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RESEARCH PAPER

Diversity and distribution of the *Aegorhinus* genus in the La Araucanía Region of Chile, with special reference to *A. superciliosus* and *A. nodipennis*

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Abstract

A. Zavala, M. Elgueta, J. Abarzúa, A. Aguilera, A. Quiroz, and R. Rebolledo. 2011. Diversity and distribution of the *Aegorhinus* genus in the La Araucanía Region of Chile, with special reference to *A. superciliosus* and *A. nodipennis*. Cien. Inv. Agr. 38(3): 367-377. The Araucanía region is a berry producing area where important behavioral aspects of species in the genus *Aegorhinus*, a pest that affects crops, are still unknown. The objectives of this study were to determine the distribution, abundance and richness of these species in agroecological zones of La Araucanía Region and to determine the hosts in which they were found. The sites where these species were found were represented on a map divided into grids of 25 x 25 km. Eight species of *Aegorhinus* were found in the area, and *Aegorhinus nodipennis* and *Aegorhinus superciliosus* were the most abundant. The diversity was analyzed using the Shannon-Wiener index, and the equitability was determined using the Pielou index. The agroecological zone with the greatest diversity of the region corresponded to mountain ranges; however, the central plain registered the highest abundance of individuals. This study introduces new hosts for six of the eight species found in the region.

Key words: *Aegorhinus*, agroecological zones, Coleoptera, hosts.

Introduction

Aegorhinus Erichson and *Alastoropolus* Kuschel are the only genera of the Aterpini tribe (Coleoptera: Curculionidae) in South America (Elgueta and Marvaldi, 2006). In Chile, they are located from the central to the southernmost zones, *i.e.*, from 32º 02' to 53º 08' south latitude. Similarly, they can be found in the Andean forests of southern Argentina (Morrone and Roig-Juñent, 1999). Within this tribe, the *Aegorhinus* genus is the most diverse and contains 24 species (Kuschel, 1951; Cekalovic, 1970; Elgueta, 2000). Moreover, A. *superciliosus, A. nodipennis* and *A. phaleratus* constitute major agricultural pests in Chile. *A. superciliosus* is considered the most important species in La Araucanía region due to its negative impact on the production of berries (Aguilera, 1988, 1990). Most species are associated with

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deciduous forests and Valdivian temperate forests from the Maule to Los Lagos Regions (Klein and Waterhouse, 2000; Marvaldi and Elgueta, 2006). Approximately 30% of *Aegorhinus* spp. are closely linked to species formations of Fagaceae (Elgueta, 1974). Of all the *Aegorhinus* species, only three are considered major agricultural pests in Chile, namely, *A. phaleratus* and *A. superciliosus* associated with berries (Gonzalez, 1989; Prado, 1991; Artigas, 1994; Klein and Waterhouse, 2000; Cisternas, 2002; Aguilera, 2005) and *A. nodipennis* found mainly in *Corylus avellana* (European hazelnut). In addition, *A. albolineatus* has been described as an occasional raspberry pest in *Rubus idaeus* (Cisternas *et al*., 2000).

The larvae and adult stages of *A. phaleratus* and *A. superciliosus,* which are reported as being responsible for the damage to their host species, are similar in shape and color; however, they have distinctive characteristics and different geographical distributions (Elgueta, 1993). The first is found from Valparaiso to the Maule Region, whereas the second is established between the Maule and Los Lagos Region. Moreover, both species have a wide host range (Prado, 1991; Elgueta and Marvaldi, 2006 and Parra *et al*., 2009a).

A. nodipennis is considered one of the most important hypogea insects that affect growing European hazelnut plants due to its frequent presence in farms and its life habits during the larvae stage (Aguilera, 2005). *A. superciliosus* is found in several fruit tree species (Kuschel, 1951; Parra *et al*., 2009a) and, together with *A. nodipennis,* is considered one of the most common pests in Valdivian forests (Artigas, 1994). Interestingly, there is plenty of literature regarding their host species (Kuschel, 1951; Prado, 1991; Artigas, 1994, Klein and Waterhouse, 2000; Cisternas, 2002; Aguilera, 2005; Elgueta and Marvaldi, 2006; Parra *et al*., 2009a).

