J. Entomol. Res. Soc., 16(2): 39-50, 2014 *ISSN:1302-0250*

Epigean Insects of Chañaral Island (Pingüino de Humboldt National Reserve, Atacama, Chile)

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ABSTRACT

The Pingüino de Humboldt National Reserve in Chile is an area of biodiversity conservation in arid island ecosystems. The reserve is located both in the Atacama and Coquimbo regions and is composed of the Choros (29º 15' S, 71º 32' W), Damas (29º 13' S, 71º 31' W) and Chañaral (29°02' S, 71°36' W) islands. Pitfall traps were used to study the taxonomic diversity of epigean insects in Chañaral Island. The study area was divided into 3 vegetationally contrasting ecotopes: E1 represented by a subdesert steppe, E2 represented by a xeric shrubland and E3 represented by a xeric shrub steppe. A total of 730 specimens were captured, belonging to 40 species arranged in 34 genera and 17 families. Four insect orders were recorded, of which the most diverse were Coleoptera, with 29 species, and Hymenoptera, with 7 species. Coleoptera was the most represented group, with 24 genera grouped in 11 families. The richest families were Curculionidae (9 species) and Tenebrionidae (8 species). The highest species richness was recorded in E1 (28 species), followed by E2 (21 species) and E3 (19 species). The number of exclusive species varied between habitats, with E1 showing the highest number (14), and E2 and E3 being represented by 5 and 3 species, respectively. On the other hand, 10 species were common to all three sampled sites. The differences in vegetation between the sites were clearly reflected in the relative abundance and species richness of epigean insects. We did not record the presence of *Gryiosomus granulipennis*, an endemic species of Choros Island, which confirms that this species is restricted to a specific area of the reserve. This work is the first biological inventory of epigean insects on Chañaral Island.

Key words: Pingüino de Humboldt National Reserve, coastal desert, insects, endemism, Chañaral Island, Atacama, SNASPE.

INTRODUCTION

Having adapted to a close and particular environment, insular insects are vulnerable to threats over their population size and, consequently, are very sensitive to biological

perturbations (Palmer, 2002; Gillespie and Roderick, 2002; Fattorini, 2010). These insects have more restricted distributions and smaller populations than continental species, therefore having higher extinction rates (Fattorini, 2002, 2011; Hambler and Speight, 2004).

This scenario can be found in certain island ecosystems of northern Chile such as the Pingüino de Humboldt National Reserve (PHNR), located off the coast of Punta de Choros and extending from the south of the Huasco province (Atacama Region) to the north of the Elqui province (Coquimbo Region), with a total surface area of 859.3 ha (CONAF, 1997). The PHNR was created in 1990 as part of the SNASPE (Sistema Nacional de Áreas Silvestres Protegidas del Estado, *National System of Wild Protected Areas*) and is composed of the Choros, Damas, and Chañaral islands (CONAF, 1997). These island ecosystems are part of the transitional coastal desert (TCD, 25-32º Lat S), a latitudinal strip characterized by the presence of an arthropodofauna with particular species richness (Cepeda-Pizarro *et al*., 2005a, 2005b; Valdivia *et al*., 2008, 2011), endemism (Pizarro-Araya and Flores, 2004; Pizarro-Araya *et al*., 2012a, 2012b, 2014; Laborda *et al*., 2013; Bustamante *et al*., 2014), and restricted distribution (Pizarro-Araya and Jerez, 2004; Agusto *et al*., 2006; Ojanguren-Affilastro *et al*., 2007a, 2007b, 2012; Alfaro *et al*., 2009; 2013; Ojanguren-Affilastro and Pizarro-Araya, 2014; Benitez *et al*., 2014). Within the arthropodofauna of the TCD, epigean insects are a characteristic group of the biota of arid and semiarid ecosystems (Deslippe *et al*., 2001; de los Santos *et al*., 2002; Cepeda-Pizarro *et al*., 2005a; Sánchez-Piñero *et al*., 2011), and are believed to play an important role in the processes of biological plant resource fragmentation, in nutrient cycles, and in the diet of other consumer organisms, particularly vertebrates (Vidal *et al*., 2011; Carevic *et al*., 2013).

