Nº PROYECTO : 1110514  
DURACIÓN : 3 años  
AÑO ETAPA : 2013

TÍTULO PROYECTO : A COMMUNITY GENETICS FRAMEWORK FOR THE STUDY OF HIGH ALTITUDE WETLANDS OF CHILE'S NORTE CHICO

DISCIPLINA PRINCIPAL : GENETICA Y EVOLUCION

GRUPO DE ESTUDIO : BIOLOGIA 1

INVESTIGADOR(A) RESPONSABLE : ANGELINE JEAN ALINE BERTIN

DIRECCIÓN :

COMUNA :
CIUDAD : La Serena
REGIÓN : IV REGION

FONDO NACIONAL DE DESARROLLO CIENTIFICO Y TECNOLOGICO (FONDECYT)
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**INFORME FINAL**

**PROYECTO FONDECYT REGULAR**

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**OBJETIVOS**

Cumplimiento de los Objetivos planteados en la etapa final, o pendientes de cumplir. Recuerde que en esta sección debe referirse a objetivos desarrollados, NO listar actividades desarrolladas.

<table>
<thead>
<tr>
<th>N°</th>
<th>OBJETIVOS</th>
<th>CUMPLIMIENTO</th>
<th>FUNDAMENTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To characterize plant and aquatic macroinvertebrate assemblages along a latitudinal gradient in high altitude wetlands from Chile’s Norte Chico.</td>
<td>TOTAL</td>
<td>Plant and macroinvertebrate samples collected from 21 high altitude wetlands along a latitudinal gradient of Chile’s Norte Chico have been fully characterized. Taxa richness showed a trend to decrease from South to North in the study zone. For both taxonomic groups, high levels of differentiation in community composition were observed.</td>
</tr>
<tr>
<td>2</td>
<td>To characterize genetic diversity and structuration in three common aquatic macroinvertebrates and two dominant plant species along a latitudinal gradient in high altitude wetlands from Chile’s Norte Chico using AFLP markers.</td>
<td>TOTAL</td>
<td>The AFLP genotyping of the five focal species has been completed during this last year of the project. Genetic diversity estimates have been calculated at each site for each species, and population differentiation assessed using standard, Bayesian clustering and multivariate methods. Genetic variation was found in all sites, and patterns of population differentiation were found to differ between species.</td>
</tr>
<tr>
<td>3</td>
<td>To evaluate the significance of various environmental variables and isolation by distance on plant and macroinvertebrate communities and populations.</td>
<td>TOTAL</td>
<td>Physico-chemical parameters of the water and other environmental variables were collected at each sampling sites. The spatial organization of the communities has been characterized and we evaluated the relative importance of environmental control and of regional processes in shaping the plant and aquatic macroinvertebrate communities. The results obtained for the macroinvertebrate community are presented in a manuscript sent to Freshwater Biology that has been reviewed already and revised according to the reviewer’s comments. Population genetic data have been analyzed as originally proposed in the project. They show significant patterns of isolation by distance in all species but with different correlation levels. In addition, to the originally planed analysis, we are pretending to take advantage of the genetic data to conduct a landscape genetic study in collaboration with Dr. Manel (AMAP-Montpellier-France).</td>
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<tr>
<td>4</td>
<td>To evaluate potential causal relationships between species and genetic correlation diversity for each model group.</td>
<td>TOTAL</td>
<td>Species-genetic diversity correlations (SGCDs) were calculated. We found positive significant SGCDs between Nei’s gene diversity and taxa richness for both biological community, the strongest evidence being observed with the plant species diversity. We analyzed the influence of habitat characteristics on both levels of biodiversity. Among the factors considered, habitat isolation stood out for influencing species diversity and genetic diversity of various species; and was found to drive some but not all the SGGCs. These results indicate that SGCDs are likely to arise from distinctive processes and demonstrate the importance of habitat isolation on wetland biodiversity.</td>
</tr>
</tbody>
</table>
To evaluate the relative importance of plant genetics and environmental factors on macroinvertebrate assemblages and to test for assemblages concordance between plant and macroinvertebrate communities.