Research on *Aegorhinus* in Chile is mostly focused on its geographic distribution (Aguilera, 1988, 1995; Elgueta, 1993; Artigas, 1994; Arias, 2000), morphological description (Kuschel, 1951; Aguilera, 1988; Aguilera and Rebolledo, 2001; Carrillo *et al*., 2002) and on damage and control (Kuschel, 1951; Aguilera, 1988, 1995; Prado, 1991; Carrillo, 1993; Elgueta, 1993; Cisternas *et al*., 2000; France *et al*., 2000; Parra *et al*., 2009b; Mutis *et al*., 2009).

In the La Araucanía Region, the diversity and distribution of species infecting cultivated and wild hosts is unknown; moreover, there is no information regarding possible preferences for certain host species. Therefore, this study aimed at determining the distribution, richness and abundance of *Aegorhinus* species in different agroecological areas of La Araucanía. Similarly, we identified the hosts where these insect species could be found.

Materials and methods

Insect sampling

Sampling was performed at different sites in each agroecological zone of the La Araucanía region (37º 35' and 39º 37' south latitude) as described by Rouanet *et al*. (1988). At each site, we identified the *Aegorhinus* species and plants on which the insects were found. A regional map including the agroecological zones and a grid of 25 x 25 km was used for sampling (Figure 1). Each grid was designated by a pair of letters, which were never repeated within the same area. At least 20 sampling points per agroecological zone were randomly chosen, resulting in a total of 122 points for the region. La Araucanía is located in the UTM (Universal Transversal Mercator) zones 18 (central meridian of longitude -75°) and 19 (central meridian of longitude -69°; Borgel, 1983).

The insect sampling was conducted between September 2008 and April 2009 using three methods: a) shaking the foliage on an entomological umbrella, b) scanning of entomological nets on herbs, shrubs and wild or cultivated trees according to the environmental situation of each sampling station and c) visual observation. Each collected individual was

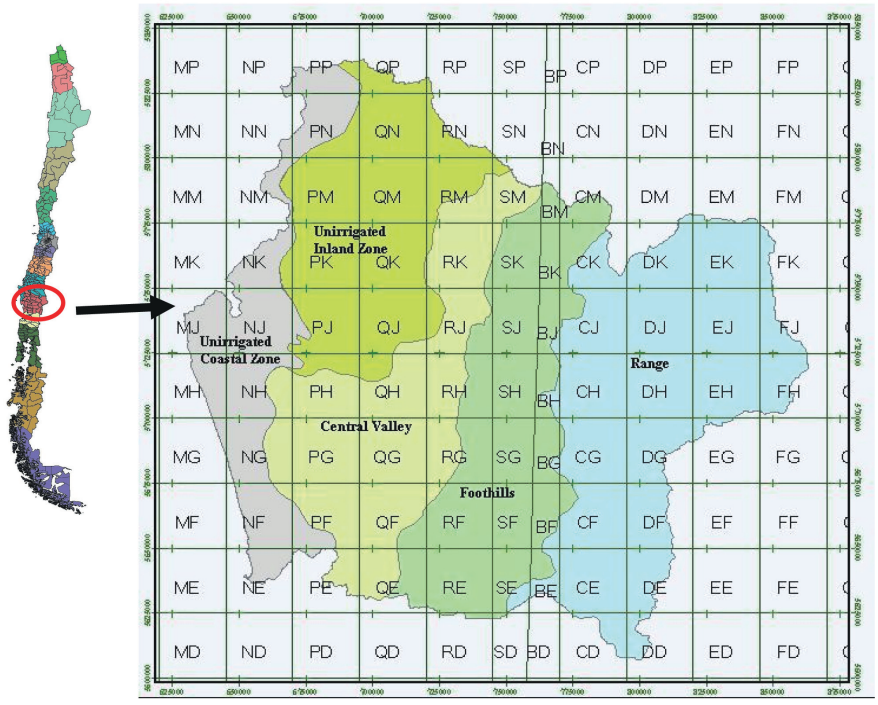

Figure 1. Map of agroecological zones with grids of 25 x 25 km in La Araucanía region. (Methodology adapted from Pascual and Montserrat, 1988).

recorded with a numerical identifier (ID), collection location, geographical location, altitude and host in which it was found.