The knowledge of insects inhabiting semiarid island ecosystems in Chile is very poor. The only available information refers to the structure of the assemblage of Tenebrionidae (Coleoptera) of the Choros, Damas and Gaviota islands (Alfaro *et al*., 2009); there is also a study of the population and categorization of *Gyriosomus granulipennis* Pizarro-Araya and Flores, an endemic species of Choros Island and the first insect to be included in a conservation category in Chile (Vulnerable) (Pizarro-Araya and Flores, 2004; MMA, 2011; Pizarro-Araya *et al*., 2012a). In view of this lack of studies concerning the entomofauna of Chañaral Island, the objectives of this work were to document and characterize the taxonomic diversity of epigean insects on Chañaral Island (PHNR).

MATERIALS AND METHODS

Study Site

The study was conducted on Chañaral Island (29°02’ S, 71°36’ W), part of the PHNR (Fig. 1), located off the southern coast of the Atacama Region in Chile. This island is located 114 km north of the city of La Serena (Coquimbo Region, Chile) and has a surface area of 507.3 ha (CONAF, 1997). Chañaral Island corresponds to a coastal desert area with Mediterraean-type climate influenced by the presence of mist. Temperatures on the area are relatively low and, due to sea influences, the

daily and annual thermal amplitude is low (di Castri and Hajek, 1976). The island is a plateau bordered by rocky cliffs with heights varying from 30 to 50 m above the sea level (Fig. 1) and topping ~150 msl.

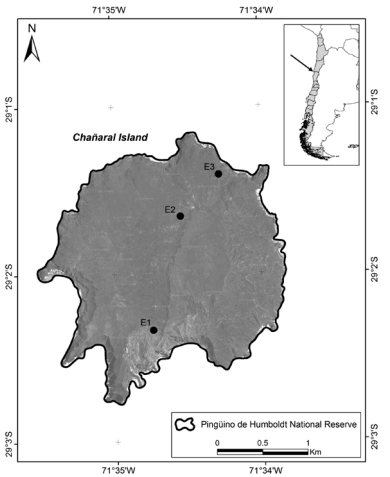

Fig. 1. Geographical location of the ecotopes (study sites) on Chañaral Island (Pingüino de Humboldt National Reserve) (Atacama Region, Chile): Ecotope 1 (E1: 29º 02' 23.1'' S; 71º 34' 45.8'' W), Ecotope 2 (E2: 29º 01' 44.2'' S; 71º 34' 32.3'' W) and Ecotope 3 (E3: 29º 01' 31.3'' S; 71º 34' 18.7'' W).

Precipitations are scarce and irregular. They are concentrated in the winter season (May through August) and reach an average of 29 days of precipitation and rainfall values not higher than 90 mm a year. Dry years with less than 25 mm annual rainfall and humid years with more than 175 mm occur in irregular cycles and are apparently related to the influence of the ENSO (El Niño Southern Oscillation) (Novoa and Villaseca, 1989). The flora of Chañaral Island is represented by different life forms, predominantly shrub species, annual and perennial herbs, and cacti (Arancio and Jara, 2007).

Sampling Methodology

The taxonomic diversity of epigean insects was analyzed using pitfall traps. We selected 3 ecotopes with contrasting vegetation, defined as E1, E2 and E3 (Table 1). E1 (29º 02' 23.1'' S; 71º 34' 45.8'' W, 95 msl) is a subdesert steppe dominated by spring hydrophytes and cacti; its geomorphology is dominated by outcrops of sedimentary rock. E2 (29º 01' 44.2'' S; 71º 34' 32.3'' W, 106 msl) is a xeric shrubland dominated by *Frankenia chilensis*. This site comprises part of a plain made up of sedimentary sea rocks with smooth relief. E3 (29º 01' 31.3'' S; 71º 34' 18.7'' W, 65 msl) is a xeric shrub steppe dominated by cacti and suffrutex shrubs. This site is part of a system of fluvial channels of varying sizes (CONAF, 1997). In each site, a transect was set up consisting of three parallel rows of 10 pitfall traps each, for a total of 30 traps per site and an effective capture area of 660 m^2 (Cepeda-Pizarro *et al*., 2005a, 2005b). The traps consisted of two plastic cups 7.4 × 10.2 cm and 7.6 × 12.0 cm in size placed one inside the other. The smaller cup was arranged in such a way that made it easy to remove.

