PALEOLIMNOLOGICAL EVIDENCE CONFIRMS THAT *PAROCHLUS STEINENII* (GERKE) IS NOT A RECENT INTRODUCTION TO THE ANTARCTIC PENINSULA REGION

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Introduction

Chironomid remains are common in lake sediments, and have been used widely as indicators of change in climatic conditions. Far fewer studies, however, have made use of the palaeobiogeographical potential of these remains to investigate past species distributions and the origins of isolated faunas.

Two models have been suggested for the origin of Antarctic populations of the chironomid *Parochlus steinenii* (Gerke) (Allegrucci et al. 2005). It was originally suggested that this species could have been introduced to the Antarctic Peninsula region from farther north by human activities, beginning with whaling in the mid-to-late 1800s (Convey and Block 1996). This suggestion was predicated on the quite recent initial observation (1950s) of this species in the South Shetland Islands and the Antarctic Peninsula (Torres 1956).

Molecular studies indicated a different story. Analysis of 28S ribosomal RNA from three distinct populations of *Parochlus steinenii* suggested that the populations on the Antarctic Peninsula and the nearby South Shetland Islands had been separated from the other populations on a time scale of million of years, and that each population was limited to particular tectonic plates (Allegrucci et al. 2005).

In this short note we use palaeolimnological techniques to test these models, and conclude an ancient origin for the Antarctic Peninsula/South Shetland Island population of *Parochlus steinenii*.

Methods

The study site was a small lake on Byers Peninsula, Livingston Island (62°40'S, 61°00'W, Figure 1), that has been the centre of a concerted scientific study (Toro et al. 2007), and which has become known as Limnopolar Lake. See www.aslo.org/photopost/showphoto.php/photo/706/ppuser/158 for a picture of the lake. Livingston Island is in an active volcanic area, with nearby Deception Island having erupted as recently as 1969 (Pallàs et al. 2001).

During the Antarctic field season of 2002/2003 a 29.2 cm sediment core was obtained from Limnopolar Lake using a modified hybrid Glew corer and Kajak corer. The core did not reach bedrock. The core was sectioned on site into 0.2 cm sections (0-10 cm), 0.5 cm sections (10-25 cm), or 1.0 cm sections (25-29 cm). The sections were then transferred into labelled whirlpak bags, and stored at 4°C until analysed.

Animal remains were isolated by placing approximately 1 g of wet sediment in a 20 ml scintillation vial and adding distilled water to disperse the sediment. The sediment was sieved on 44 μm and 100 μm mesh, and the material retained on the sieves was treated with Rose Bengal to stain biological components. The material was examined under a dissecting microscope and chironomid remains isolated for further study.

Radiocarbon dating of the sediments, estimation of the relative abundance of aquatic moss (on an arbitrary scale), and measurement of abundance of tephra (microscopic shards of volcanic glass) were undertaken as described elsewhere (Agius 2006).

