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Taxonomic composition and abundance of epigean tenebrionids (Coleoptera: Tenebrionidae) in the Chilean Coastal Matorral

Composición taxonómica y abundancia de tenebriónidos epígeos (Coleoptera: Tenebrionidae) en el matorral costero de Chile

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ABSTRACT

Taxonomic composition and abundance of epigean tenebrionids (Coleoptera: Tenebrionidae) in the Chilean Coastal Matorral. Pitfall traps were used to examine the taxonomic composition and abundance of the Tenebrionidae (Coleoptera) assemblage in the desert portion of the Chilean Coastal Matorral. During the study period, the assemblage was dominated by four genera: *Gyriosomus*, *Nycterinus*, *Praocis* and *Scotobius*. The most diverse genus was *Gyriosomus*, with 6 species, followed by *Praocis*, with 4 species. In terms of abundance, *Gyriosomus hoppei* (Gray) accounted for 41% of total captures, followed by *Gyriosomus foveopunctatus* Fairmaire (10%), *Nycterinus rugiceps* Curtis (10%), and *Praocis (Praocis) spinolai* Solier (7%). Some species (e.g., *Gyriosomus foveopunctatus*, *G. reedi* Kulzer, *G. modestus* Kulzer, and *Praocis* (*Praocis*) *elliptica*) Philippi & Philippi showed restricted distribution in the study area and may be indicators of endemism. The dominance of *Gyriosomus* raises a series of questions regarding their levels of endemism, species diversity and distribution, and functional role in the ecosystem under study.

Key words: coastal matorral, coastal desert, *Gyriosomus*, Tenebrionidae, epigean arthropods, pitfall traps.

RESUMEN

Composición taxonómica y abundancia de tenebriónidos epígeos (Coleoptera: Tenebrionidae) en el matorral costero de Chile. Se emplearon trampas de intercepción de caída para estudiar la composición taxonómica y la abundancia del ensamble de Tenebrionidae (Coleoptera) en la porción desértica del matorral costero de Chile. Durante el periodo de estudio el ensamble de tenebriónidos estuvo dominado por cuatro géneros: Gyriosomus, Nycterinus, Praocis y Scotobius. El género más diverso fue Gyriosomus (6 especies), seguido por Praocis (4 especies). En lo que respecta a la abundancia, Gyriosomus hoppei (Gray) representó 41% del total de ejemplares capturados, seguido por Gyriosomus foveopunctatus Fairmaire (10%), Nycterinus rugiceps Curtis (10%) y Praocis (Praocis) spinolai Solier (7%). Algunas especies (p. ej., Gyriosomus foveopunctatus, G. reedi Kulzer, G. modestus Kulzer y Praocis (Praocis) elliptica Philippi & Philippi) presentaron un ámbito de distribución restringido en el área de estudio, por lo que podrían ser indicadores de endemismo. La dominancia de Gyriosomus plantea diversas preguntas respecto de los niveles de endemismo de este género, su diversidad y distribución de especies, y su función dentro del ecosistema en estudio.

Palabras clave: *matorral costero, desierto costero,* Gyriosomus*, Tenebrionidae, artrópodos epígeos, trampas de intercepción de caída.*

Introduction

In Chile, studies on the role of arthropods in the structure and function of arid and semiarid ecosystems have focused mainly on the transitional coastal desert (26-32º Lat S), a desert which extends across different ecological and geomorphological areas (Rundel *et al.*, 2007). The range of habitats found in this desert has favored the evolution of biota adapted to the arid conditions and the oscillations in humidity and dryness characteristic of this area (Gajardo, 1993; Rundel *et al.*, 2007), and the formation of biodiversity and endemism hotspots in different areas of its geography (Cabrera & Willink, 1973). This desert is characterized by the presence of coleopteran species with particular

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species richness (Cepeda-Pizarro *et al*., 2005a, 2005b; Pizarro-Araya *et al.*, 2012a), endemism (Jerez, 2000; Pizarro-Araya *et al.*, 2012b), and restricted distribution (Pizarro-Araya & Jerez, 2004; Alfaro *et al.*, 2013; Flores & Pizarro-Araya, 2012).

