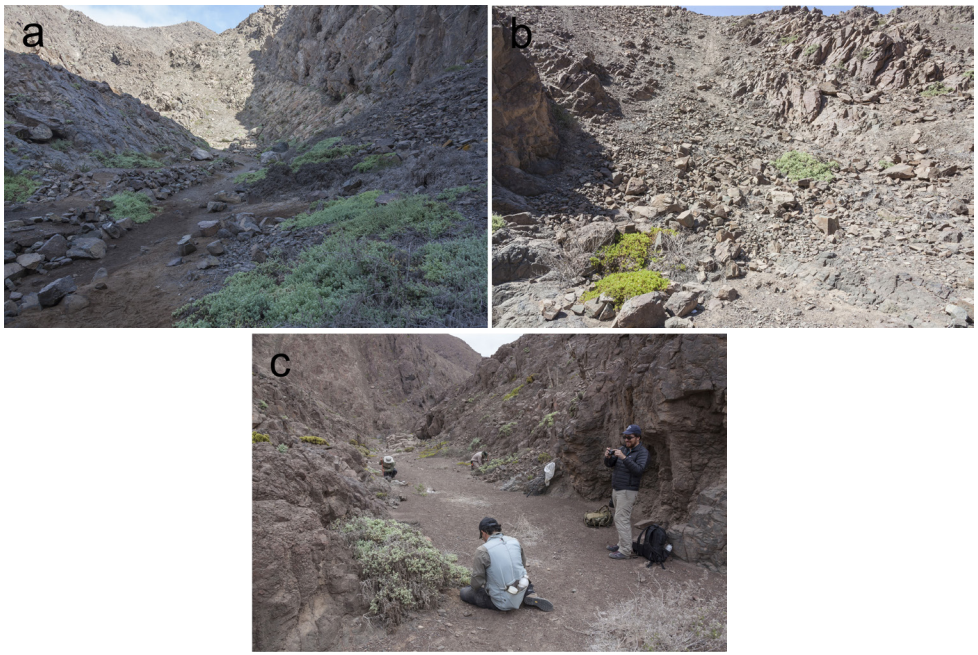

Figure 2. Study sites (habitats) within La Chimba National Reserve. a) La Chimba (LCh1) ravine, b) Guanaco (G1) ravine, and c) Los Cactus (LC2) ravine.

The reserve's geomorphology is complex and dominated by a highly degraded landscape with a broken topography, formed by the pluvial-fluvial action resulting from a wetter past climate (CONAF, 1995). These extreme weather conditions cause cycles of erosion mostly by water, wind, and thermal stress. These elements act selectively

and superficially upon large volumes of rock. This superficial action generates shallow saline soil profiles dominated by calcium and sodium sulfides (CONAF, 1995). In a normal year, the most important hydrometereological phenomenon are fog banks with grazing clouds known as “camanchacas”, which cause horizontal rains in the altitudinal strip ranging from 300 to 900 m a.s.l. Although these precipitations occur during the entire year, they are more common in the spring and winter (CONAF, 1995; Carvajal, Mora-Carreño, Sandoval, & Espinoza, 2022).

Sampling methods

The taxonomic richness and relative abundance of epigean arthropods were estimated based on the number of species and the number of collected individuals per species, respectively. For capture, pitfall traps were chosen, a widely used method to assess assemblages of terrestrial arthropods (Cepeda-Pizarro et al, 2005a, 2005b). For sampling, 7 sites representative of the different environments and ravines present in the reserve were selected (Table 1). Following SIMEF procedures (2017), 10 traps were installed in each site, in vegetation representative of that environment. Each trap consisted of two plastic cups one inside the other, with the interior cup easily removable (*sensu* Cepeda-Pizarro et al, 2005a, 2005b). The cups were 7.4 and 7.6 cm in diameter by 10.2 and 12.0 cm in height, respectively. The interior cup was two-thirds filled with a solution of water, domestic washing liquid, and 70% alcohol. The traps remained active between December 18 and December 22, 2019.