Abundance and infestation

The abundance of insects per plant was estimated according to the following scale:
Low = one to three individuals
Median = four to six
Abundant = seven to ten
Very abundant = more than ten individuals
The percentage of *Aegorhinus* infestation per plant was determined by the following equation:

$$\text{Infestation percentage} = \frac{\text{Total infested trees for species A}}{\text{Total sampled trees for species A}} \times 100$$

Distribution map and population indices

To prepare the distribution maps of the *Aegorhinus* species, coordinates were obtained at each sampling site using a global positioning system and the GPS III Plus software (GARMIN International, Kansas, USA, 2008). The maps were elaborated from the GPS database in the laboratory of Ordenación y Planificación Territorial of the Facultad de Ciencias Agropecuarias y Forestales of the Universidad de la Frontera using the ArcGIS 9 software program, version 9.2 ArcMap (ESRI USA, 2004). With the obtained data, several population variables such as richness (S), total abundance of individuals (N), relative abundance (AB%) and alpha diversity were calculated for each agroecological area using the Shannon-Wiener (H'), Pielou equity index (J) and maximum diversity (H' max) indices (Moreno, 2001).

Results and discussion

Richness

Eight *Aegorhinus* species were identified in the region: *A. superciliosus* (Guérin), *A. nodipennis* (Hope), *A. schoenherri* (Gay & Solier), *A. suturalis* (Blanchard), *A. ochreolus* Kuschel, *A. oculatus*

Kuschel, *A. silvicola* Kuschel and *A. bulbifer* Kuschel. Of the eight species, three were found in the coastal rain-fed area, three in the interior rain-fed zone, five in the central plain, four in the Andes foothills and six in the Andes mountains. Of all the species, *A. superciliosus* and *A. nodipennis* were collected in the five assessed agroecological areas (Table 1).

Distribution and abundance

A total of 11,770 Aegorhinus spp. individuals were counted, and the central plains and the Andean foothills had the highest number of individuals, 6,629 and 4,793, respectively. Most of the specimens were collected from blueberries (Vaccinium corymbosum) and raspberries (R. idaeus) plants. The lowest abundance was found in the Andes mountains, with 69 individuals (Figure 2).

Of all the species found in this study, the two most abundant in the Araucanía region were *A. superciliosus* (9,963 individuals) and *A. nodipennis* (1,692 individuals), which corresponded to 99.02% of the total registered (Table 1). The abundance of these two species might be explained by their host preference, berry plants, as suggested by several authors (Aguilera, 1988, 1990 and 1995; Parra *et al*., 2009b). In addition, *A. ochreolus*, *A. schoenherri*, *A. suturalis* and *A. silvicola* were considered fairly abundant species, where as the remaining species were considered median.

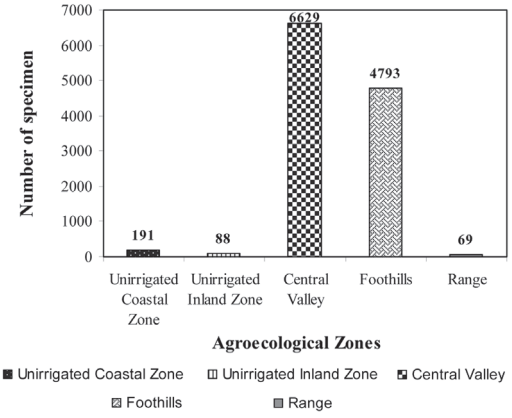

Figure 2. Total number of specimens of the genus *Aegorhinus* registered in the agroecological zones of La Araucanía region, Chile. Foothills and range correspond the Andes mountain range (see Figure 1).

Regarding the geographic distribution of each species, *A. superciliosus* dominated in four agroecological zones: the Andes foothills (87.57%), the coastal rain-fed zone (85.86%) and the central plains (83.77%), where the highest relative abundances were found. The second most abundant species was *A. nodipennis,* with a higher total abundance in the central plains and in the Andean foothills; however, its higher relative abundance, *i.e.*, the percentage of total individuals, occurred in the mountains and in the interior rain-fed zone. The third most abundant species was *A. schoenherri*, with the highest abundance and relative abundance in the Andes foothills (Table 1).

Interestingly, most *Aegorhinus* species found in La Araucanía had low population levels and did

Table 1. Total abundance of *Aegorhinus* registered in the agroecological zones of La Araucanía region.

