**Study of leaf herbivory in South America as a guide to palaeoherbivory in Antarctic fossil plants**

## Introduction

The award given by the Antarctic Science Bursary made it possible to carry out six months of field work investigating the insect fauna of Chile. The main of the study was to obtain a greater understanding of the insect diversity in Antarctica and the climate range in which they would have lived by investigating the herbivory levels and the insect fauna of Chilean forests. The logistical organisation of the work also involved collaborations with Dr Luis Felipe Hinojosa, University of Chile, Santiago and Dr, Mario Elgueta at the Museo Nacional de Historia Natural. The entomological collections from Chile were examined at the museum prior to the fieldwork.

## Study Sites

All of the study sites in Chile were chosen due to the vegetation composition of the area and accessibility (Figure 1). The main site, Parque Nacional Puyehue was visited three times for sampling (Dec 2006, Jan 2007, and March 2007) and the other sites visited once.

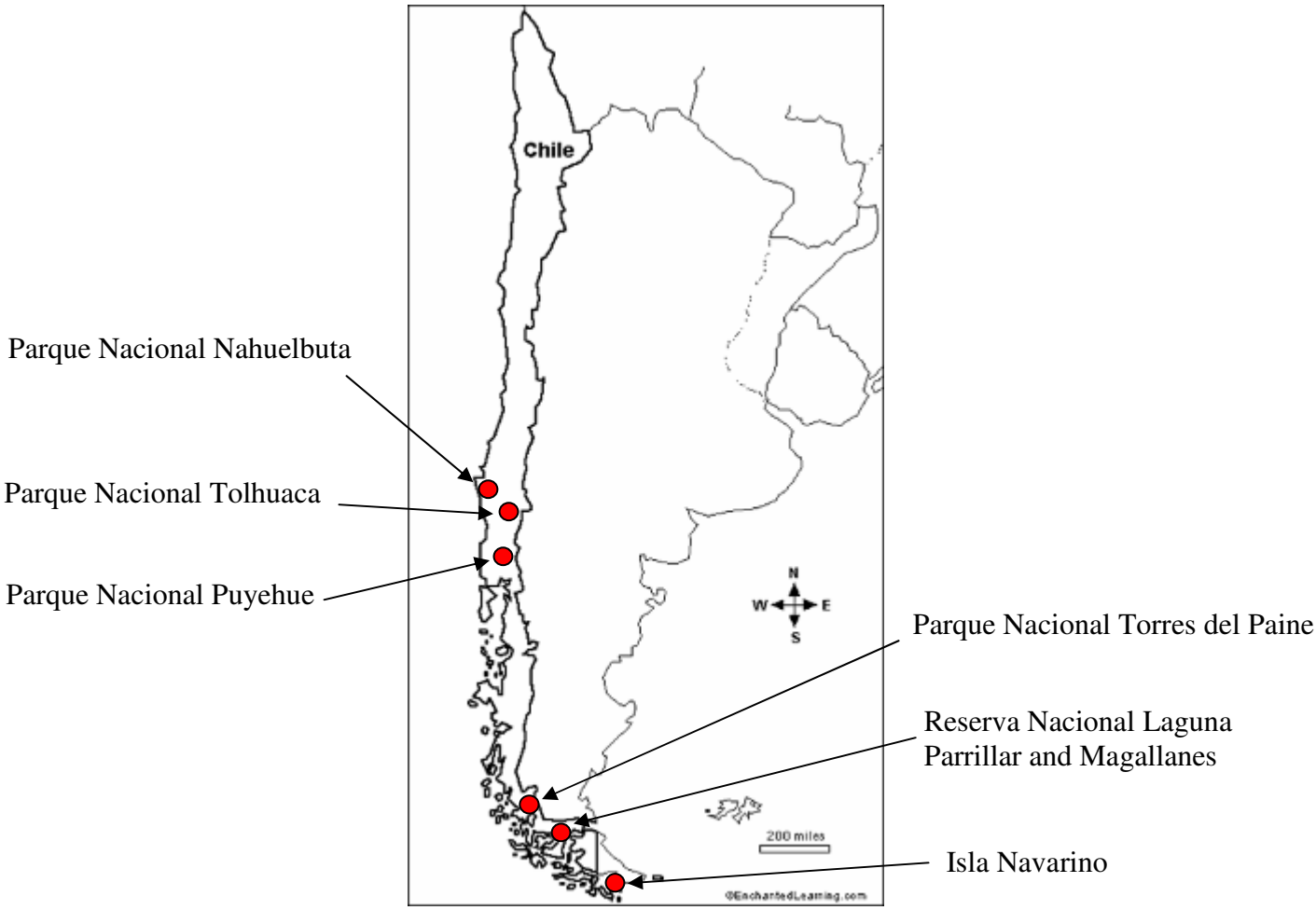


**Figure 1** Map of Chile showing distribution of study sites (red circles)

## Collection

At all study sites insects were sampled from the two Nothofagaceae species, *Nothofagus pumilio* and *Nothofagus antarctica* using sweep nets. Twelve individual trees were sampled of each species. Of these, six trees of each species were chosen for leaf collection using extendable pruning poles at 1m intervals and at North and South orientations. The leaves collected were counted and the number of leaves with herbivore traces, mines, galls and skeleton feeding noted. The leaves that were eaten were