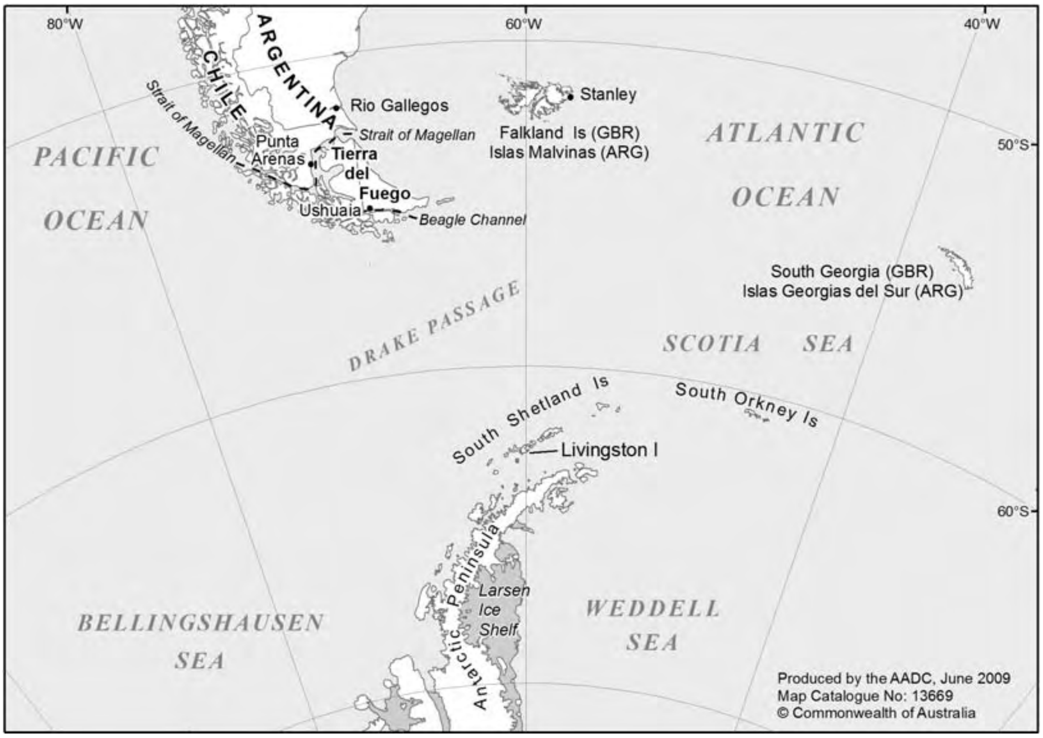

Figure 1. Map of southern South America and the Antarctic Peninsula showing the location of Livingston Island, as well as other areas inhabited by *Parochlus steinenii* (Terra del Fuego and continental South America, South Georgia, South Shetland Islands, Antarctic Peninsula mainland).

Results

Chironomid remains were encountered at abundances up to 180 per g dry weight (g_{dw}^{-1}). The remains, which were typically of the order of 200 µm in length, were mainly portions of adults and discarded pupae, with many anatomical features present (Figure 2). The remains could be identified by comparison to literature figures, in particular the figure of adult and pupa in Wirth and Gressitt (1967). Identification was confirmed by P. Convey, British Antarctic Survey, UK. Somewhat surprisingly, no larval head capsules were observed.

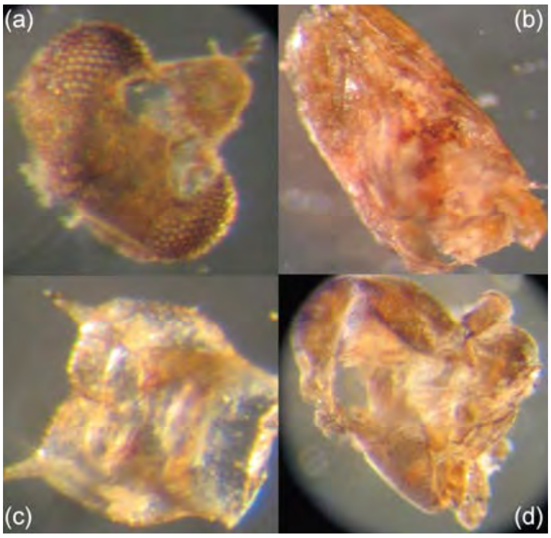

Figure 2. Photographs of representative *Parochlus steinenii* remains: (a) head capsule and eyes of adult; (b) wings and legs of pupa; (c) tail of pupa; and (d) adult thorax.

The distribution within the core (Figure 3) exhibited peaks at depths of 8 cm, 10-15 cm and 25 cm separated by periods of low abundance. The distribution of the chironomid remains showed qualitatively similar trends to that of aquatic moss, with both the moss and the chironomids less abundant after periods of significant tephral input.

The age of the sediments was difficult to determine due to contamination with old carbon, possibly through partial melting of permafrost (J. Gibson and A. Quesada, unpublished results). The most parsimonious interpretation of the data suggested that the core covered approximately 2000 years of sedimentation, but this figure must be viewed with caution.