Species	Unirrigated coastal zone		Unirrigated inland zone		Central valley		Andes foothills		Andes mountain range	
	TE, no.	AR %	TE no.	AR %	TE no.	AR %	TE no.	AR %	TE no.	AR %
A. superciliosus	164	85.86	47	53.41	5553	83.77	4197	87.57	2	2.90
A. nodipennis	26	13.61	23	26.14	1029	15.52	591	12.33	23	33.33
A. schoenherri					1	0.02			23	33.33
A. suturalis	1	0.52	18	20.45	13	0.20	3	0.06		
A. bulbifer									7	10.14
A. silvicola							2	0.04	13	18.84
A. ochreolus					33	0.50				
A. oculatus									1	1.45
Total individuals per zone	191		88		6629		4793		69	

TE, Total specimens; AR, Relative abundance.

not become pests in orchards or other crops of economic importance in the region. In contrast, the most abundant species were *A. superciliosus* and *A. nodipennis*, which are considered pests with a wide host range and great economic impact on fruit trees in Chile. The presence of these species might be a limiting factor for growing fruit trees in the area.

Diversity

The area with the lowest species diversity, according to the Shannon-Wiener index, corresponded to the Andes foothills (H' = 0.3822), followed by the coastal rain-fed zone (H'= 0.4298), central plains (H'= 0.4775), interior rain-fed zone (H'= 1.0103) and the Andes mountains (H'= 1.2109; Table 2). Although the abundance of individuals was higher in these last two areas, their distribution was not even because, in both sectors, *A. superciliosus* represented over 80% of the individuals collected.

Less diverse areas could be the result of environmental degradation due to anthropogenic factors such as the introduction of exotic plant species, location of urban zones and land use for livestock and agriculture (Vergara *et al*., 2006). Similarly, the diversity and distribution of other Coleoptera species in the area might reflect the impact of these factors. For example, the most abundant plant species in the coastal rain-fed zone are *Pinus radiata* and *Eucalyptus globulus*. In the central plain, blueberries (*V. corymbosum*) were introduced as an exotic monoculture.

These results are consistent with previous studies (CONAMA, 2002) in which the greater distance among native forest species (with the coastal rain-fed area presenting the greatest distance), the greater intervention they have suffered, so that the natural conditions for establishment and natural flows between species, *i.e.*, biodiversity, considerably declines. However, our results differ from those of Vidaurre *et al*. (2008), who in a study with dung beetles in Bolivia, described decreased levels of abundance and richness in forests better preserved versus in disturbed habitats. Therefore, disturbed areas supported relatively less abundance and richness than native forests, demonstrating the close relationship that exists with conservation. While this result was coincident with regard to species richness, the abundance differed because the interior rain-fed area and the Andes mountains were the sectors with the lowest levels of exotic plant introduction (CONAMA, 2002) and presented the lowest abundances of *Aegorhinus* individuals. The persistence of species in natural environments largely depends on the intensity and frequency of spatial disturbances of natural and man-made habitats on the land (Escobar and Chacón de Ulloa, 2000).

According to our results, the lowest *Aegorhinus* diversity occurred in the Andean foothills,

Table 2. Population parameters of *Aegorhinus* obtained in the agroecological zones of La Araucanía region, Chile.

Agroecological Zone	S	N	H'	H' max	J'
Unirrigated coastal zone	3	191	0.4298	1.0986	0.3912
Unirrigated inland zone	4	88	1.0103	1.0986	0.9196
Central valley	5	6629	0.4775	1.6094	0.2967
Andes foothills	4	4793	0.3822	1.3863	0.2757
Andes mountain range	6	69	1.2109	1.7918	0.6758

S: specific richness; N: total abundance; H': diversity. Shannon-Wiener index; H' max: maximum diversity; J': Pielou equity index.

and the most diverse sector was the Andean mountains, which, together with the central plain, had the highest species richness. The scarcity of some *Aegorhinus* species might be the result of the sampling dates because they might have been directly linked to certain stages in the phenology of their hosts. Others, however, appeared to be associated with certain environments, such as *A. ochreolus*, which was found in dense forests of *Drymis winteri* in the central plain, whereas *A. schoenherri* and A. *silvicola* were exclusively related to the Andes mountains.