In the desert's southern limit, which also represents the southern limit of the plant biodiversity hotspots recognized for central Chile (Gaston, 2000), it is possible to distinguish a coastal scrub interface (30-32º Lat S) featuring changes in the biotic structure of its components, mainly plants (Gajardo, 1993; Squeo *et al.*, 2001) and rain (Novoa & Villaseca, 1989). Among the studies on coleopterans conducted in the Coastal Matorral we can mention Solervicens (1973) research on the coleopterans of the forests of Quinteros; Sáiz & Vásquez (1980) and Vásquez & Sáiz (1983-1985) on the taxocenosis of coleopterans in some Chilean steppes; Sáiz *et al.* (1990) on the impact of forest fires on the coleopteran fauna of the coastal sclerophyll forest; and Barbosa & Marquet (2002) on the effect of habitat fragmentation on the coleopteran fauna of the Fray Jorge National Park (Coquimbo Region, Chile). From these studies we can gather that (1) in general, the epigean arthropod fauna in the Matorral is poor both in species and specimens; (2) assemblages are characterized by the presence of few abundant species and some accessory ones; (3) assemblages tend to have a particular composition in each plant formation; (4) abundance and diversity appear to bear a positive correlation to plant diversity; (5) the phenological activity is markedly seasonal and related to food availability and quality; and (6) Tenebrionidae is apparently one of the most abundant and diverse Arthropoda families.

Tenebrionidae is a well-studied family of the entomofauna of desert ecosystems (Cloudsley-Thompson, 2001; Cepeda-Pizarro *et al.*, 2005b). These insects are known to play a key role in the biological fragmentation of plant resources, in nutrient cycles, and in the diet of other consumer organisms, particularly vertebrates (Pizarro-Araya, 2010; Vidal *et al.*, 2011). In addition, some Tenebrionidae species are used as indicators of climate conditions (Fattorini, 2010) or to identify areas of endemism or hotspots (Pizarro-Araya & Jerez, 2004; Carrara *et al.*, 2011). In this context, the objective of this study is to determine the taxonomic composition and the variations in relative abundance of epigean tenebrionids in the desert portion of the Coquimbo Region's Coastal Matorral (30-32º Lat S), in Chile.

Materials and Methods

Location and description of the study site

The study was conducted in the coastal area of Chile's nothern-central region, which extends from 30º S (Las Tacas) to 32º S (Caracas, Los Vilos) in the Coquimbo Region, Chile (Fig. 1). The climate in the area is of Mediterranean type with low daily and annual temperature variation as a result of the sea influence (Novoa & Villaseca, 1989). The area corresponds to an interior desert area. The average annual precipitation in the valley is *ca* 104 mm (Novoa & Villaseca, 1989); June is the rainiest month, with 25.9 mm. The estimated evaporation reaches 1220 mm during the year with a monthly maximum of 172 mm in January and a monthly minimum of 47 mm in June. The dry season lasts 9 months. The average monthly temperature stays above 10 ºC between January and December (Novoa & Villaseca, 1989).

The vegetation is mostly of steppe type with some influences both from northern and central Chile (Squeo *et al.*, 2001). It consists of a series of patches of different sizes, most of them small and surrounded by a homogeneous matrix degraded by desertification. According to Gajardo (1993), the original plant formations of the study area are represented, from north to south, by a steppe of shrubs, scrubs, and sclerophyll scrubs. For purposes of this study, we divided the study area into three sectors, based on the plant formations, following Gajardo (1993): Sector A (shrubby steppe scrub), which includes the localities of Las Tacas, Lagunillas, and Morrillos; Sector B (forest steppe scrub), which includes the localities of Alcones Altos, Alcones Medios, and Pata de León; Sector C (arborescent steppe scrub), which includes the localities of Caracas 1, Caracas 2, and Subestación Quereo (Table 1 and Fig. 1).

Sector A is characterized by low plant coverage and the presence of low shrubs distributed on the coastal plains and the slopes of the coastal mountain range.The main plant communities in this sector are *Adesmia microphylla* Hook. & Arn. and *Senna cumingii* (Hook et Arn.) Irw. et Barneby var.; *Heliotropium stenophyllum* H. et A. and *Fuchsia lycioides* (Juss.) Mold., *Myrcianthes coquimbensis* (Barneoud) Landrum & Grifo and *Echinopsis coquimbana* (Molina) Friedich & Rowley; *Alona filifolia* (Hook. & Arn.) I.M.Johnst. and *Plantago*

Table 1. Temporal percentage relationships of epigean tenebrionids present in three localities of the steppe matorral (Coquimbo Region, Chile).