Table 1. Plant species present in the study sites within Chañaral Island (Atacama Region, Chile).

Ecotope	Homogeneous units of vegetation communities	Family	Species	Life form	Conservation status
E1	Subdesert steppe dominated by spring hydrophytes and cacti.	Aizoaceae	*Mesembryanthemun* sp	H	OD
		Asteraceae	*Amblyopappus pusillus* Hook. et Arn.	A	OD
			Ophryosporus triangularis Meyen	P	OD
		Cactaceae	*Eulychnia acida* Phil.	C	OD
		Aizoaceae	*Mesembryanthemun cristallinum* Linnaeus	H	OD
		Asteraceae	*Amblyopappus pusillus* Hook. et Arn.	A	OD
			Ophryosporus triangularis Meyen	P	OD
		Boraginaceae	*Heliotropium huascoense* I.M. Johnst.	P	OD
		Cactaceae	*Copiapoa pseudocoquimbana* F. Ritter	C	IK
			Eulychnia acida Phil.	C	OD
		Nolanaceae	*Nolana sedifolia* Poepp.	S	OD
E2	Xeric shrubland dominated by *Frankenia chilensis*.	Asteraceae	*Amblyopappus pusillus* Hook. et Arn.	A	OD
		Cactaceae	*Eulychnia acida* Phil.	C	OD
		Frankeniaceae	*Frankenia chilensis* K. Presl	S	OD
		Nolanaceae	*Nolana sedifolia* Poepp.	S	OD
		Aizoceae	*Mesembryanthemun* sp	H	OD
		Asteraceae	*Amblyopappus pusillus* Hook. et Arn.	A	OD
		Cactaceae	*Eulychnia acida* Phil.	C	OD
E3	Xeric shrub steppe dominated by cacti and suffrutex shrubs.	Aizoaceae	*Mesembryanthemun cristallinum* Linnaeus	H	OD
		Asteraceae	*Amblyopappus pusillus* Hook. et Arn.	A	OD
			Ophryosporus triangularis Meyen	P	OD
		Boraginaceae	*Heliotropium huascoense* I.M. Johnst.	P	OD
		Cactaceae	*Copiapoa pseudocoquimbana* F. Ritter	C	IK
			Eulychnia acida Phil.	C	OD
		Nolanaceae	*Nolana sedifolia* Poepp.	S	OD
		Asteraceae	*Amblyopappus pusillus* Hook. et Arn.	A	OD
		Cactaceae	*Copiapoa pseudocoquimbana* F. Ritter	C	IK
			Eulychnia acida Phil.	C	OD
		Frankeniaceae	*Frankenia chilensis* K. Presl	S	OD
		Oxalidaceae	*Oxalis virgosa* Molina	P	OD
		Polygonaceae	*Chorizanthe frankenioides* J. Remy	S	VU

Abbreviation Key. H: Hemichryptophyte; A: Annual grass; P: Phanerophyte; C: Cactaceous; S: Suffrutescent; OD: Out of Danger; IK: Insufficiently Known; VU: Vulnerable. (Classification taken from Squeo *et al*., 2008.)

The inner cup was filled up to one third of its capacity with a mixture of seawater (80%), ethanol (10%) and laundry powder (10%). The traps operated for five days during November 2012. The captured material was preserved in 70% alcohol until it was processed and mounted. For the nomenclature and the taxonomic identification we followed Mello-Leitão (1939), Peña (1971, 1980), Snelling and Hunt (1975), Elgueta and Arriagada (1989), Artigas (1994), Aalbu and Andrews (1996), Solervicens (2001), Roig-Juñent and Domínguez (2001), Elgueta and Marvaldi (2006), Bouchard *et al*., (2011) and Flores and Pizarro-Araya (2012, 2014). The collected material is stored in the collection of the Ecological Entomology Laboratory of the University of La Serena, La Serena, Chile (LEULS).