Table 1. Geographical location of study sites in La Chimba National Reserve (Antofagasta Region, Chile).

N° site	Site	Site code	Latitude	Longitude	Altitude (m a.s.l.)
1	La Chimba 1 ravine (wetland)	LCh1	23°32'20.76"S	70°21'35.82"W	402
2	Mirador ravine	M	23°32'19.66"S	70°21'53.54"W	568
3	La Chimba 2 ravine	LCh2	23°31'49.71"S	70°20'2.30"W	749
4	Los Cactus 1 ravine	LC1	23°31'23.87"S	70°20'27.11"W	712
5	Los Cactus 2 ravine	LC2	23°31'41.82"S	70°20'56.63"W	712
6	Guanaco 1 ravine	G1	23°33'8.24"S	70°21'18.95"W	434
7	Guanaco 2 ravine	G2	23°32'50.84"S	70°21'42.79"W	308

Scorpions were collected by hand at night using portable UV lamps (395 nm), since they fluoresce under this light (*sensu* Ojanguren-Affilastro & Pizarro-Araya, 2014; Ojanguren-Affilastro et al, 2018). Apart of those specimens collected by traps, the arthropods of the remaining groups were also collected by hand at night using portable lights, or during the day searching under stones, around plants and in rock crevices at each of the sites described above.

In Arachnida (Arthropoda: Chelicerata), the taxonomic identification for Araneae followed Platnick & Shadab (1982), Coyle (1986), Goloboff (1995), and Ramírez (2003); for Solifugae we used Kraus (1966), Muma (1971), and Maury (1987); and for Scorpiones, we followed Ojanguren-Affilastro (2002, 2005), Ojanguren-Affilastro & Ramírez (2009), and Ojanguren-Affilastro et al, (2007a, 2007b). In Insecta (Arthropoda: Mandibulata), the taxonomic identification followed Peña (1966, 1971, 1973, 1974, 1980, 1995); Snelling & Hunt (1975), Cigliano (1989), Cigliano, Ronderos, & Kemp (1989), Chiappa, Rojas, & Toro (1990), Artigas (1994), Estrada & Solervicens (1999),

Elgueta, Camousseight, & Carbonell (1999), Roig-Juñent & Domínguez (2001), and Pizarro-Araya & Jerez (2004). It should be noted that some taxa (e.g., Diptera and Hymenoptera) were taxonomically identified only at the level of morphotype/family due to the poor taxonomic knowledge of these groups in the area. All the captured specimens were removed, cleaned, and preserved in alcohol (e.g., insects and myriapods in 70% alcohol; arachnids in 80% alcohol) until their processing and taxonomic identification. The captured specimens were deposited in the entomological and arachnological collection of the Ecological Entomology Laboratory of Universidad de La Serena, Chile (LEULS, Jaime Pizarro-Araya) and the Arachnology Division of the Bernardino Rivadavia Museum of Natural Science, Buenos Aires, Argentina (MACN-Ar, Martín J. Ramírez).

Data analysis

To determine the richness patterns between the study sites, we used species rarefaction curves based on individuals to remove the effects introduced by the sites' difference in area (Gotelli & Colwell, 2001). The analysis was based on the species abundance data obtained from the sample set and performed using PAST 2.16 (Hammer, Harper, & Ryan, 2001). The richness was estimated using the non-parametric estimators ICE, Chao 2, and Jack 2 (second-order jackknife) (Chazdon, Colwell, Denslow, & Guariguata, 1998; Colwell, 2013). These estimators are universally valid for any species abundance distribution and more robust than estimators based on parametric models of species abundance (Chao & Chiu, 2016). For that reason, they provide the most precise estimations of species abundance (Hortal, Borges, & Gaspar, 2006). The incidence-based coverage estimator (ICE) is a robust and precise estimator of species richness (Chazdon et al, 1998), whereas Chao 2 and Jack 2—both based on rare species—provide less biased estimates for small samples (Colwell & Coddington, 1994). All the estimators were computed using EstimateS version 9.1.0 (Colwell, 2013).