Taxon		S1	S2	S3	Total	
Tribe	Species	n	n	n	n	%
Nycteliini	*Gyriosomus foveopunctatus* Fairmaire	0	1,878	0	1,878	10
	Gyriosomus freyi Gebien	39	732	0	771	4
	Gyriosomus hoppei (Gray)	7,590	583	0	8,173	46
	Gyriosomus luczotii Laporte	968	512	0	1,480	8
	Gyriosomus reedi Kulzer	0	209	0	209	1
	Gyriosomus modestus Kulzer	0	0	53	53	0
	Auladera crenicosta (Guérin-Méneville)	24	0	39	63	0
Praociini	*Praocis* (*Praocis*) *sanquinolenta* Gay & Solier	14	60	1	74	0
	Praocis (Praocis) spinolai Gay & Solier	1,156	171	8	1,334	7
	Praocis (Praocis) curta Solier	19	0	48	67	0
	Praocis (Praocis) elliptica Philippi & Philippi	0	0	49	49	0
Scotobiini	*Scotobius bullatus* Curtis	905	177	111	1,192	7
	Diastoleus girardi Peña	73	22	0	95	1
Epitragini	*Geoborus lineatus* (Guérin-Méneville)	119	151	15	285	2
	Nyctopetus sp.	22	458	90	570	3
Physogasterini	*Entomochilus tomentosus* (Guérin-Méneville)	3	2	4	8	0
Edrontini	*Arthroconus elongatus* Solier	77	659	452	1,188	7
Eleodini	*Nycterinus rugiceps* Curtis	439	1,208	353	2,000	11
Opatrini	*Blapstinus punctulatus* (Philippi)	0	0	257	257	1
	Total	10,849	6,213	880	17,942	100

S1: shrubby steppe scrub, S2: forest steppe scrub, S3: arborescent steppe scrub.

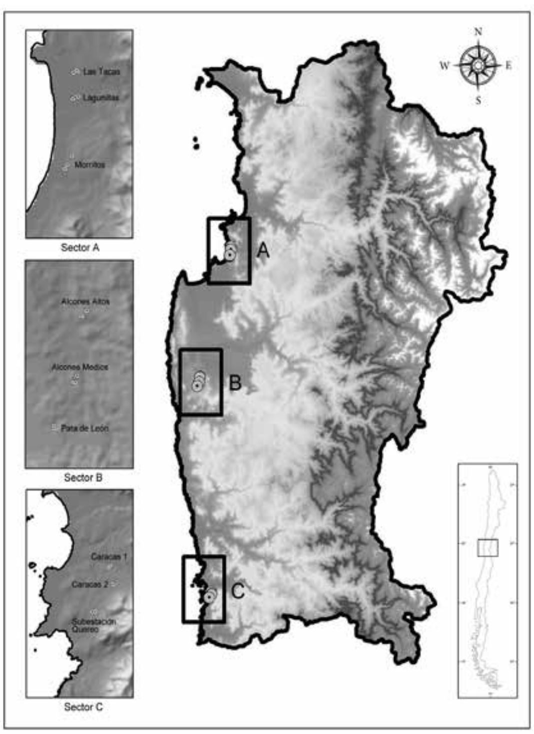

Figure 1. Geographical location of the study sites within the Coquimbo Region, Chile. Sector A: shrubby steppe scrub; Sector B: forest steppe scrub; Sector C: arborescent steppe scrub.

hispidula Ruiz & Pav. Sector B is characterized by low shrubs of heterogeneous density. The most common plant communities found in this sector are *Azara celastrina* D. Don. and *Schinus latifolius* (Gill. ex Lindl.) Engler.; *Lithrea caustica* (Molina) Hook & Arn. and *Porlieria chilensis* I.M.Johnst., *Bahia ambrosioides Lag.* and *Puya chilensis* Mol.; *Helenium aromaticum* (Hook.) Bailey; *Baccharis vernalis* F.H.Hellw. and *Ribes punctatum* Ruiz & Pav.; *Adesmia tenella* H. et A. and *Erodium cicutarium* (L.) L'Hér.; *Puya chilensis* Mol. Finally, sector C is characterized by the predominance of tall shrubs. The plant communities characteristic of this formation are *Peumus boldus* Mol. and *Podanthus mitiqui* Lindl.; *Pouteria splendens* (A.DC.) Kuntze and *Sphacele salviae* (Lindl). Briq.; *Piptochaetium montevidense* and *Haplopappus rosulatus* H.M. Hall; *Nolana paradoxa* Lindl. and *Eriosyce chilensis* (Hildm. ex K.Schum.).