Altitude and hosts

With respect to altitude, the most abundant *Aegorhinus* species ranged from 10 to 1,350 m in altitude (Figure 3).

The greatest but least diverse abundance, registered in the central plain, was associated with the most abundant species (*A. superciliosus* and *A. nodipennis*), which colonized a greater number of hosts distributed in lower elevation locations (Kuschel, 1951; Prado, 1991; Artigas, 1994; Klein and Waterhouse, 2000; Cisternas, 2002; Aguilera, 2005; Elgueta and Marvaldi, 2006).

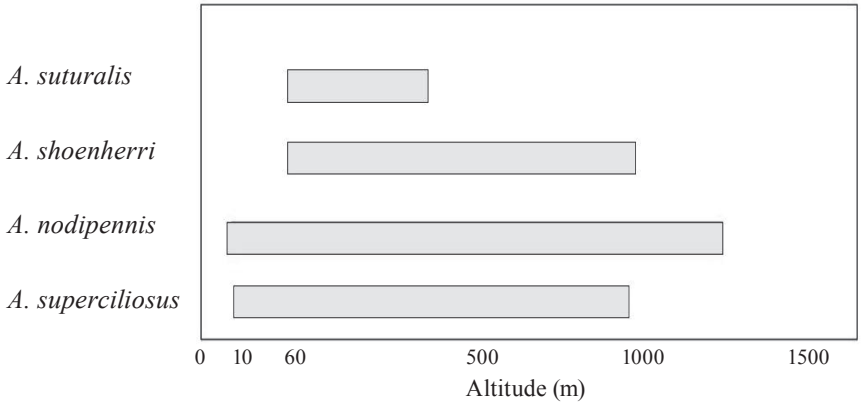

Figure 3. Altitudinal range in which the most abundant *Aegorhinus* species were found in La Araucanía region, Chile.

Table 3. Altitudinal range and hosts where the especies of *Aegorhinus* were found in La Araucanía region, Chile.

Species of *Aegorhinus*	Altitudinal ranges (m)	Hosts
A. bulbifer	360	*Nothofagus dombeyi*
A. nodipennis	6 – 1320	*Maytenus boaria*(1), *Nothofagus obliqua*, *Salix viminalis*(1), *Aristotelia chilensis*, *Vaccinium corymbosum*, *Betula pendula*(1), *Gevuina avellana*, *Peumus boldus*(1), *Lomatia hirsuta*(1), *Drimys winteri*, *Nothofagus pumilio*.
A. ochreolus	132	*Drimys winteri*
A. oculatus	805	*Discaria serratifolia*(1)
A. schoenherri	54 – 959	*Discaria serratifolia* y *Maytenus boaria*(1)
A. silvícola	959	*Nothofagus antartica*(1)
A. superciliosus	6 – 908	*Acacia dealbata*(1), *Maytenus boaria*, *Rubus ulmifolius*, *Salix viminalis*, *Vaccinium corymbosum*, *Rosa moschata*, *Nothofagus obliqua*(1), *Nothofagus dombeyi*, *Nothofagus pumilio*(1), *Populus alba*(1), *Drimys winteri*, *Rubus idaeus*, *Betula pendula*(1), *Cynara scolymus*(1), *Discaria serratifolia*(1), *Lomatia hirsuta*(1)
A. suturalis	54 – 580	*Lomatia hirsuta*(1), *Rubus idaeus*(1), *Salix viminalis*(1)

[1]New record of host for the species.

In the highest areas of the region, except for the mountains, plant diversity was lower because exotic forest species (*e.g.*, pine and eucalyptus) have been uniformly planted (CONAMA, 2002). In the Andes mountain range, the predominant vegetation corresponded to forests of *Nothofagus*, *Araucaria araucana* and Rhamnaceae species, such as *Discaria serratifolia*, which presented *Aegorhinus* species closely associated to only one host; similarly, *A. schoenherri* was found in *D. serratifolia* and *Maytenus boaria* (Table 3).

There were eight new hosts for *A. superciliosus*, but its presence on *Acacia dealbata* was probably accidental. *A. nodipennis* was observed on five new hosts, and it was abundant in *M. boaria*, *Betula pendula* and *Salix viminalis*. *A. suturalis* was first found in *Lomatia hirsuta* and *R. idaeus*, which constituted unknown hosts for this species. *A. schoenherri* was associated with hosts of the Rhamnaceae family. These results are coincident with those of Arias (2000), who mentioned *Discaria serratifolia* (chacay) as host plant, but it was also found in *M. boaria*, which would be a new host for this species.