RESULTS

Taxonomic diversity of epigean insects on Chañaral Island (Pingüino de Humboldt National Reserve)

A total of 730 specimens of epigean insects were captured, corresponding to 40 species arranged in 34 genera and 17 families (Table 2). Four orders of Insecta were recorded, of which the most diverse were Coleoptera (29 species) and Hymenoptera (7 species) (Table 2).

The order Coleoptera was the most represented group, with 24 genera grouped in 11 families. The Coleoptera families with highest species richness were Curculionidae (9 species) and Tenebrionidae (8 species). Within the order Hymenoptera, Formicidae, with 5 species, was the most represented family (Table 2).

Species richness was higher in E1 (28 species), followed by E2 (21 species) and E3 (19 species). The number of exclusive species varied between habitats; for example, E1 was represented by 14 species (the highest number), whereas E2 and E3 were represented by 5 and 3 species, respectively. A total of 10 species were common to all three sampled sites.The highest relative abundance was observed in E1 (444 specimens; 60.8% of total capture), followed by E3 (185; 25.3%) and E2 (101; 13,8%); however, the high abundance found in E1 was due to the presence of the ant *Solenopsis gayi* Spinola (Hymenoptera: Formicidae) (Tables 2 and 3).

The most abundant orders were Coleoptera (47.7% of total capture) and Hymenoptera (42.2%). The main families within Coleoptera were Tenebrionidae, Ptinidae, and Curculionidae; in Hymenoptera, the main family was Formicidae. The orders Orthoptera and Thysanura accounted for only 9.7% and 0.4% of the total capture, respectively (Table 3).

The families Carabidae, Hybosoridae, Cleridae, Elateridae, Mordellidae and Trogossitidae (Coleoptera) were not found in significant numbers, and each of them was represented by only one species, except for Cleridae, which had two species belonging to two genera (Tables 2 and 3).

The most abundant species were *Solenopsis gayi* Spinola (34.0% of total capture) and *Ptinus* sp. (Coleoptera: Ptinidae) (15.8%), most of them occurring mainly in E3 and E1, respectively (Table 1).

Table 2. Insects recorded on Chañaral Island (Atacama Region, Chile).

Order	Family	Species	E1		E2		E3		Total captured	
			n	%	n	%	n	%	n	%
Coleoptera	Anthicidae	Anthicidae sp	10	2.3	0	0	1	0.5	11	1.5
	Carabidae	*Mimodromius* sp	1	0.2	0	0	0	0	1	0.1
	Chrysomelidae	*Henicotherus* sp	8	1.8	2	2.0	1	0.5	11	1.5
	Cleridae	Cleridae sp1	0	0	1	1.0	0	0	1	0.1
		Inhumeroclerus thomsoni	0	0	1	1.0	4	2.2	5	0.7
	Curculionidae	Curculionidae sp1	5	1.1	0	0	0	0	5	0.7
		Curculionidae sp2	3	0.7	0	0	0	0	3	0.4
		Cnemecoelus sp	3	0.7	0	0	0	0	3	0.4
		Cnemecoelus valparadisiacus	1	0.2	0	0	0	0	1	0.1
		Cylydrorhinus sp	1	0.2	0	0	0	0	1	0.1
		Geniocremnus sp	1	0.2	0	0	0	0	1	0.1
		Listroderes sp	2	0.5	0	0	0	0	2	0.3
		Listroderes robustior	0	0	8	7.9	0	0	8	1.1
		Strangaliodes sp	36	8.1	3	3.0	1	0.5	40	5.5
	Elateridae	*Cardiophorus elegans*	1	0.2	0	0	0	0	1	0.1
	Hybosoridae	Hybosoridae sp	2	0.5	0	0	0	0	2	0.3
	Mordellidae	*Mordellistena* sp	1	0.2	0	0	0	0	1	0.1
	Ptinidae	Ptinidae sp1	0	0	1	1.0	0	0	1	0.1
		Ptinidae sp2	0	0	2	2.0	0	0	2	0.3
		Ptinus sp.	94	21.2	9	8.9	12	6.5	115	15.8
	Tenebrionidae	*Arthroconus* sp	20	4.5	8	7.9	5	2.7	33	4.5
		Discopleurus quadricollis	0	0	1	1.0	3	1.6	4	0.5
		Entomochilus freudei	1	0.2	14	13.9	9	4.9	24	3.3
		Entomochilus pilosus	0	0	1	1.0	0	0	1	0.1
		Nycterinus mannerheimi	29	6.5	1	1.0	5	2.7	35	4.8
		Nycterinus rugiceps	1	0.2	0	0	0	0	1	0.1
		Praocis (*Praocis*) *subaenea*	18	4.1	1	1.0	1	0.5	20	2.7
		Praocis (*Praocis*) *curta*	13	2.9	0	0	1	0.5	14	1.9