| TOTAL | The analysis of the relative importance of plant genetic diversity and environmental factors on macro-invertebrate communities is completed. It demonstrated significant partial effects of C. gayana genetic diversity, a finding that corroborates the conjecture that local genetic diversity of dominant plant species may represent a contributing determinant of higher levels of biodiversity. The analysis of the cross-taxa concordance has been performed as well. Significant cross-taxa concordance between the plant and benthic macroinvertebrate communities was detected. Based on analysis of residual effects, we found that regional processes and biotic interactions may favor cross-taxa concordance between plants and benthic macroinvertebrates of high altitude wetlands. In contrast, local habitat characteristics do not contribute to cross-taxa concordance. |

Otro(s) aspecto(s) que Ud. considere importante(s) en la evaluación del cumplimiento de objetivos planteados en la propuesta original o en las modificaciones autorizadas por los Consejos.
RESULTS OBTAINED:
For each specific goal, describe or summarize the results obtained. Relate each one to work already published and/or manuscripts submitted. In the Annex section include additional information deemed pertinent and relevant to the evaluation process.

The maximum length for this section is 5 pages. (Arial or Verdana, font size 10).

To characterize plant and aquatic macroinvertebrate assemblages (Specific goal 1)
Plant and macroinvertebrate samples were collected in March and April 2011 from 21 high altitude wetlands spanning the full latitudinal range of Chile’s Norte Chico (See Appendix 1). As originally planned, we calculated typical alpha diversity parameters, Bray-Curtis dissimilarity scores and \( F_{STC} \) indices both for the plant and macroinvertebrate communities (See Appendix 2). As postulated in the hypothesis 1 of our project, negative relationships were detected between latitude and various community diversity indices in plants (Fig. 1 in Appendix 2) indicating lower species diversities for this taxonomic group in the northern parts of the study zone. In contrast, we did not find clear evidence for such a pattern for the benthic macroinvertebrates (see Fig. 2 in Appendix 2). However, a negative linear relationship of borderline significance between latitude and species richness was detected \( (R^2 = 0.17, F_{1,19} = 3.95, P = 0.06) \) which became highly significant when eliminating a regression outlier \( (R^2 = 0.39, F_{1,18} = 11.31, P = 0.003) \). This suggests that macroinvertebrate species richness might actually also decrease from South to North in the study zone.

In support to the hypothesis that communities are highly differentiated across the whole study zone (see H_{1,3} of the project), the pairwise Bray-Curtis dissimilarity scores demonstrated high divergence levels between wetlands in the composition of the plant and aquatic macroinvertebrate communities: the Bray-Curtis dissimilarity scores actually reached extremely high levels (i.e. >0.99) and they were greater than 0.6 - 0.7 in 75% of the cases (Fig. 1). The pairwise \( F_{STC} \) matrices are given in Tables 4 and 5 of Appendix 2. The average \( F_{STC} \) was 0.22 (95% CI: 0.2194-0.2198) for the macroinvertebrates and 0.20 (95% CI: 0.2045-0.2048) for the plants. The average \( F_{STC} \) per site are displayed in Figure 2. They ranged from 0.13 to 0.41 in the macroinvertebrates and from 0.15 to 0.34 in the plants. Overall, these results indicate high structure levels and therefore brings additional support to the hypothesis that macroinvertebrate and plant communities of high altitude Andean wetlands are strongly structured.