Regarding host preference, we found the highest presence of *Aegorhinus* in the following species: *M. boaria* (79%), *Rosa moschata* (54.2%), *D. winteri* (46.3%), *Rubus ulmifolius* (44.4%) and *L. hirsuta* (44.1%; Table 4). Despite being one of the species with the greatest *Aegorhinus* presence in the city of Temuco, *B. pendula* only reached 15.8% at the regional level. Consistent with our results, Parra *et al*. (2009a) reported *M. boaria*, *D. winteri* and *R. ulmifolius*, among others, as hosts of *A. superciliosus*. *V. corymbosum* and *R. idaeus* were excluded from the analysis because the insects counted in

Table 4. Total number of hosts for the *Aegorhinus* species sampled, infestation percentage and species of *Aegorhinus*.

Hosts	Total plants	% AI	APAAI	1	2	3	4	5	6	7	8	Total
Maytenus boaria	266	79	2.17	414	41							455
Acacia dealbata	6	17	1.02	1								1
Nothofagus oblicua	130	8	1.53	2	13							15
Lomatia hirsuta	68	44.1	1.17	3	5		27					35
Rubus ulmifolius	376	44.4	0.9	143	1							144
Rosa moschata	83	54.2	1.02	46								46
Salix viminalis	41	19.5	3.25	3	20		3					26
Populus alba	36	27.8	1	10								10
Nothofagus dombeyi	35	43	3	36				9				45
Aristotelia chilensis	20	45	1.55	12	2							14
Drimys. winteri	205	46.3	1.04	2	64					33		99
Peumus boldus	17	12	1.47		3							3
Vaccinium corymbosum	Orchard			9194	1506							10700
Betula pendula	76	15.8	2.58	10	21							31
Gevuina avellana	5	20	1		1							1
Nothofagus antartica	21	5	12.38						13			13
Discaria serratifolia	95	20	1.37	1		24					1	26
Nothofagus pumilio	37	30	1.62	1	17							18
Rubus ideaus	5 rows			100			5					105
Cynara scolymus	25	64	1.88	30								30
Eucaliptus globulus	13	8	1		1							1

% IA: infested trees; AAAIT: average abundance of *Aegorhinus* per infected trees; 1**:** *A. superciliosus*; 2: *A. nodipennis*; 3: *A. schoenherri*; 4**:** *A. suturalis*; 5: *A. bulbifer*; 6: *A. silvicola*; 7: *A. ochreolus* and 8**:** *A. oculatus.*

these host species corresponded to sporadic catches made by farm workers (Table 4).

Aegorhinus specimens were not found in *A. araucana*, *Citrus sinensis*, *Crinodendron patagua*, *Cryptocaria alba*, *Cupressus macrocarpa*, *Eriobotrya japonica*, *Eucryphia cordifolia*, *Luma apiculata*, *Malus* sp., *Persea lingue*, *Prunus cerasus* and *Prunus domestica*. However, there are reports on *Cryptocaria alba* as a host of *A. phaleratus*; *Eucryphia cordifolia* as a host of *A. nodipennis*; *Malus domestica* as a host of *A. nodipennis*, *A. phaleratus* and *A. superciliosus*; *Prunus cerasus* as a host of *A. phaleratus* and *A. superciliosus*; and *P. domestica* as a host of *A. nodipennis*, *A. phaleratus* and *A. superciliosus* (Kuschel, 1951; Prado, 1991; Artigas, 1994; Arias, 2000; Klein and Waterhouse, 2000; Cisternas, 2002; Aguilera, 2005; Elgueta and Marvaldi, 2006).

Maps

The distribution of species considered most important as agricultural pests, *A. superciliosus* and *A. nodipennis* (Figure 4), and the least abundant or of less agricultural importance (Figure 5) were represented separately in maps of the La Araucanía region. The agroecological zones were illustrated in both maps.