then measured using categories of leaf damage such as 0-25% leaf loss. Insects collected were placed in containers and feeding behaviour examined. Leaves with mines or galls were stored in Petri dishes and reared to adults where possible. Qualitative recording was carried out after the quantitative measuring to provide a more complete survey of the diversity of herbivory types on the focal trees as some types of herbivory may be missed through the quantitative recording. This involved searching the branches of the study tree for herbivory traces. The position the herbivory was found was noted and the same measurements as before carried out.

At the main site, Parque Nacional Puyehue, an evergreen Nothofagaceae, *Nothofagus betuloides* was sampled using the same method. Fourteen individual trees were sampled. Also, at this site seven trees of *N.pumilio* were chosen for sampling using a novel tree climbing technique. Small branches were again collected at North and South orientations, but at top, middle and bottom sections of the tree.

**Preliminary Results**

In total, 207 trees of Nothofagaceae were sampled for insect diversity and traces and 101, 023 leaves were counted using the method described (Table 1). The insect traces found on the modern leaves included general leaf chewing, leaf mines, leaf galls, skeleton feeding as well as insect eggs. The insects collected were both in adult and larval forms and are currently being identified. Initial identification of the Coleopteran has shown 7 families including at least 17 genera. The superfamily Curculionoidea is a very large group of beetles that have an anteriorly prolonged head. Of the samples identified so far 7 are within this superfamily each belonging to a different subfamily, highlighting the diversity sampled. Several specimens in the family Apionidae were found associated with leaf galls on the Nothofagaceae.

| | Number |
|---|---|
| Leaves counted | 101,023 |
| Leaves chewed | 27212 |
| Mines | 1143 |
| Galls | 1703 |
| Insects | 1798 |

**Table 1** Number of samples collected in Chile for each category for both *N. pumilio* and *N. antarctica*

The results of preliminary comparisons between the insect traces found on the fossil and modern are highlighted in Figures 2-4. Marginal general leaf chewing of large amounts of the leaf can be found on the same areas both in the fossil and in the modern leaf (Figure 2a). The presence of single elliptical bite marks in the leaf tissue of the inter-vein part of the basal area of the leaf was also comparable (Figure 2b).

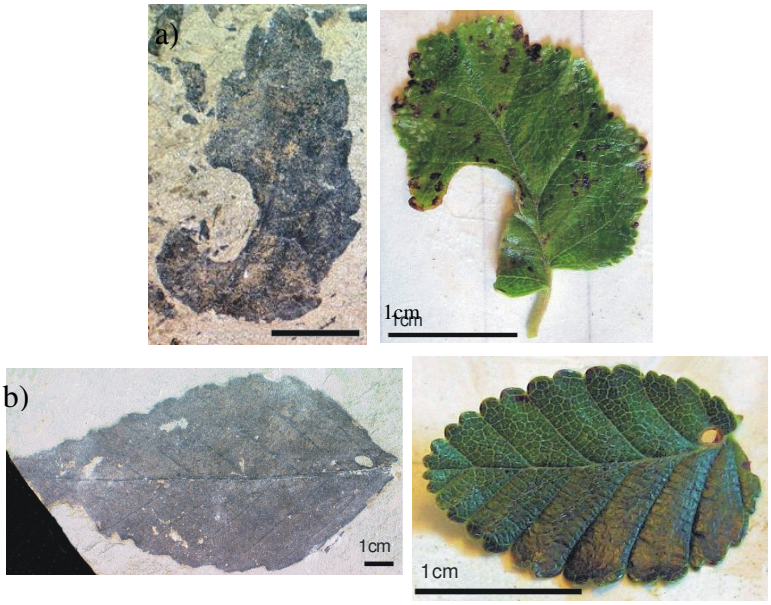


**Figure 2** a) Marginal general leaf chewing present on fossil leaf (left side) and modern *N. antarctica* leaf (right side). b) Non-marginal chewing present on fossil leaf (lefts side) and modern *N. pumilio* leaf (right side).

The different types of leaf mine found on the fossil leaves examined where also seen on the modern leaves. Various types of serpentine and blotch mines were collected. One blotch mine on a fossil leaf fragment is very similar to the earlier stages of the blotch mine found on a modern *N. pumilio* leaf (Figure 3a). The blotch started at the primary vein and in between two secondary veins and as the larva developed the blotch grew in size to cover more of the leaf. Leaf galls were abundant in the Chilean forests with the most common type being similar to a fossil gall (Figure 3b). The multiple small galls were found either on secondary veins or at the junction of a secondary vein with the primary vein.