Table 2. Insects recorded on Chañaral Island (Atacama Region, Chile).

Order	Family	Species	E1		E2		E3		Total captured	
			n	%	n	%	n	%	n	%
Coleoptera	Trogossitidae	*Diontolobus* sp	1	0.2	0	0	0	0	1	0.1
Hymenoptera	Formicidae	Formicidae sp1	0	0	0	0	5	2.7	5	0.7
		Camponotus sp	0	0	5	5.0	5	2.7	10	1.4
		Dorymyrmex sp	0	0	12	11.9	22	11.9	34	4.7
		Dorymyrmex pogonius	0	0	0	0	6	3.2	6	0.8
		Solenopsis gayi	164	36.9	6	5.9	78	42.2	248	34.0
	Mutillidae	Mutillidae sp1	4	0.9	0	0	0	0	4	0.5
		Mutillidae sp2	0	0	0	0	1	0.5	1	0.1
Orthoptera	Gryllidae	Gryllidae sp1	16	3.6	18	17.8	22	11.9	56	7.7
	Proscopiidae	*Astroma* sp	1	0.2	1	1.0	0	0	2	0.3
	Tettigoniidae	*Platydecticus* sp	5	1.1	5	5.0	3	1.6	13	1.8
Thysanura	Undetermined	Thysanura sp1	2	0.5	1	1.0	0	0.0	3	0.41
Total			444	100	101	100	185	100	730	100

Tenebrionidae showed its highest relative abundance in E2 (25.7% of total capture per habitat), whereas Ptinidae (21.2%) and Curculionidae (11.7%) showed higher abundance in E1 (Table 3).

Table 3. Taxonomic composition (family level) of insects recorded on Chañaral Island (Atacama Region, Chile).

Order	Family	Habitat			Total captured	
		E1	E2	E3	n	Family
Coleoptera	Anthicidae	2.3	0	0.5	11	1.5
	Carabidae	0.2	0	0	1	0.1
	Chrysomelidae	1.8	2.0	0.5	11	1.5
	Cleridae	0	2.0	2.2	6	0.8
	Curculionidae	11.7	10.9	0.5	64	8.8
	Elateridae	0.2	0	0	1	0.1
	Hybosoridae	0.5	0	0	2	0.3
	Mordellidae	0.2	0	0	1	0.1
	Ptinidae	21.2	11.9	6.5	118	16.2
	Tenebrionidae	18.5	25.7	13.0	132	18.1
	Trogossitidae	0.2	0	0	1	0.1

Order	Family	Habitat			Total captured	
		E1	E2	E3	n	Family
Hymenoptera	Formicidae	36.9	22.8	62.7	303	41.5
	Mutillidae	0.9	0	0.5	5	0.7
Orthoptera	Gryllidae	3.6	17.8	11.9	56	7.7
	Proscopiidae	0.2	1.0	0	2	0.3
	Tettigoniidae	1.1	5.0	1.6	13	1.8
Thysanura	**Undetermined**	0.5	1.0	0	3	0.4
Total captured		444	101	185	730	100
Number of species in each site	28	21	19			

Certain species of Curculionidae (e.g., Curculionidae sp1, Curculionidae sp2, *Cnemecoelus* sp, *C. valparadisiacus* Philippi, *Cylydrorhinus* sp, *Geniocremnus* sp, *Listroderes* sp) were observed only in E1. *Listroderes robustior* Schenkling and Marshall were found only in E2, whereas *Strangaliodes* sp was found in all habitats and in high relative abundance as compared to the other species of this family (Table 2).