Regarding the ecosystem associated with these species, *A. bulbifer* was found in areas of arborescent matorral and open native forest. *A. suturalis* was found in open areas of open arborescent matorral and open prairie matorral. *A. silvicola* and *A. schoenherri* were associated with semi-dense adult native forest and open prairie matorral. *A. oculatus* was associated with semi-dense regrowth areas and open matorral. *A. ochreolus* was described in areas of perennial prairie with open native forests. *A. superciliosus* and *A. nodipennis* were distributed in areas strongly dominated by arborescent matorral.

According to our results, the species of *Aegorhinus* in the Araucanía region were *A. bulbifer*, *A. nodipennis*, *A. ochreolus*, *A. oculatus*, *A. schoenherri*, A. *silvicola*, *A. superciliosus* and *A. suturalis*. Six of these species, *A. superciliosus*, *A. nodipen-*

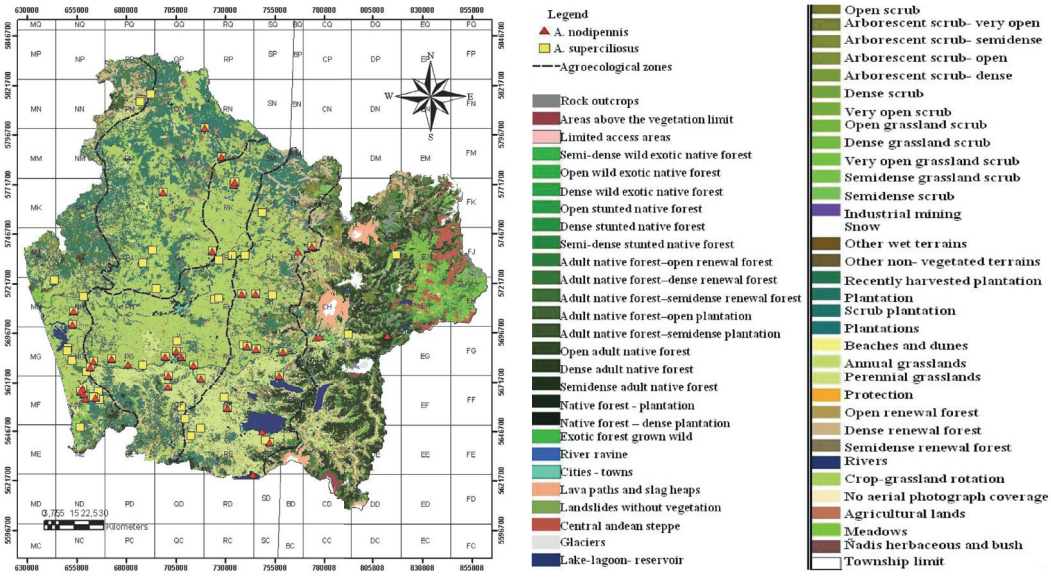

Figure 4. Distribution of *Aegorhinus superciliosus* and *A. nodipennis* in different ecosystems of the La Araucanía region, Chile.

nis, *A. suturalis*, *A. silvicola*, *A. oculatus* and *A. schoenherri* presented new hosts in La Araucanía region. Thus, the most novel findings of this study were the following: 1) *A. superciliosus* was found on *A. dealbata*, *N. obliqua*, *N. pumilio*, *Populus alba*, *Betula pendula*, *Cynara scolymus*, *Discaria serratifolia* and *Lomatia hirsuta*; 2) *A. nodipennis* was found on *M. boaria*, *Salix viminalis*, *Betula pendula*, *Peumus boldus* and *Lomatia hirsuta*; 3) *A. suturalis* was found on *Lomatia hirsuta*, *R. idaeus* and *Salix viminalis*; 4) *A. silvicola* was found on *N. antartica;* 5) *A. oculatus* was found on *Discaria serratifolia* and 6) *A. schoenherri* was found *M. boaria*.