![Figure 1](image1.png)

Figure 1. Boxplot of Bray-Curtis dissimilarity scores calculated between pairwise sites

![Figure 2](image2.png)

Figure 2. \( F_{STC} \) calculated as the mean pairwise \( F_{STC} \) of each site (v1 to v21) vs all other localities. Full lines indicate the lower limits recognized as indicative of moderate, high and very high structuration levels.
To characterize genetic diversity and structuration of dominant species (Specific goal 2)
AFLP markers have been amplified and genotyped in all sites for each species. As recommended in the literature, we retained only those with a size higher than 100 bp and with less than 10% genotyping error. After filtering, we had a total 90 markers in *Andesiops peruvianus* (Ap), 99 in *Austrelmis sp* (Au) and 84 in *Hyallela fossamancini* (Hf) for the invertebrates, and 104 in *Carex gayana* (Cg) and 81 in *Patosia clandestina* (Pc) for the plants. Variation in genetic diversity was found in each site for each species, with variation between sites (see Appendix 3). Globally, levels of genetic diversity differed slightly between invertebrate species (Average Shannon diversity index: Ap = 0.464, Hf = 0.407, Au = 0.329). The plant species harbored less variation in genetic diversity than the invertebrates and showed no difference between them (Average Shannon diversity index: Cg=0.160, Pc=0.161). Regarding levels of population differentiation, among the invertebrate species Ap, the most vagile, harbored slightly lower levels than the two others (Global $F_{ST}$: Ap=0.24, Hf=0.30, Au=0.35). Plant populations appeared more structured with notable differences between the two species (Global $F_{ST}$: Cg=0.34, Pc=0.47). This indicates that populations of plant and macroinvertebrate species of high altitude Andean wetlands are globally highly structured spatially (see also Appendix 4 of pairwise $F_{ST}$). Bayesian clustering and multivariate analyses revealed that the patterns of population differentiation were different between species (Fig. 3; Appendix 5). Indeed, the number of identified clusters varied between species. In addition, for the two invertebrate species Ap and Au and the plant species Pc, a North/South population differentiation could be observed at the level of the Elqui basin in the middle of the study area, which likely reflects similar responses to historical events. In contrast, populations of the crustacean Hf and the plant Cg followed more a stepping-stone model without an intermediate barrier. All the differences observed in the patterns of population diversity and differentiation between these species can be due to differences in their dispersal capacity, their life history traits, and different responses to historical, ecological and demographic events.

![Figure 3. Results of discriminant analysis of principal components (DAFPC) for each species.](image-url)
To evaluate the significance of various environmental variables and isolation by distance on plant and macroinvertebrate communities and populations (Specific goal 3)

The influence of the gathered environmental variables on the composition of plant and macroinvertebrate communities was assessed by performing redundancy analyses together with a forward selection. Spatial structure of the plant and macroinvertebrate communities was evaluated using eigenvector-based spatial analyses. These methods allow generating spatial variables whose effects on community composition can be tested through redundancy analysis. Spatial structure was modeled both in relation to the Euclidean geographical distance between wetlands and according to wind currents because we hypothesized that wind may represent an important vector of dispersion in both taxonomic groups. In order to assess the effects of dispersion per se in driving spatial structure, we controlled for influence of exogenous factors themselves spatially structured by carrying out partial analyses and by using a variance partitioning approach. Full details about the methodology used can be found in the revised manuscript by Bertin et al. submitted to Freshwater Biology. This manuscript presents the results obtained with the macroinvertebrate data by considering assemblages with distinctive dispersal abilities.

In both taxonomic groups, we detected significant environmental and spatial effects on species composition. Environmental control accounted for about one third of the variance in community composition (Fig. 4). In plants, the selected environmental variables included altitude, mean annual precipitation and water turbidity while in macroinvertebrates they included altitude, the concentration of total dissolved solids in water and river width. The spatial models explained between 10 to 20% of the variation in community composition (Fig. 4). In both community types, higher degrees of spatial structure were detected by considering wind flows compared to the sole use of Euclidean geographic distances (Fig. 4). According to the variation partitioning results, a relatively large fraction of the detected spatial structure may in fact result from the influence of spatially structured environmental variables (see shared fraction between environment and spatial structure in Fig. 5) with spatially structured factors accounting for all the spatial structure driven by wind in plants and for all the spatial structure based on Euclidean distance in macroinvertebrates. The fraction of the variation explained by the spatial variables after controlling for environmental effects may be caused either by spatially-structured environmental factors not included in the analysis or by spatial processes occurring over the landscape. It is thus the fraction that accounts for the effects of dispersion. Significant unique effects of the spatial variables were detected in both taxonomic groups but they relate to different spatial schemes: i.e. Euclidean configuration in plants and wind-driven spatial structure in macroinvertebrates (Fig. 5).