Epigean tenebrionids sampling methodology

The specimens were captured using pitfall traps. Each trap consisted of two plastic cups placed one inside the other; the inner cup could be easily detached. The size of both cups was 7,4 and 7,6 cm in diameter and 10,2 and 12,0 cm in height, respectively. The inner cup was filled two thirds full with a 3:1:6 solution of formaline (10%), glycerine, and water. The traps were arranged following Cepeda-Pizarro *et al.* (2005a, 2005b). The traps operated for three days in each study site during the month of September 2008. A grid of 45 x10 m was defined containing 30 pitfall traps, for a total sampling effort of 810 traps per day. The traps were installed under the plant cover or close to dominant plant species in each of the formations under study. The captured specimens were removed, cleaned, dried, and preserved in alcohol (70º) until their processing and mounting. The material is now stored in the collection of the Ecological Entomology Laboratory (LEULS) of the University of La Serena, Chile. The captured specimens were taxonomically identified by comparing them to reference material stored in the collections of the Natural History National Museum (MNNC, Santiago, Chile) and the Ecological Entomology Laboratory (LEULS), and using the descriptions in Pizarro-Araya & Flores (2004, 2006), and Flores & Pizarro-Araya (2012).

Results and Discussion

Taxonomic composition and relative abundance distribution of the tenebrionid assemblage

A total of 17.942 specimens were captured that represented 8 tribes, 11 genera, and 19 species (Table 1). *Gyriosomus* Guérin-Méneville, with 6 species, was the most diverse genus, followed by *Praocis* Eschscholtz, with 4 species. The remaining genera were represented by only 1 species (Table 1).

The most abundant genus was *Gyriosomus* (63% of total capture), followed by *Nycterinus* Eschscholtz (10%), *Praocis* (7%), and *Scotobius* Germar (6%). It is worth noting that the abundance of *Nycterinus* corresponds exclusively to *Nycterinus rugiceps* Curtis, a species widely distributed in the Coastal Matorral (Peña, 1971) (Fig. 1). The numerically dominant species were *Gyriosomus hoppei* (Gray) (41% of total capture), followed by *Gyriosomus foveopunctatus* Fairmaire (10%), *Nycterinus rugiceps* (10%), and *Praocis* (*Praocis*) *spinolai Gay &* Solier (7%) (Fig. 1).

Distribution of the relative abundances of the tenebrionid assemblage per sector

Differences in the taxonomic composition and abundance of the tenebrionid assemblage were observed between sectors. Sector A (shrubby steppe scrub) was represented by 14 species, among which the most abundant were *Gyriosomus hoppei*, *Gyriosomus luczotii*, *Praocis* (*Praocis*) *spinolai*, *Scotobius bullatus* and *Nycterinus rugiceps*, all taxa endemic of coastal dune ecosystems (Table 2). Sector B (arborescent steppe scrub) was represented by 14 species, among which the most abundant were *Gyriosomus foveopunctatus*, *Gyriosomus freyi*, and *Nycterinus rugiceps* (Table 3). Sector C (woody steppe scrub) was represented by 13 species, among which the mos abundant were *Arthroconus elongatus*, *Nycterinus rugiceps* and *Blapstinus punctulatus* (Table 4).

We identified *Gyriosomus* species with sympatric distribution patterns: *Gyriosomus freyi*, *Gyriosomus hoppei*, and *Gyriosomus luczotii* (found in sectors A and B); *Praocis* was represented by 4 species–two of them sympatric in sector B and sector C. Among these four species, *Praocis* (*Praocis*) *sanquinolenta* and *Praocis* (*Praocis*) *spinolai* were found in the entire study area, in accordance with Flores & Pizarro-Araya (2012). Other species showed restricted distribution ranges, such as *Gyriosomus foveopunctatus* and *G. reedi*, species found only in sector B, and *G. modestus*, *Praocis* (*Praocis*) *elliptica*, and *Blapstinus punctulatus*, found only in sector C (Table 1).

