

Phylogenetic and morphometric analysis of the species of *Orestias* (Teleostei; Cyprinodontidae) of the southern Chilean Altiplano support the hypothesis of a recent origin of the species of the Lauca National Park modulated by the collapse of the Parinacota volcano.

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ABSTRACT.

The genus *Orestias* is composed of 44 species distributed along the Altiplano of South America. Seven species have been described for Chile, four of which inhabit Lauca National Park (LNP). We sampled all species in Chile, and also new discovered localities with *Orestias* populations. The phylogenetic reconstruction of three mitochondrial markers (ND2, Cyt b and the control region) showed one lineage (species) for each site. The exception to this pattern was found in the species described in the LNP, for which a polytomy was recovered. Additionally, a new lineage was found within LNP, composed of localities not previously analyzed.

In the morphometric analysis, individuals from salt pan habitat were differentiated from those from rivers, lakes and wetlands. A second analysis focusing on localities showed that *O. ascotanensis* and *O. gloriae* (both of salt-pan habitat) are different among them, and also different from all individuals of LNP. In the LNP there is little differentiation among the individuals from different localities and environments.

Based on these results, we infer that the differentiation process of *Orestias* in the Chilean Altiplano has been mainly allopatric. Additionally, the high morphological and phylogenetic similarity found in the species described in LNP suggests a recent differentiation. This is concordant with geological information, which indicates that the formation in the LNP occurred about 12 kya due to the collapse of the Mt. Parinacota volcano.

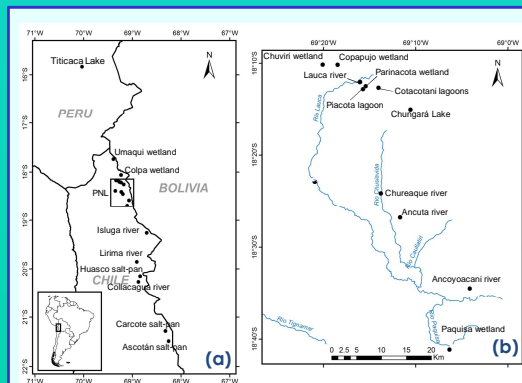
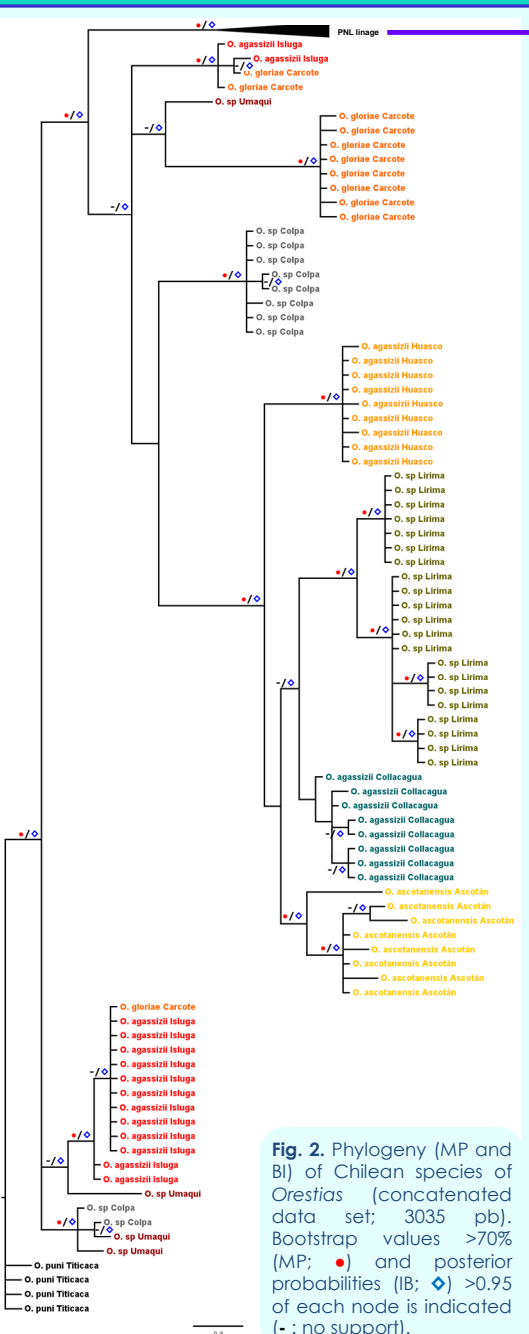