In conclusion, our results suggest that both dispersal limitation and environmental effects are shaping wetland communities, with a predominant influence of environmental filters; and that distinctive dispersal mechanisms are participating to the structuring of the macroinvertebrate and plant communities. To further explore, this hypothesis, analyses were performed separately on
macroinvertebrate and plant assemblages depending on their dispersal mode. This was the subject of the Magister thesis of Evelyn Alvarez. The results for the macroinvertebrate assemblages are presented in the manuscript sent to Freshwater Biology.

At the population level, analyses of isolation by distance using Mantel tests revealed significant positive correlations between genetic and geographical distances in all the species, the strongest relationships being observed in the plant *P. clandestina* and the invertebrates *A. peruvianus,* and *H. fossamancini* (Pc: \( r = 0.632, p = 0.001; \) Ap: \( r = 0.695, p < 0.001; \) Hf: \( r = 0.720, p = 0.001; \) Cg: \( r = 0.557, p = 0.001; \) Au: \( r = 0.460, p < 0.001\)).

To evaluate potential causal relationships between species and genetic correlation diversity for each model group (Specific goal 4)

To examine co-variations patterns between taxa and genetic diversities, we calculated Pearson correlations between taxa richness, estimated as the total number of taxa recorded in each wetland, and two genetic indices: the proportion of polymorphic loci of each population and Nei’s gene diversity. However, only the combination of indices showing significant features is presented here and was considered for further analysis. As expected (see H2 of our working hypothesis), positive and significant species-genetic diversity correlations (SGCDs) were detected between Nei’s gene diversity and taxa richness for both biological community (Table 1).

The SGCDs ranged from 0.45 to 0.57 with the plant community and were all of statistical or borderline significance. In contrast, significant evidence of SGCDs with benthic macroinvertebrate taxa richness was only found with *P. clandestina.*

To evaluate if the positive SGCDs arose from processes acting in parallel on both levels of biodiversity, we investigated the influence of habitat characteristics on taxa and genetic diversity and examined if the SGCDs were maintained after controlling for the influence of these factors. We focused on long-term habitat characteristics that are well recognized to influence biodiversity such as habitat size and habitat stability (estimated over the last 20 years), habitat isolation, altitude, plant biomass and variation. Plant diversity was influenced by habitat isolation (Table 2). When the mean distance of the habitat patch to neighboring patches increases, both species and genetic plant diversity decrease. Such negative effects of habitat isolation were also detected on taxa diversity of the benthic macroinvertebrates and on genetic diversity of the Baetidae species. This indicates that neutral processes are important drivers of biodiversity in high altitude wetlands. Altitude was the only local characteristics found to influence diversity (Table 2). It has a strong negative effect on taxa diversity of the benthic macroinvertebrates.

After eliminating the effects of habitat connectivity and local characteristics, the SGCDs decreased in most cases (Table 1). This was particularly striking for the *C. gayana / Plant SGCD,* suggesting that differences in wetland isolation had a strong incidence on the co-variation patterns previously detected between these two diversity components. In contrast, no obvious evidence of this was detected with *P. clandestina* and the insect *A. peruvianus,* and genetic diversity and examined if the SGCDs were maintained after controlling for the influence of these factors. We focused on long-term habitat characteristics that are well recognized to influence biodiversity such as habitat size and habitat stability (estimated over the last 20 years), habitat isolation, altitude, plant biomass and variation. Plant diversity was influenced by habitat isolation (Table 2). When the mean distance of the habitat patch to neighboring patches increases, both species and genetic plant diversity decrease. Such negative effects of habitat isolation were also detected on taxa diversity of the benthic macroinvertebrates and on genetic diversity of the Baetidae species. This indicates that neutral processes are important drivers of biodiversity in high altitude wetlands. Altitude was the only local characteristics found to influence diversity (Table 2). It has a strong negative effect on taxa diversity of the benthic macroinvertebrates.