The fact that *Gyriosomus* prefers sandy environments agrees with observations made by Pizarro-Araya *et al.* (2011) indicating that those habitats allow for deeper ovipostures and lower energy expenditure. The resulting saved energy is used for egg production and searching for microhabitats (Deslippe *et al.*, 2001; Pizarro-Araya, 2010).

The presence of *Gyriosomus* in the strip extending from 30º to 32º Lat S supports the idea put forward by some authors (Jerez, 2000; Pizarro-Araya & Jerez, 2004) who say that species with less vagile species would be an indication of different degrees of diversity and local endemism. This apparently is consistent with the characteristics of the flora (Armesto *et al.*, 1993) or with a better supply of high-quality food resources, as it has been suggested by Rau *et al.* (1998) and Spotorno *et al.* (1998) in relation to the entomological elements of the 21-26º Lat S transect,

Table 2. Temporal percentage relationships of epigean tenebrionids present in three localities of the shrubby steppe scrub (Sector A) (Coquimbo Region, Chile).

	Las Tacas		Lagunillas		Morrillos		Total	
Species	n	%	n	%	n	%	n	%
Gyriosomus foveopunctatus	0	0	0	0	0	0	0	0
Gyriosomus freyi	39	1	0	0	0	0	39	0
Gyriosomus hoppei	3,240	82	2,613	80	1,737	48	7,590	70
Gyriosomus luczotii	0	0	206	6	762	21	968	9
Gyriosomus reedi	0	0	0	0	0	0	0	0
Gyriosomus modestus	0	0	0	0	0	0	0	0
Auladera crenicosta	0	0	0	0	24	1	24	0
Praocis (*Praocis*) *sanquinolenta*	0	0	0	0	14	0	14	0
Praocis (*Praocis*) *spinolai*	212	5	288	9	656	18	1,156	11
Praocis (*Praocis*) *curta*	13	0	6	0	0	0	19	0
Praocis (*Praocis*) *elliptica*	0	0	0	0	0	0	0	0
Scotobius bullatus	575	15	105	3	225	6	905	8
Diastoleus girardi	2	0	33	1	38	1	73	1
Geoborus lineatus	1	0	14	0	104	3	119	1
Nyctopetus sp.	0	0	0	0	22	1	22	0
Entomochilus tomentosus	0	0	0	0	3	0	3	0
Arthroconus elongatus	68	2	4	0	5	0	77	1
Nycterinus rugiceps	9	0	192	6	238	7	439	4
Blapstinus punctulatus	0	0	0	0	0	0	0	0
Total	3,959	100	3,261	100	3,629	100	10,849	100

Table 3. Temporal percentage relationships of epigean tenebrionids present in three localities of the forest steppe scrub (Sector B) (Coquimbo Region, Chile).

Species	n	%	n	%	n	%	n	%
Gyriosomus foveopunctatus	985	42	253	14	641	31	1,878	30
Gyriosomus freyi	270	12	226	12	237	11	732	12
Gyriosomus hoppei	15	1	373	21	194	9	583	9
Gyriosomus luczotii	112	5	226	12	174	8	512	8
Gyriosomus reedi	120	5	18	1	71	3	209	3
Gyriosomus modestus	0	0	0	0	0	0	0	0
Auladera crenicosta	0	0	0	0	0	0	0	0
Praocis (*Praocis*) *sanquinolenta*	39	2	0	0	20	1	60	1
Praocis (*Praocis*) *spinolai*	47	2	75	4	48	2	171	3
Praocis (*Praocis*) *curta*	0	0	0	0	0	0	0	0
Praocis (*Praocis*) *elliptica*	0	0	0	0	0	0	0	0
Scotobius bullatus	46	2	71	4	60	3	177	3
Diastoleus girardi	3	0	11	1	7	0	22	0
Geoborus lineatus	99	4	0	0	52	3	151	2
Nyctopetus sp.	286	12	17	1	156	8	458	7
Entomochilus tomentosus	1	0	0	0	1	0	2	0
Arthroconus elongatus	0	0	439	24	220	11	659	11
Nycterinus rugiceps	500	22	310	17	398	19	1,208	19
Blapstinus punctulatus	0	0	0	0	0	0	0	0
Total	2,323	100	1,819	100	2,071	100	6,213	100

Table 4. Temporal percentage relationships of epigean tenebrionids present in three localities of the arborescent steppe scrub (Sector C) (Coquimbo Region, Chile).