The abundance structure of the terrestrial arthropod fauna was analyzed by means of non-metric multidimensional scaling (NMDS) based on Bray-Curtis and Jaccard similarity matrices. Finally, we performed a one-way analysis of similarities (ANOSIM) based on the distance between the Bray-Curtis and Jaccard indices to determine the differences between the main ravines (study sites) in the national reserve. The significance level was calculated using 50,000 permutations. All the analyses were performed in PAST 2.16 (Hammer et al, 2001).

RESULTS

Species richness, abundance and similarity of the terrestrial arthropod fauna

A total of 2,852 arthropod specimens representing 188 species were collected across all the study sites in La Chimba National Reserve. Among these, four classes were identified: Arachnida, Chilopoda, Crustacea, and Insecta. Insecta was the most represented taxon, with 123 species, 56 families, and 11 orders, whereas Arachnida

was represented by 62 species, 27 families, and 5 orders. Crustacea, in turn, was represented only by 2 species, *Transorchestia chiliensis* Milne-Edwards, 1840 (Talitridae) and *Scyphoniscus* sp. (Scyphacidae), whereas Scutigeromorpha was represented by a single species (Table 2). Diptera, Hymenoptera, and Lepidoptera were the orders with the largest number of species within Insecta, whereas Acari and Araneae were the more diverse orders within Arachnida (Table 2).

Table 2. Taxonomic composition of terrestrial arthropods registered in La Chimba National Reserve (Antofagasta Region, Chile).

Class	Order	Species	Individuals	Singletons-species
Arachnida	Acari	25	143	8
	Araneae	30	94	10
	Pseudoscorpiones	2	8	1
	Scorpiones	2	66	0
	Solifugae	3	10	1
Chilopoda	Scutigeromorpha	1	1	1
Malacostraca	Amphipoda	1	166	0
	Isopoda	1	261	0
Insecta	Coleoptera	18	120	8
	Collembola	2	371	0
	Diptera	33	312	11
	Hemiptera	9	228	1
	Hymenoptera	32	288	17
	Lepidoptera	18	81	10
	Orthoptera	3	17	1
	Psocoptera	4	161	0
	Siphonaptera	1	1	1
	Thysanoptera	1	519	0
	Thysanura	2	5	1
Totals		188	2,852	71

The accumulation rates for the study sites did not stabilize. Due to the overlapping confidence intervals, no significant differences were observed in sampling levels between study sites (Fig. 3). Although 188 species were identified, the richness values for the different arthropod groups under analysis were large. In this respect, the groups with the largest species values were Diptera and Hymenoptera (Table 3).

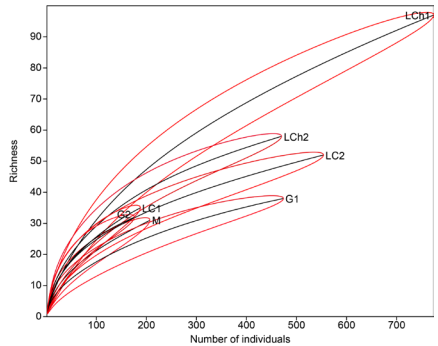

Fig. 3. Individual-based rarefaction curves for the study sites in La Chimba National Reserve. Lines in red indicate the 95% confidence interval.

Table 3. Richness estimated for terrestrial arthropods and principal groups registered.

Group	Richness observed	ICE	Chao 2	Jack 2
All species	188	365.55	305.92	333.31
Arachnida	62	103.15	92.17	105.52
Insecta	123	258.86	206.43	222.24
Acari	25	47.43	43	46.19
Araneae	30	51.14	40.29	49.79
Coleoptera	18	54.21	34.71	36.64
Diptera	33	77.76	57.75	63.4
Hymenoptera	32	58.67	50.1	58.67

The ordination analysis suggests a potential difference in the abundance structure of the arthropod community between the sites located in the ravines under study. For instance, we observed a group composed of the La Chimba, Los Cactus, and Mirador ravines, and another group composed of the sites in the Guanaco ravine (Fig. 4). However, the ANOSIM based on the Bray-Curtis (Global R = −0.2, P = 0.855) and Jaccard (Global R = 0.2, P = 0.172) matrices indicated that these differences may not be significant.