### Table 1. Pearson correlations between taxa and genetic diversity (SGCD).

<table>
<thead>
<tr>
<th>Biological community</th>
<th>Benthic macroinvertebrates</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total SGCD</td>
<td>Residual SGCD</td>
</tr>
<tr>
<td><em>C. gayana</em></td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td><em>P. clandestina</em></td>
<td>0.63**</td>
<td>0.41*</td>
</tr>
<tr>
<td><em>H. fossamancini</em></td>
<td>0.33</td>
<td>0.15</td>
</tr>
<tr>
<td><em>A. peruvianus</em></td>
<td>0.34</td>
<td>0.49†</td>
</tr>
<tr>
<td>Austrelmis sp</td>
<td>0.42</td>
<td>0.19</td>
</tr>
</tbody>
</table>

†: \( P < 0.08, \) *: \( P < 0.05, \) **: \( P < 0.01 \)

### Table 2. Effects of habitat connectivity and local characteristics on genetic diversity and taxa diversity using partial-least squares regression (PLSR)

<table>
<thead>
<tr>
<th></th>
<th>Number of PLSR axes</th>
<th>Most contributing variables</th>
<th>Explained variance (( R^2 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taxa diversity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants</td>
<td>2</td>
<td>Closeness centrality</td>
<td>0.45***</td>
</tr>
<tr>
<td>Benthic Macroinvertebrates</td>
<td>3</td>
<td>Closeness centrality, Altitude</td>
<td>0.50***</td>
</tr>
<tr>
<td><strong>Species Diversity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. gayana</em></td>
<td>2</td>
<td>Closeness centrality</td>
<td>0.43***</td>
</tr>
<tr>
<td><em>P. clandestina</em></td>
<td>1</td>
<td>Closeness centrality</td>
<td>0.20*</td>
</tr>
<tr>
<td><em>H. fossamancini</em></td>
<td>0</td>
<td>NA</td>
<td>0.00</td>
</tr>
<tr>
<td><em>A. peruvianus</em></td>
<td>1</td>
<td>Closeness centrality</td>
<td>0.37*</td>
</tr>
<tr>
<td><em>Austrelmis sp</em></td>
<td>0</td>
<td>NA</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*: \( P < 0.05 \) and ***: \( P < 0.001 \)
which still have relatively high SGCDs of borderline significance even when the effects of habitat characteristics were accounted for. Overall, our results indicate that SGCDs are likely to arise from distinctive processes and are not limited to species diversity and genetic diversity of component species (i.e. species from the same community). They also demonstrate the importance of habitat isolation on wetland biodiversity, highlighting the necessity of considering habitat connectedness for adequate management of these ecosystems.

To evaluate the relative importance of plant genetics and environmental factors on macroinvertebrate assemblages and to test for assemblages concordance between plant and macroinvertebrate communities (Specific goal 5)

The influence of plant genetic diversity on macroinvertebrate community was evaluated with redundancy analyses. Only genetic diversity (Nei’s index) of *C. gayana* explained a significant fraction of the variation in the benthic macroinvertebrate communities. It accounted for 13% of the community composition variation with high levels of genetic diversity of *C. gayana* being positively associated with high abundances of the macroinvertebrate families Baetidae and Leptophlebidae but negatively associated with abundance of ostracods, Naididae family and other oligochaets (Fig. 6). The relative importance of plant genetic diversity and environmental factors on macroinvertebrate communities was estimated through partial redundancy analyses. Partial effects of *C. gayana* genetic diversity were significant ($R^2 = 0.05, F_{1,16}, P = 0.03$) which suggests that local genetic diversity of dominant plant species may represent a contributing determinant of higher levels of biodiversity.