	Caracas 1		Caracas 2		Subestación Quereo		Total	
Species	n	%	n	%	n	%	n	%
Gyriosomus foveopunctatus	0	0	0	0	0	0	0	0
Gyriosomus freyi	0	0	0	0	0	0	0	0
Gyriosomus hoppei	0	0	0	0	0	0	0	0
Gyriosomus luczotii	0	0	0	0	0	0	0	0
Gyriosomus reedi	0	0	0	0	0	0	0	0
Gyriosomus modestus	27	17	0	0	26	4	53	6
Auladera crenicosta	18	11	0	0	21	3	39	4
Praocis (*Praocis*) *sanquinolenta*	1	1	0	0	0	0	1	0
Praocis (*Praocis*) *spinolai*	0	0	0	0	8	1	8	1
Praocis (*Praocis*) *curta*	20	12	19	18	9	1	48	5
Praocis (*Praocis*) *elliptica*	4	2	43	40	3	0	49	6
Scotobius bullatus	32	20	64	60	15	2	111	13
Diastoleus girardi	0	0	0	0	0	0	0	0
Geoborus lineatus	15	10	0	0	0	0	15	2
Nyctopetus sp.	54	34	10	9	26	4	90	10
Entomochilus tomentosus	0	0	0	0	4	1	4	0
Arthroconus elongatus	111	69	0	0	341	56	452	51
Nycterinus rugiceps	78	49	151	141	124	20	353	40
Blapstinus punctulatus	0	0	20	19	237	39	257	29
Total	160	100	107	100	613	100	880	100

and Vidal *et al.* (2011) on *Gyriosomus batesi* Fairmaire and *Gyriosomus subrugatus* Fairmaire, both species endemic from the Atacama desert (28º Lat S).

The diet strategies of *Gyriosomus* species may depend on physiological factors of each species. For example, *Gyriosomus* species show marked sexual dimorphism, which can modulate food search and manipulation based on the nutritional quality potential, especially in desert ecosystems (Polis, 1991). Therefore, females may show preference for prey of higher quality, such as exoskeletons or preimaginal stages of other arthropods. This strategy may be related to the amount of energy invested during the reproductive stage, which may improve their egg-laying and oviposture capacities. However, the trophic strategies showed by *Gyriosomus* lead us to postulate that this taxon occupies higher trophic levels, and as such their ability to influence the modulation of activities in these environments has been clearly underestimated. These species are likely responsible for the increase in the primary and secondary production of these ecosystems (Oksanen *et al.*, 1981) either as a result of their yet unknown pollinating capacity or the role they play in the decomposition of elements in the environment. As is the case with *Gyriosomus*, it is expectable that other tenebrionid assemblages will also show variations in their ecological-trophic strategies neccesary to optimize the use of the more abundant and better quality resources available during the wet season (i.e., humid non-ENSO years or ENSO years) (Cepeda-Pizarro *et al.*, 2005a, 2005b). The variations in the trophic selection behavior of this Nycteliini group raise a series of questions related to the functional role played by these species in the arid and semiarid ecosystems of Chile.

As the limited distribution of these endemic taxa increases their likelyhood of extinction (Myers *et al.*, 2000), establishing areas of endemism is essential for the sustainable use and conservation of the biodiversity (Szumik *et al.*, 2002). Knowledge of these taxonomical aspects is fundamental for building a general record of the entomofauna of these coastal scrub ecosystems in Chile.

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Literature Cited

Alfaro, F.M.; Pizarro-Araya, J.; Flores, G.E.
2009. Epigean tenebrionids (Coleoptera: Tenebrionidae) from the Choros archipelago (Coquimbo Region, Chile). *Entomological News*, 120: 125-130.

Alfaro, F.M.; Pizarro-Araya, J.; Letelier, L.; Cepeda-Pizarro, J.
2013. Distribución geográfica de los ortópteros (Insecta: Orthoptera) presentes en las provincias biogeográficas de Atacama y Coquimbo (Chile). *Revista de Geografía Norte Grande*, 56: 235-250.

Armesto, J.J.; Vidiella, P.E.
1993. Plant life forms and biogeographic relations of the flora of Lagunillas (30ºS) in the fog-free pacific coastal desert. *Annals of the Missouri Botanical Garden*, 80: 499-511.