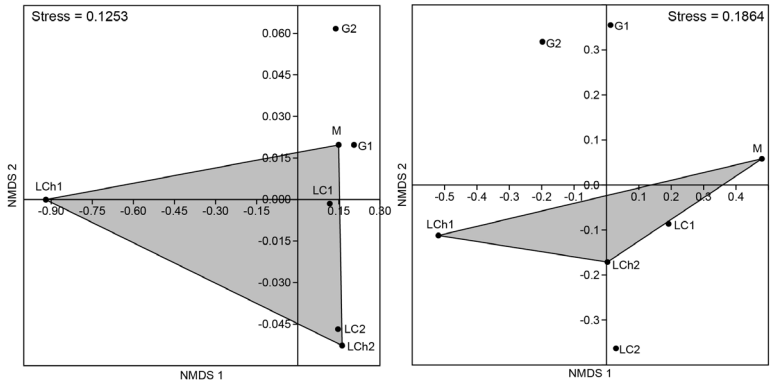

Figure 4. Non-metric multidimensional scaling ordination of study sites analyzed according to terrestrial arthropods from La Chimba National Reserve. Plot based on the Bray-Curtis (left) and Jaccard (right) similarity indices.

New species and endemisms

Even though some groups (e.g., Acari, Diptera, and Hymenoptera) were represented by a large number of morphospecies, it was impossible to identify them at species level -not even preliminary- due to the limited or non-existent knowledge of these groups in the area.

Some of the positively identified species included the locust *Uretacris lilai* Liebermann, 1943 (Orthoptera: Tristiridae), a restricted-range species found only in rocky habitats of the La Chimba 2 and Guanaco 2 ravines. Other endemic species recorded in the reserve were the darkling beetles *Nycterinus* (*Paranycterinus*) *penai* Kulzer, 1961 and *Entomochilus wilsoni* Peña, 1980 (Coleoptera: Tenebrionidae), both recorded exclusively in La Chimba ravine, and the spiders *Anisaedus pellucidas*

Platnick, 1975 (Araneae: Palpimanidae) and *Sicarius thomisoides* Walckenaer, 1847 (Araneae: Sicariidae), recorded in the La Chimba and Guanaco ravines, respectively (Fig. 5). All the individuals from these species were collected from the sparse vegetation of the reserve's desert environments, associated with coastal shrubs such as *Frankenia chilensis*, *Nolana lachimbensis*, *Ophryosporus triangularis,* and *Tetragonia angustifolia* (see Fig. 2).

As a result of this work, we identified *Brachistosternus chimba* Ojanguren-Affilastro, Alfaro & Pizarro-Araya, 2021 a species of scorpion recorded exclusively in La Chimba National Reserve and 4 new species undescribed to date: *Rumikiru* sp. nov. (Scorpiones: Bothriuridae), recorded exclusively in the La Chimba and Los Cactus ravines (Fig. 5); a solpugid from the family Ammotrechidae (Solifugae), recorded only in La Chimba 2 ravine; a spider from the family Filistatidae (Araneae), captured in the La Chimba 1 (wetland) and Guanaco 2 ravines, and a centipede from the family Scutigeridae (Scutigeromorpha), recorded in La Chimba 1 ravine.