The concordance between the two taxonomic groups were examined as usual using Mantel tests performed on distance matrices and using co-inertia analyses, a more powerful approach to assess taxonomic concordance. Both approaches demonstrated significant cross-taxa concordance between the plant and benthic macroinvertebrate communities (Table 3), even though the co-inertia analysis was able to reveal a much stronger association. Assemblage concordance can result from biotic interactions or due to similar responses of different taxa to environmental gradients or to common spatial organization. To attempt to discern between these hypotheses, assemblage concordance was also analyzed after controlling for the effects of environmental and spatial variables previously found to significantly influence the composition of the communities (see specific goal 3).

While the composition of both taxonomic groups were found influenced by common environmental factors (i.e. altitude, see results of specific goal 3), the detected levels of cross-taxa concordance did not drop after controlling for environmental influence (Table 3). This suggests that common responses to environmental gradient do not play a key role in generating the concordance between the plant and macroinvertebrate communities. In contrast, when the spatial structure of community composition was partialled out, a weaker degree of concordance was detected (Table 3). This finding indicates that regional processes are likely to participate to the cross-taxa concordance. The significance (or borderline significance) of the correlations after controlling for environmental effects and spatial structure suggests that biotic interactions may favor cross-taxa concordance between plants and benthic macroinvertebrates of high altitude wetlands.

![Table 3. Mantel tests and co-inertia results for concordance between plant and macroinvertebrate communities. $r_m$ is the Mantel correlation between Euclidean matrices and RV the co-inertia correlation.](image)

![Figure 6. Projections of the 21 wetland sites from the plant (beginning of the arrow) and benthic macroinvertebrate (end of the arrow) communities on the two first co-inertia axes.](image)
OTHER ACHIEVEMENTS OF THE PROJECT:
- Research visit(s) to other institution(s).
- Outreach activities related to the project’s main topic.
- Any other contribution, not addressed elsewhere, that you consider important.

The maximum length for this section is 1 page. (Arial or Verdana, font size 10).

The plant genetic data obtained in the present project have provided the basis for two additional research projects:
- Landscape genetics of High-Andean wetland plants: screening the genetic connectivity driven by spatial, environmental and historical processes. Fondecyt Postdoctorado nº3130761. Principal Investigador: Dra. Alejandra Troncoso

As part of the present project, Dr. Gouin will be performing a stay in December 2014 at the Centre of Ecologie Fonctionnelle and Evolutive to complete the analysis of the genetic data using recent landscape genetics techniques. This will maximize the data produced by the current project to help improve our understanding of the processes shaping genetic biodiversity in high altitude wetlands of Chile’s Norte Chico.

Finally, to evaluate the importance of habitat characteristics representative of drift, extinction and immigration (i.e. habitat capacity, stability and connectivity) on species and genetic diversity, we are developing a GIS-method to map the high altitude wetlands and assess their connectivity and stability over the years. While this work was not a primary objective of the present project, it is of relevance for adequate management of the wetlands and will be presented in a manuscript soon.
PRODUCTOS

ARTÍCULOS
Para trabajos en Prensa/ Aceptados/ Enviados adjunte copia de carta de aceptación o de recepción.

Nº: 1
Autor (a)(es)/as: Bertin A.; Alvarez E.; Gouin N.; Gianoli E.; Montecinos S.; Lek S.; Gascoin S.; Lhermitte S.
Nombre Completo de la Revista: Freshwater Biology
Título (Idioma original): Wind-driven spatial structure and environmental heterogeneity effects on high altitude wetland macroinvertebrate assemblages in relation to dispersal mode.
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OTRAS PUBLICACIONES / PRODUCTOS

Sin información ingresada.

CONGRESOS

Nº: 1
Autor (a)(es)/as: Alvarez E, Gianoli E, Gouin N, Osorio R, Montecinos S, Gascoin S & Bertin A
Título (Idioma original): Importancia relativa de procesos ambientales y espaciales sobre la estructuración de comunidades de humedales altoandinos
Nombre del Congreso: Primera Reunión Conjunta de Botánica, Ecología y Evolución
País: CHILE
Ciudad: Concepción
Fecha Inicio: 06/10/2012
Fecha Término: 09/10/2012
Nombre Publicación:
Año:
N°: 2
Autor (a)(es/as): Bertin A, Alvarez E, Gouin N, Gianoli E, Montecinos S & Gascoin S.
Título (Idioma original): La influencia del modo de dispersión sobre la dinámica de metacomunidades de macroinvertebrados acuáticos de vegas alto-andinas.
Nombre del Congreso: Primera Reunión Conjunta de Botánica, Ecología y Evolución.
País: CHILE.
Ciudad: Concepción.
Fecha Inicio: 06/10/2012.
Fecha Término: 09/10/2012.
Nombre Publicación: 