Fig. 1. Sampling sites of *Orestias* (a) in the Chilean Altiplano and (b) in the LNP.

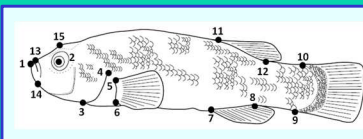


Fig. 4. Location of the 15 landmarks used in the morphometric analysis of Chilean species of genus *Orestias*.

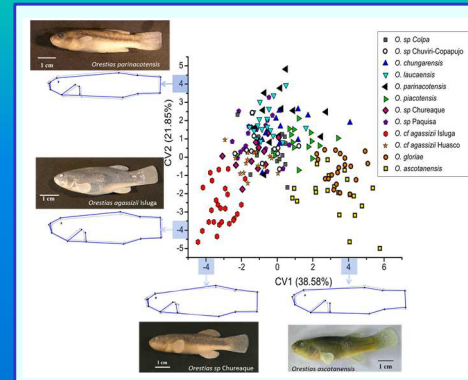


Fig. 5. Canonical variable analysis of morphometric measures for the Chilean species of *Orestias*. The maximum shape changes according the escalated factor is indicated in each axis (-4 and 4 values); consensus configuration in grey line; pondered value shape in blue line.

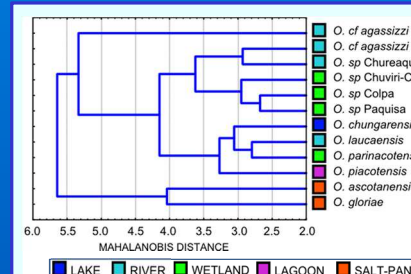


Fig. 6. UPGMA dendrogram derived from the Mahalanobis distances.

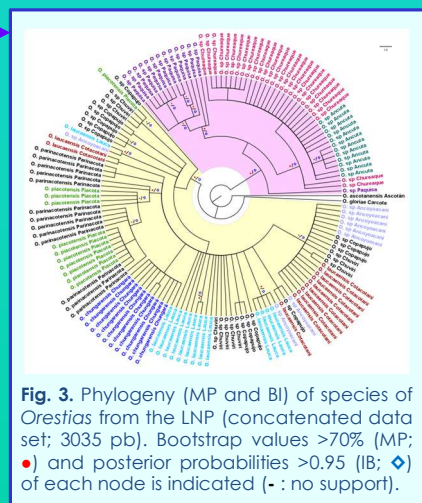
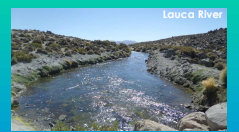


Fig. 3. Phylogeny (MP and BI) of species of *Orestias* from the LNP (concatenated data set; 3035 pb). Bootstrap values >70% (MP; ●) and posterior probabilities >0.95 (IB; ◆) of each node is indicated (- : no support).



Results & Discussion

- *Orestias* in the Chilean Altiplano: allopatric differentiation process.
- LNP species: high morphological and phylogenetic similarity suggests a recent differentiation. This lineage could have formed 12-8 kyr ago, when the Parinacota volcano collapsed.

- The lack of differences observed in PNL species, could be explained by incomplete lineage sorting in mtDNA or introgression due to recent divergence.
- The morphological differences observed out of the PNL could be the result of local adaptation to different environments (i.e., wetland, river, lake).