Orthopterans were observed in the majority of the island's habitats, with the family Gryllidae standing out because of its high relative abundance (7.7% of total capture) compared to other elements of this order, such as Proscopiidae (0.3%) and Tettigoniidae (1.8%).

DISCUSSION

According to MacArthur and Wilson (1967), the number of species on an island tends to diminish as the distance to the continent increases, and is a function of the balance between the fauna's migration and extinction rates in that particular ecosystem. However, Fattorini (2002) points out that the distance from the islands to the continent is not affecting the species richness of epigean tenebrionids in the Aegean Islands (Greece).

The low species richness observed on Chañaral Island is in stark contrast with what Fattorini (2002) and Fattorini and Fowles (2005) report when they say that islands with larger surface area and diversity of habitats would tend to hold a higher number of species. This claim agrees with Morrison (2005), who points out that the abundance and diversity of arthropods were positively associated with oceanic island areas.

The abundance and species richness of epigean insects varied between ecotopes. The sites which showed the highest relative abundance were E1 and E3, located in the northern and southern parts of Chañaral Island, respectively. The high relative abundance and species richness observed in E1 may be a result of the vegetation characteristics of the site, which is dominated by spring hygrophites that are used as food sources by phytophagous and detritivorous adults and larvae (Slobodchikoff 1983). This information, however, should be taken as a first approximation to the characterization of the assemblage of epigean insects of this island. More studies-which include other collection techniques, as well as other ecotopes and seasons-are necessary to have a better understanding of the population dynamics of the epigean insect assemblages found in the area under study.

The species richness of Tenebrionidae (Coleoptera) recorded on Chañaral Island was lower than what Alfaro *et al*. (2009) report for the islands of the archipelago of Los Choros. Of all epigean tenebrionid species recorded both on Chañaral Island and in the archipelago of Los Choros, only *Entomochilus pilosus* (Solier) and *Nycterinus rugiceps* Curtis were also found on Gaviota Island, and only the latter was found both on the Choros and Damas islands. Our preliminary results show that *Gryriosomus granulipennis* Pizarro-Araya and Flores, an endemic species of Choros Island (Pizarro-Araya and Flores, 2004) with a very particular distribution, as later confirmed by Alfaro *et al*. (2009), does not occur on Chañaral Island, which shows and confirms that the species' distribution is restricted to Choros Island.

In that respect, Fattorini (2006) thinks it is important to assess the levels of endemism in island systems as these are elements of high conservation priority. According to him, the restricted distribution of certain species in island ecosystems can be considered as an indicator of species rarity, a basic criterion to identify species in need of conservation (Fattorini, 2008).

Conducting more comprehensive samplings in hard-to-reach areas will likely extend the distribution range of the recorded taxa. In that respect, Jerez (2000) points out that most of the information currently available in collections and in the literature comes from surveys conducted near populated areas or roads, and in general does not provide complete information about this insular ecosystem. This work is intended to contribute to making a general inventory and categorizing the future conservation status of the entomofauna of desert island ecosystems in Chile, which would help to more effectively manage this wild area.

ACKNOWLEDGEMENTS

We are grateful to CONAF for allowing us to work in the National System of Wild Protected Areas (SNASPE) projects: Nº 18/2011 and Nº 006/2014. Our acknowledgments to Mario Meléndez and Carla Louit (CONAF, Atacama Region) for helping us obtain permits and accomodation to work on Chañaral Island. We also thank Luis Letelier (Centro de Investigaciones en Ecosistemas, UNAM, México) for providing assistance with GIS. Fermín M. Alfaro thanks the scholarship CONICYT-PCHA/Magíster Nacional/2013-22130123. This research was funded by the DIULS PR13121 and VACDDI001 projects of the University of La Serena, La Serena, Chile (JPA).

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Received: January 31, 2013 *Accepted: April 07, 2014*