Barbosa, O.; Marquet, P.A.
2002. Effects of forest fragmentation on the beetle assemblage at the relict forest of Fray Jorge, Chile. *Oecologia*, 132: 296-306.

Cabrera, A.; Willink, A.
1973. *Biogeografía de América Latina*. Monografías de la OEA, Serie Biología. 122 pp.

Carrara, R., Cheli, G.H.; Flores, G.E.
2011. Patrones biogeográficos de los tenebriónidos epígeos (Coleoptera: Tenebrionidae) del Área Natural Protegida Península Valdés, Argentina: implicancias para su conservación. *Revista Mexicana de Biodiversidad*, 82: 1297-1310.

Cepeda-Pizarro, J.; Pizarro-Araya, J.; Vásquez, H.
2005a. Composición y abundancia de artrópodos epígeos del Parque Nacional Llanos de Challe: impactos del ENOS de 1997 y efectos del hábitat pedológico. *Revista Chilena de Historia Natural*, 78: 635-650.

Cepeda-Pizarro, J.; Pizarro-Araya, J.; Vásquez, H.
2005b. Variación en la abundancia de la artropodofauna, con énfasis en tenebriónidos epígeos del desierto costero transicional de Chile. *Revista Chilena de Historia Natural*, 78: 651-663.

Cloudsley-Thompson, J.L.
2001. Thermal and water relations of desert beetles. *Naturwissenschaften*, 88: 447-460.

Deslippe, R.J.; Salazar, J.R.; Guo, Y.L.
2001. A darkling beetle population in West Texas during the 1997-1998 El Niño. *Journal of Arid Environments*, 49: 711-721.

Di Castri, F.; Hajek, E.R.
1976. *Bioclimatología de Chile*. Imprenta-Editorial de la Universidad Católica de Chile. Santiago, Chile. 128 pp.

Fattorini, S.
2010. Use of insect rarity for biotope prioritisation: the tenebrionid beetles of the Central Apennines (Italy). *Journal of Insect Conservation*, 14: 367-378.

Flores, G.E.; Pizarro-Araya, J.
2012. Systematic revision of species of the South American genus *Praocis* Eschscholtz, 1829 (Coleoptera: Tenebrionidae). Part 1: Introduction and subgenus *Praocis* s. str. *Zootaxa*, 3336: 1-35.

Gajardo, R.
1993. *La vegetación natural de Chile: clasificación y distribución geográfica*. Editorial Universitaria, Santiago, Chile. 165 pp.

Gaston, K.J.
2000. Global patterns in biodiversity. *Nature*, 405: 220-227.

Jerez, V.
2000. Diversidad y patrones de distribución geográfica de insectos coleópteros en ecosistemas desérticos de la región de Antofagasta, Chile. *Revista Chilena de Historia Natural*, 73: 79-92.

Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; da Fonseca, G.A.B.; Kent, J.
2000. Biodiversity hotspots for conservation priorites. *Nature*, 403: 853-858.

Novoa, R.; Villaseca, S.
1989. (Eds.) *Mapa agroclimático de Chile*. Instituto de Investigaciones Agropecuarias, Santiago, Chile. 126 pp.

Oksanen, L.; Fretwell, S.D.; Arruda, J.; Niemela, P.
1981. Exploitation ecosystems in gradients of primary productivity. *American Naturalist*, 118: 240-261.

Peña, L.E.
1971. Revisión del género *Nycterinus* Eschscholtz, 1829 (Coleoptera-Tenebrionidae). *Boletín del Museo Nacional de Historia Natural (Chile)*, 32: 129-158.

Pizarro-Araya, J.
2010. Hábitos alimenticios del género *Gyriosomus* Guérin-Méneville, 1834 (Coleoptera: Tenebrionidae): ¿qué comen las vaquitas del desierto costero? *Idesia*, 28: 115-119.

Pizarro-Araya, J.; Flores, G.E.
2004. Two new species of *Gyriosomus* Guérin-Méneville from Chilean coastal desert (Coleoptera: Tenebrionidae: Nycteliini). *Journal of the New York Entomological Society*, 112: 121-126.

Pizarro-Araya, J.; Flores, G.E.
2006. La posición sistemática de *Geoborus lineatus* (Guérin-Méneville), comb. nov. (ex. *Gyriosomus*) (Coleoptera: Tenebrionidae). *Revista de la Sociedad Argentina de Entomología*, 65: 85-90.