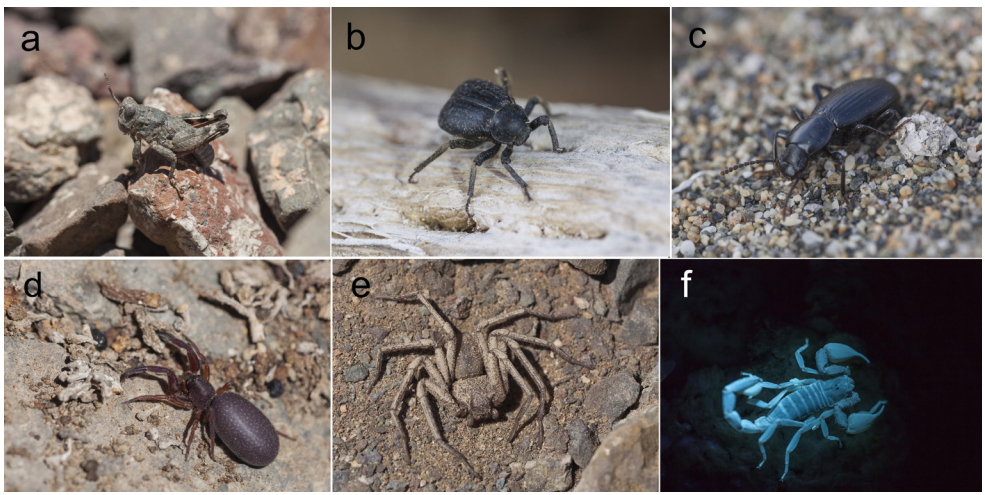

Figure 5. Different species of arthropods recorded in La Chimba National Reserve. a) Lateral view of *Uretacris lilai* Liebermann, 1943 (Orthoptera: Tristiridae); b) lateral view of *Entomochilus wilsoni* Peña, 1980 (Coleoptera: Tenebrionidae); c) lateral view of *Nycterinus* (*Paranycterinus*) *penai* Kulzer, 1961 (Coleoptera: Tenebrionidae); d) lateral view of *Anisaedus pellucidas* Platnick, 1975 (Araneae: Palpimanidae); e) lateral view of *Sicarius thomisoides* Walckenaer, 1847 (Araneae: Sicariidae), and f) lateral view of *Rumikiru* sp. nov. (Scorpiones: Bothriuridae) taken with UV light.

DISCUSSION

Species richness, similarity and singleton-species

Although this study includes only a single seasonal sampling in a representative area of the coastal desert of Chile, it provides the only updated records to date of a poorly studied taxonomic group.

The richness estimations showed high values for most arthropod groups (orders) and the steep slope of the species accumulation curves for all the study sites may be evidence of an incomplete inventory of species richness. This is a recurrent theme in studies of large taxonomic groups using different sampling scales (Legros, Rochat, Reynaud, & Strasberg, 2009; Pryke & Samways, 2009; Andersen, Lanoue, & Radford, 2010). Overall, the similarity analyses revealed comparable communities between the study sites, most of which are coastal desert shrublands (Luebert & Pliscoff, 2006).

The large number of species with only one individual (singletons) in some arthropod groups (see Table 2) suggests the existence of communities with rare species restricted to environments with unique environmental and vegetation conditions embedded in a vast arid matrix. Another possible explanation for this may be the lack of balance in the dynamics of these communities (Coddington, Gnarsson, Miller, Kuntner, & Hormiga, 2009; Richardson & Arias-Bohart, 2011) due to the pressure of predators and parasitoids on common species, the species' grouped distributions (due to the reproductive structure of arthropod species and the uneven distribution of resources) (Longino, Coddington, & Colwell, 2002), or the changing interannual weather conditions, e.g., ENSO years (EL Niño-Southern Oscillation), non-ENSO years, or La Niña years (Azarbayjani, Burgin & Richardson, 1999; Cepeda-Pizarro et al, 2005a, 2005b). Under these conditions, species richness estimates play an increasingly important role in biological and conservation inventories (Cardoso, Gaspar, Pereira, Silva, Henriques, da Silva, & Sousa, 2008; Shen & He, 2008; Schoeman, Nel, & Soares, 2008; Legros et al, 2009; Alfaro & Pizarro-Araya, 2017).