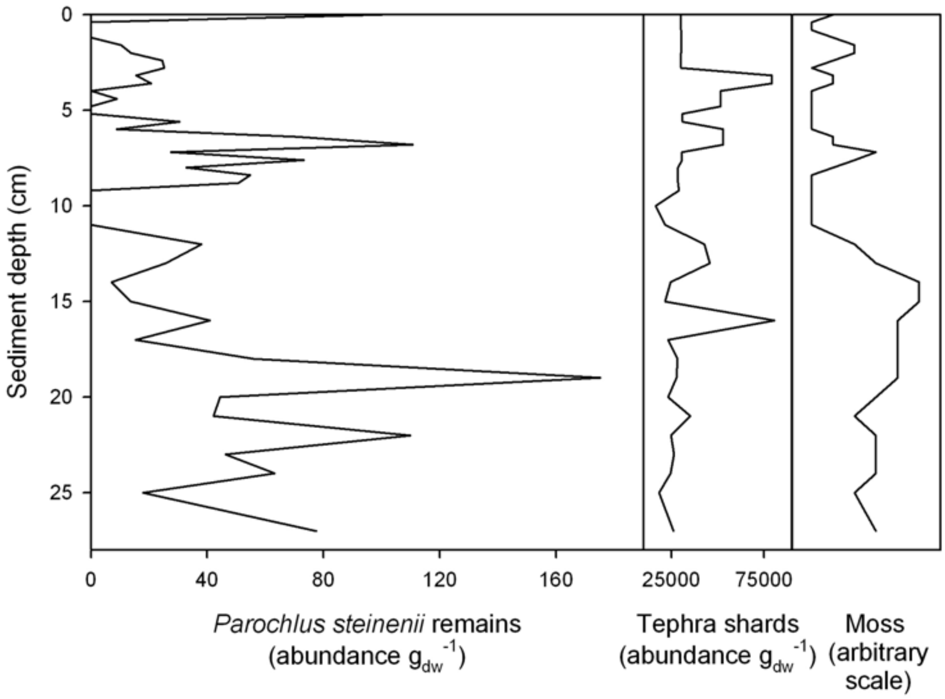

Figure 3. Abundance of *Parochlus steinenii* remains (per gram dry weight) in a sediment core from Limnopolar Lake as a function of depth. Also shown are the abundance of tephra shards and a qualitative estimate of the amount of dead moss present in the sediment. The time span covered by the sediment core is probably of the order of 2000 years.

Discussion

The occurrence of remains of *Parochlus steinenii* at nearly all depths sampled within the sediment core indicates that the species was present throughout the time the sediment was deposited. While the precise time interval the core represents cannot be determined, it is certain that the chironomid has been present on Byers Peninsula for an extended period, and that the suggestion that the species was introduced by whalers can be almost certainly refuted. The observed distribution within the sediment is consistent with the conclusions of Allegrucci et al. (2005), who suggested an ancient origin for this species and therefore the presence of glacial refugia either on the Antarctic Peninsula or within the South Shetland Islands. Recognition of similar glacial refugia across Antarctica is increasing (Convey et al. 2008)

The distribution of the remains in the core gives some indication of the habitat preferences of the species: it appears to be more abundant when significant moss growth occurs in the lake. Toro et al. (2007) reported that *Parochlus steinenii* was most likely to be present in Livingston Island lakes that also contained benthic mosses, which is consistent with this conclusion. Abundance appears to be negatively impacted by deposition of tephra from nearby volcanic eruptions, which would smother food sources. Similar observations have been made during the study of a Chilean lake impacted by tephral deposition (Urrutia et al. 2007). However, it may also be that these apparent correlations are artefacts stemming from changes in sedimentation rates as a result of tephra and other volcanic inputs. The absence of larval head capsules in the sediment is surprising, as larvae inhabit Limnopolar Lake (Toro et al. 2007). The conclusion to be drawn from this observation is that the head capsules of *Parochlus steinenii* are not preserved in the sediment.

Acknowledgements

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