Pizarro-Araya, J.; Jerez, V.
2004. Distribución geográfica del género *Gyriosomus* Guérin-Méneville, 1834 (Coleoptera: Tenebrionidae): una aproximación biogeográfica. *Revista Chilena de Historia Natural*, 77: 491-500.

Pizarro-Araya, J.; Jerez, V.; Cepeda-Pizarro, J.; Alfaro, F.M.
2011. Caracteres preimaginales y aspectos bionómicos de *Gyriosomus luczotii* Laporte, 1840 (Coleoptera: Tenebrionidae), elemento endémico y erémico del desierto costero chileno. *Animal Biodiversity and Conservation*, 34.2: 37-44.

Pizarro-Araya, J.; Vergara, O.E.; Flores, G.E.
2012a. *Gyriosomus granulipennis* Pizarro-Araya & Flores 2004 (Coleoptera: Tenebrionidae) un caso extremo a conservar. *Revista Chilena de Historia Natural*, 85: 345-349.

Pizarro-Araya, J.; Alfaro, F.M.; Castillo, J.P.; Ojanguren-Affilastro, A.A.; Agusto, P.; Cepeda-Pizarro, J.
2012b. Assemblage of arthropods in the Quebrada del Morel private protected area (Atacama Region, Chile). *Pan Pacific Entomologist*, 88: 1-14.

Polis, G.A.
1991. Complex trophic interactions in deserts an empirical critique of food-web theory. *American Naturalist*, 138: 123-155.

Rau, J.R.; Zuleta, C.; Ganz, A.; Sáiz, F.; Cortes, A.; Yates, L.; Spotorno A.E.; Couve, E.
1998. Biodiversidad de artrópodos y vertebrados terrestres del Norte Grande de Chile. *Revista Chilena de Historia Natural*, 71: 527-554.

Rundel, P.W.; Villagra, P.E.; Dillon, M.O.; Roig-Juñent, S.; Debandi. G.
2007. Deserts and Semi-Desert Environments. *In*: Veblen, T.; Young, K.; Orme, A. (Eds). The Physical Geography of South America: 158-183 p. Oxford Regional Environment Series. Oxford University Press.

Sáiz, F.; Vásquez, E.
1980. Taxocenosis coleopterológicas epígeas en estepas de Chile semiárido. *Anales del Museo de Historia Natural de Valparaíso (Chile)*, 13: 145-157.

Sáiz, F.; Solervicens, J.; Vivar, C.
1990. Incendios forestales en el Parque Nacional La Campana, sector Ocoa, V Región, Chile. VI. Coleópteros epígeos. Impacto y recuperación. *Anales del Museo de Historia Natural de Valparaíso (Chile)*, 6: 131-159.

Solervicens, J.
1973. Coleópteros del bosque de Quintero. *Anales del Museo de Historia Natural Valparaíso (Chile)*, 6: 115-159.

Spotorno, A.E.; Zuleta, C.; Gantz, A.; Sáiz, F.; Rau, J.; Rosenmann, M.; Cortes, A.; Ruiz, G.; Yates, L.; Couve, E.; Marín. J.C.
1998. Sistemática y adaptación de mamíferos, aves e insectos fitófagos de la Región de Antofagasta, Chile. *Revista Chilena de Historia Natural*, 71: 501-526.

Squeo, F.A.; Arancio, G.; Gutiérrez, J.R.
2001. *Libro rojo de la flora nativa y de los sitios prioritarios para su conservación: Región de Coquimbo*. Ediciones Universidad de La Serena, La Serena, Chile. 372 pp.

Szumik, C.; Cuezzo, F.; Goloboff, P.; Chalup, A.
2002. An optimality criterion to determine areas of endemism. *Systematic Biology*, 51: 806-816.

Vásquez, E.; Sáiz, F.
1983-1985. Respuesta de Carabidae y Tenebrionidae (Coleoptera) de una estepa de *Acacia caven* a la presencia de un foco de agua permanente. *Anales del Museo de Historia Natural Valparaíso (Chile)*, 16: 71-86.

Vidal, M.A.; Pizarro-Araya, J.; Jerez, V.; Ortiz, J.C.
2011. Daily activity and thermoregulation in predatore-prey interaction during the Flowering Desert in Chile. *Journal of Arid Environments*, 75: 802-808.