New species and endemisms

One of the most striking findings regarding the arthropod assemblage of La Chimba National Reserve made during the recent survey was the discovery of a new species of scorpion from the genus *Rumikiru* (see Fig. 5). This genus is endemic to northern Chile. It currently includes only two species from a narrow area 200 km in length, extending from central Atacama to the south of the Antofagasta Region. All known species of this genus are remarkable among the family Bothriuridae, because they are lithophilous, inhabiting exclusively in rocky environments of the western slopes of the Chilean "Cordillera de la Costa" (Ojanguren-Affilastro, Ochoa, Mattoni, & Prendini, 2012). This genus is closely related to the genus *Mauryius* Ojanguren-Affilastro & Mattoni 2017 from central Argentina and *Pachakutej* Ochoa, 2004 from southern Peru, and seems to be a relic from ancient fauna that occupied most of the southern South American Andes, and its area of influence, before its last uplift and the consequent extreme aridification of the area (Ojanguren-Affilastro et al, 2012). The presence of this species in this area extends the distribution of the genus about 300 km northward, duplicating its previous known distribution, and projecting it towards a much more arid area. Additionally, due to the high degree of endemicity and unique distribution of the species of the group, this species is likely endemic to the area of La Chimba National Reserve or from an area slightly larger than the reserve itself, since the conditions in which it has been collected are unique to this area and until now it has

not been collected in the neighboring protected area of Morro Moreno National Park (Pizarro-Araya *pers. obs.*).

The presence of other arthropod species, such as the scorpion species recently described (*Brachistosternus chimba*), a new solifuge from the family Ammotrechidae, and a new Filistatid spider, were expected since these are common groups in the deserts of northern Chile, and because there were no previous surveys of these groups in the area. Most probably, these findings also represent species with very narrow distributions, limited to the area of the reserve and neighboring areas with similar environments. In the case of the new scorpion from the genus *Brachistosternus*, it has not been collected in the Morro Moreno National Park, *ca* 20 km west from La Chimba National Reserve (Pizarro-Araya *pers. obs.*), nor in the Paposo Norte reserve, located some 100 km to the south, so we can assume that its presence may be, at most, restricted to this area. More field research would be necessary to clearly establish the distribution of all these species. The case of the Scutigeromorpha is also interesting since its most closely related species were collected in central Chile (Andrés Porta *pers. com.*).

All the above findings show that La Chimba National Reserve has a fauna that is unique to this area and very geographically restricted. Besides, this is the only protected area where this particular arthropod community is under some kind of protection since the nearby Morro Moreno National Park and Paposo Norte Natural Monument host communities that are clearly different.

Current threats

Although Chile has recently made some positive advances in terms of the allocation of new protected areas through private donations, and nowadays more than 20% of the country is protected (Terram, 2018), there is still a big differentiation between the designation of protected areas in the north and south of the country. Even though regions in Patagonia, like Magallanes, have more than 50% of their territory under conservation, in the north, places like the Antofagasta Region only have around 3% of their land designated as protected areas (MMA, 2015). Moreover, governmental funding for protected areas is scarce nationwide, with less than USD$2 per hectare every year (FAO, 2010), placing Chile in 9th place among the most under-financed countries in terms of biodiversity conservation worldwide (Waldron et al, 2013). This situation directly affects the capacity of protected areas to achieve the conservation objectives for which they were conceived, and in the case of La Chimba National Reserve, it has implied the absence of park rangers for almost three decades, leading to anthropic damage due to garbage accumulation, gravel extraction, illegal burnings, among others. Moreover, La Chimba National Reserve is located only 700 meters from Antofagasta's former city dump, one of the biggest of South America, which operated without major sanitary protocols for five decades, until December 2019, generating a complex environmental and social context for conservation to occur. Despite this complex environmental context, recent studies conducted by the FIC-R project have identified the presence of numerous native and endemic species