N°: 3
Autor (a)(es/as): Gouin N; Rodomiro O; Hereme R; Gianoli E & Bertin A.
Título (Idioma original): Variación genética del gen RuBisCo en dos especies de plantas altoandinas, Carex gayana y Patosia clandestina a lo largo del Norte Chico Chileno.
Nombre del Congreso: Primera Reunión Conjunta de Botánica, Ecología y Evolución.
País: CHILE.
Ciudad: Concepción.
Fecha Inicio: 06/10/2012.
Fecha Término: 09/10/2012.
Nº : 4  
Autor (a)(es/as) : Rivera, M.; Vargas, P.; Arancio, G.; Bertin, A.; Squeo, F.A.  
Título (Idioma original) : Productividad y diversidad vegetal en turberas andinas del norte center de Chile: variación interanual y espacial  
Nombre del Congreso : Primera Reunión Conjunta de Botánica, Ecología y Evolución  
País : CHILE  
Ciudad : Concepción  
Fecha Inicio : 06/10/2012  
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Envía documento en papel : no  
Archivo Asociado :  

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Autor (a)(es/as) : Gouin N; Hereme R; Gianoli E; Bertin A  
Título (Idioma original) : Patrones divergentes de diversidad genética del locus COI entre tres especies de invertebrados acuáticos de vegas altoandinas a lo largo del Norte Chico de Chile  
Nombre del Congreso : XLVI Reunión Anual de la Sociedad Chilena de Genética de Chile  
País : CHILE  
Ciudad : La Serena  
Fecha Inicio : 07/11/2013  
Fecha Término : 09/11/2013  
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Páginas :  
Envía documento en papel : no  
Archivo Asociado :  
Archivo Asociado: ResumenGouinSochigen2013_(1).pdf  
Autor (a)(es/as) : Rivera M; Bertin A; Squeo F
Título (Idioma original) : Patrones de diversidad-productividad en vegas altoandinas y su relación con factores ambientales
Nombre del Congreso : V Reunión Binacional de Ecología
País : CHILE
Ciudad : Puerto Varas
Fecha Inicio : 03/11/2013
Fecha Término : 06/11/2014
Nombre Publicación :
Año :
Vol. :
Nº :
Páginas :
Enviar documento en papel : no
Archivo Asociado :
Resumen_congreso2013.pdf

Autor (a)(es/as) : Verdugo, C; Bertin, A; Alvarez, E; Gouin, N
Título (Idioma original) : Rasgos funcionales: una medida alternativa para evaluar la diversidad demacroinvertebrados bentónicos en humedales altoandinos
Nombre del Congreso : X Congreso de la Sociedad Chilena de Limnología
País : CHILE
Ciudad : Concepción
Fecha Inicio : 20/10/2013
Fecha Término : 23/10/2013
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Páginas :
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Archivo Asociado :
CataConcepcion.pdf

Autor (a)(es/as) : Rivera, M; Squeo, FA; Bertin A
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TESIS/MEMORIAS

1
Importancia relativa del ambiente local y de la dispersión sobre la estructuración de comunidades de humedales altoandinos
Evelyn Elizabeth Álvarez Olivares
Angéline Bertin
Magister
Universidad de La Serena
CHILE
La Serena
Terminada
15/03/2012
23/08/2013
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2
Variación de la diversidad Taxonómica y funcional de macroinvertebrados bentónicos en humedales alto andinos a lo largo de un gradiente latitudinal
Catalina Verdugo Arriaga
Angéline Bertin
Magister
Universidad de La Serena
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