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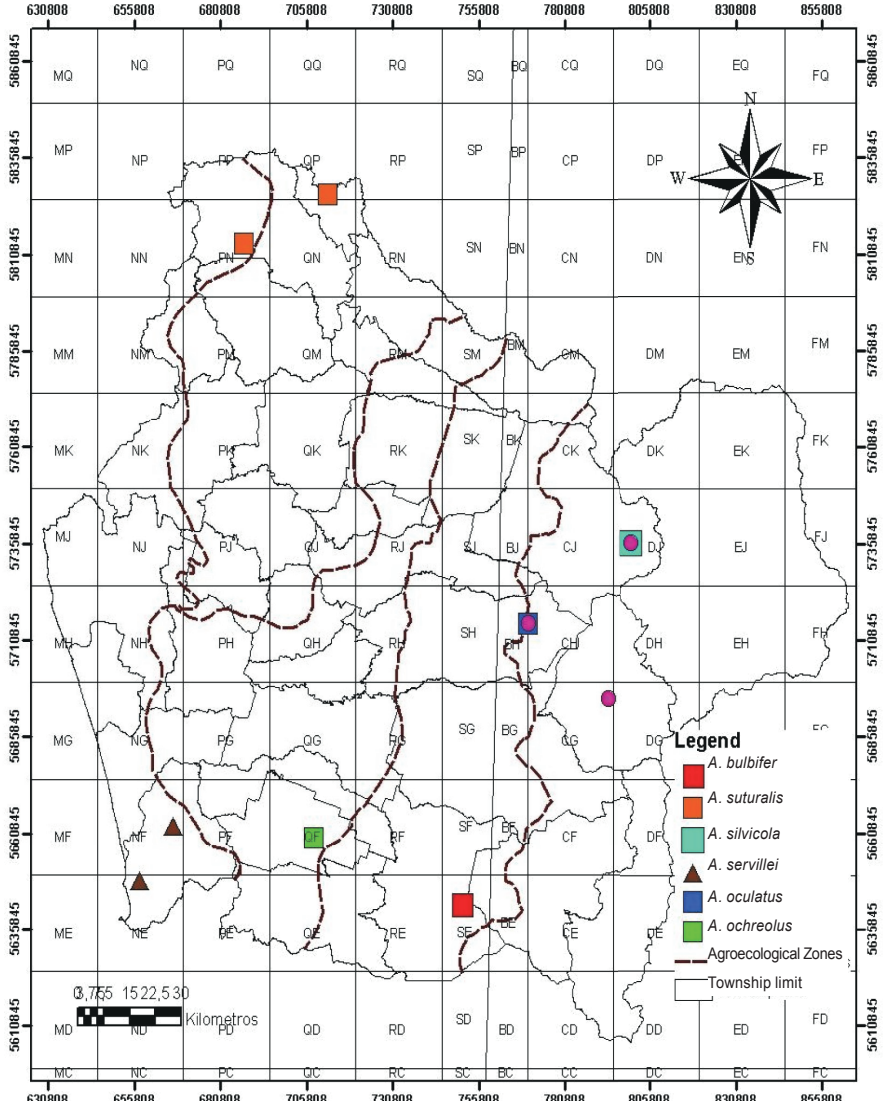

Figure 5. Map of *Aegorhinus* species distribution with less agricultural importance in La Araucanía region, Chile.

Resumen

A. Zavala, M. Elgueta, J. Abarzúa, A. Aguilera, A. Quiroz y R. Rebolledo. 2011. El género *Aegorhinus*, diversidad y distribución en la Región de La Araucanía, Chile, con especial referencia a *A. superciliosus* y *A. nodipennis*. Cien. Inv. Agr. 38(3): 367-377. En la región de La Araucanía, área productora de berries, aún se desconocen aspectos relevantes del comportamiento de los integrantes del género *Aegorhinus*, considerados plagas importantes en estos cultivos, por lo que este estudio tuvo como objetivos determinar la distribución, riqueza y abundancia de estas especies en las zonas agroecológicas de La Araucanía y sus hospederos. Los puntos donde se encontraron estas especies fueron representados en un mapa dividido en cuadrículas de 25 km x 25 km. Se registraron ocho especies de *Aegorhinus*, siendo *Aegorhinus superciliosus* y *Aegorhinus nodipennis* las especies más abundantes. La diversidad se analizó a través del índice de Shannon-Wiener; y la equiparabilidad con el índice de Pielou. La zona agroecológica con mayor diversidad para la región correspondió a la cordillera, sin embargo en el llano central se registró la mayor abundancia de individuos. En este trabajo se dan a conocer nuevos hospederos para seis de las ocho especies encontradas en la región.

Palabras clave: *Aegorhinus*, Coleoptera, hospederos, zonas agroecológicas.

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