of vascular flora, lichens and vertebrates, confirming the existence of 352 native species (Mora-Carreño, Faúndez, Vargas, Pizarro-Araya, Alfaro, Ojanguren-Affilastro, Mella, Tejeda, & Villalobos, 2022). However, considering recent evidence showing the decrease of rainfall frequency and cloud cover in the coastal region of northern Chile (Schulz, Aceituno, & Richter, 2011), both vital for the maintenance of fog oases ecosystems (Larraín, 2007), it might be expected that the survival of species occurring in La Chimba National Reserve might be highly compromised if these signs of climate change continue to increase (Pinto, 2007a), jeopardizing the survival of more native and endemic species. An example of this worrying signs of climate change is the high mortality rate of the columnar cacti *Eulychnia iquiquensis*, recorded with 70% of dead individuals during botanist surveys (Pinto, 2007b; Faúndez, 2022). These cacti are considered a keystone species for fog oases in the north of Chile due to its capacity to accumulate water from the fog, contributing with water supply for other native species occurring nearby (Pinto, 2014). The habitat perturbation and degradation (conditioned by climate and anthropic factors) observed in La Chimba National Reserve may pose a hidden threat to the arthropod communities that depend upon the availability and seasonality of primary resources.

Threatened species and local experiences

Since 2005 the Chilean Ministry of Environment has been initiating species listing processes based on a review of the species status through the “Reglamento para la clasificación de especies silvestres” (Regulations for the classification of wildlife species). These listing processes are intended to assess the level of threat to biological diversity with the goal of focusing resources on threatened species, developing conservation programs, promoting research on these species, and considering these species in land management efforts (MMA, 2021).

In recent years, several arthropod species have been categorized at a national level based on the restricted geographic distribution criterion proposed by the IUCN (International Union for Conservation of Nature). As part of the classification processes, the level of endemism and the species’ habitat have also been of great importance (Jerez, Zuñiga-Reinoso, Muñoz-Escobar, & Pizarro-Araya, 2015; Le Breton et al, 2019).

Considering the current threats faced by this national reserve, we proposed three insect species for the 17th Process for the Classification of Species, namely, *Uretacris lilai*, *Entomochilus wilsoni,* and *Nycterinus* (*Paranycterinus*) *penai* (see Fig. 5), all of them restricted-range and endemic species of the Coastal desert of Tocopilla, a vegetation unit that is only represented in La Chimba National Reserve among all the currently protected areas of Chile (Gajardo, 1993; CONAF, 1995). As a result, the three species proposed were considered as threatened with extinction by the Classification Committee: *Uretacris lilai* was classified as Endangered, while *Entomochilus wilsoni* and *Nycterinus* (*Paranycterinus*) *penai* were both classified as Critically Endangered. Overall, these and other recent species classifications highlight the presence of 13 species in risk of extinction occurring in La Chimba National Reserve (Mora-Carreño et al, 2022).

Conclusion and management recommendations

Complementary to the findings on the arthropod assemblage registered in La Chimba National Reserve, results for other surveys of different taxa conducted by the FIC-R project have confirmed remarkable richness of vascular flora, lichens and vertebrates (Mora-Carreño et al, 2022), some of them at risk of extinction, highlighting the importance to establish effective management and conservation measures in the short term. On the one hand, allocating more financial resources for the management of protected areas in the Antofagasta Region might help enforce the regulations established for protected areas, preventing numerous anthropic actions that nowadays threaten La Chimba National Reserve (Pinto, 2007a; Dillon, Leiva-González, & Quipuscoa-Silvestre, 2007; MMA, 2015). Moreover, establishing monitoring programs for the diverse taxa occurring in the protected area might be crucial to have a better understanding of the ecological processes related with climate change (Schulz et al, 2011) that seem to be silently affecting La Chimba National Reserve (Pinto, 2007a; Mora-Carreño et al, 2022). In this regard, establishing restoration/reforestation programs like those successfully established by Pinto (2014) for keystone species (*Eulychnia iquiquensis*) in other fog oases located in the north of Chile, might have positive cascade effects and be of great value to contribute to the preservation of the unique biodiversity of La Chimba National Reserve.

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