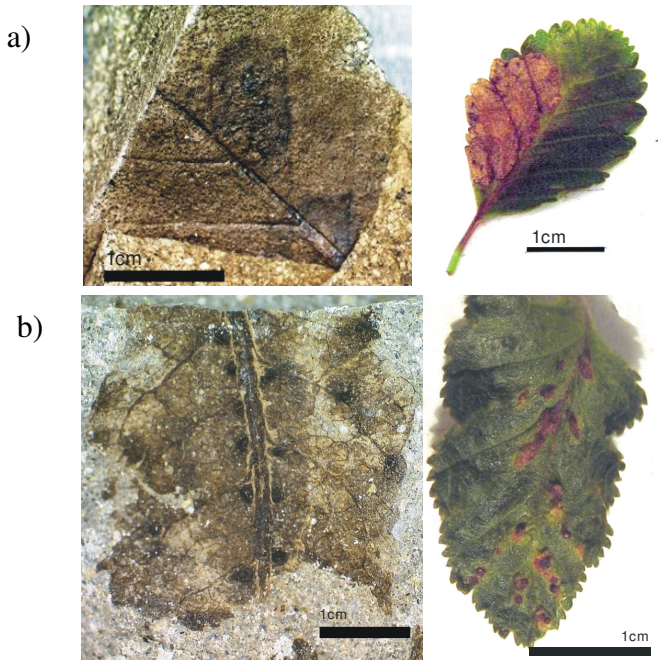


**Figure 3** a) Blotch type of leaf mine on fossil leaf (left side) and modern *N. pumilio* leaf (right side) b) Multiple small leaf galls found on fossil leaf fragment (left side) and modern *N. antarctica* (right side).

The final category of insect trace that was found in both the fossils and the modern leaves was skeleton feeding. Several species of adult Coleopteran and larval Lepidoptera that were collected were observed feeding in this way. The beetle (Coleoptera: Chrysomelidae) in Figure 4 is a common example of a skeleton feeding insect found on both *N. pumilio* and *N. antarctica*.

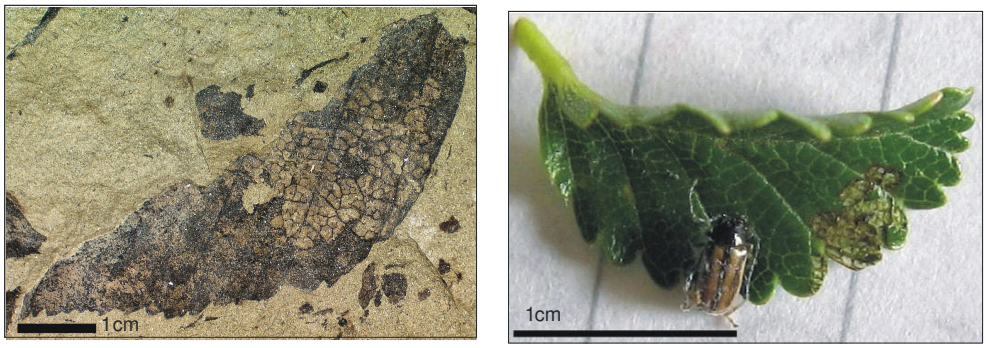


**Figure 4** Fossil leaf showing trace of skeleton feeding (left side) and modern *N. pumilio* leaf with beetle, Chrysomelidae, making a similar trace (right side).

The data collected will be analysed further by comparing insect diversity between the two tree species studied and altitudinal, latitudinal and temporal differences. The range of insect species which make the same feeding trace on the leaf will also be investigated as well as the diversity of herbivore traces from Chile that are comparable to insect trace fossils from Antarctica.

## Further Outcomes

The fieldwork that was carried out in the national parks gave the unique chance to talk to the park guards and explain the purpose of the project. The technique was even demonstrated and explanations given in Spanish. The project also received a lot of interest from the public with many people asking what the equipment was for and why I was collecting insects. I think this is important as it gave the chance not only to increase awareness of polar science, but also for people to experience different aspects of nature. On Isla Navarino, I contacted The Omora Foundation, a Chilean non-governmental organization (NGO) dedicated to biocultural conservation in the extreme southern tip of South America. The island is part of the Cape Horn Biosphere Reserve and the foundation has volunteers and students on gap year projects. I taught one such student about insect biology, collection techniques and fieldwork. Therefore, Antarctic Science Bursary gave me the opportunity not only to carry out interesting science, but also to increase public awareness in the parks and allow me to develop communication skills and networking skills for future projects. I would like to thank Antarctic Science for making the fieldwork in Chile possible and giving me both a vital work and personal experience.