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Analysis of exotic pollen grains and spores from thawing lakes of King George Island, Antarctic Peninsula

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ABSTRACT

Desertification of areas of the Antarctic Peninsula in recent years has been associated with the introduction of heat and abiotic aerosols from the tropics via atmospheric circulation. This environmental transformation has permitted colonization by plants and the establishment of microorganisms in the long-term; however, the mechanisms responsible are not well understood. The present work presents the results of an analysis of exotic pollen grains and spores collected from thawing lakes located on King George Island, Antarctica Peninsula. Atmospheric transport patterns for the region and the main source of the palynomorphs were determined. A total of 13 pollen types of the families Cyperaceae, Apocynaceae, Asteraceae, Malpighiaceae, Meliaceae, Leguminosae, Polygalaceae, Ranunculaceae, Rubiaceae, Ruscaceae and Urticaceae and one spore (Gleicheniaceae) were identified. These groups occur in open areas and are propitious to winds in subtropical, pantropical and neotropical terrestrial regions. Through analysis of the spore-pollen morphology and biogeography of source plants, air transport was found to be a potential, and perhaps the main, transport mechanism for the austral region.

1. Introduction

Polar regions have been identified as hotspots for environmental impacts and as strong indicators of global climate change (IPCC, 2013). Since the Mesozoic, the Antarctic Continent has remained covered by a glacial mantle and isolated from other continents across the Indian, Atlantic and Pacific oceans, yet it plays an important role in the maintenance of the climate of South America (Goldemberg et al., 2011). However, recent elevations in temperature and changes in precipitation patterns in the region of the Antarctic Peninsula represent significant ecological and climatic alterations to the ecosystem of the region (Convey et al., 2009). According to Simões et al. (2015), Collins Glacier, located on the Fildes Peninsula of King George Island (KGI), has exhibited shrinkage over the years in response to increases in local temperature, which has opened ice-free habitats.

Environmental and climatic changes in Antarctica may be related to modifications to the composition of the local atmosphere through the introduction of exotic physical, chemical and biological components (Simões et al., 2011). The macroflora of the region is currently composed of bryophytes and populations of *Colobanthus quitensis* (Kunth) Bartl. (Caryophyllaceae), *Deschampsia antarctica* E. Desv. (Poaceae) and *Poa annua* L. (Poaceae), the latter being an exotic invasive species (Olech, 1996; Olech et al., 2011; Gonçalves et al., 2008).

Cosmopolitan algae, fungi, bacteria and protozoa are found in the Antarctic atmosphere, some of which are considered exotic (Pearce et al., 2009). According to Mandrioli et al. (1973), these microorganisms are possibly transported while adhered to minerals, dust, pollen, spores or hail. Pearce et al. (2009) highlight the relevance of the introduction and possible establishment of microorganisms in the region, integrating with, and compromising, the local microbiota.

Understanding the processes associated with the transport of aerosols with the potential to generate climate change requires studies on their origin, transport and deposition (Licínio, 2006). South America is a possible source of particulate matter deposited in the Antarctica and different climatic patterns can influence the dynamics of transport and deposition, including the Antarctic Ring-Module, cyclone systems (Li et al., 2010; Simões et al., 2011) and low-level jet streams (Rodrigues, 2016). The migration of seabirds as well as anthropic activity may constitute other introductory pathways for palynomorphs and pollutants (Olech, 1996; Parnikoza et al., 2007; Chwedorzewska, 2008; Gonçalves et al., 2008; Peter et al., 2008). Parnikoza et al. (2007) emphasize that the seabirds *Larus dominicanus* Lichtenstein (1823) and *Catharacta lonnbergi* Matthews (1912) are potential foci for the transport of *Acaena* (Rosaceae) and *Uncinia* (Cyperaceae) into the region.

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Pollen grains and spores have been suggested as promising tracers for understanding particulate deposition (Rodrigues et al., 2016). The literature on the Antarctic Peninsula shows that exogenous pollen has been found in Admiralty Bay of King George Island (Kappen and Straka, 1988; Harmata and Olech, 1991), on Joinville Island (Rodrigues, 2016), on Wilkes Land (Kappen and Straka, 1988), on Victoria Land (Likkens et al., 1993) and on the islands of Signy and South Georgia (Smith, 1991).

Pollen structure and morphology are taxonomically useful characters, which can also directly influence the hydrodynamic behavior of palynomorphs and their adhesion, such as through pollenkitt, for zoophilous transport (Armstrong and Brasier, 2005). Thus, the identification of the source of palynomorphs found in melting lakes in the Fildes Peninsula of KGI, may reveal the occurrence of atmospheric aerosol transport to the studied region. This would make it possible to predict environmental interference in Antarctica, when there is any environmental variation in the source area, such as sea level reduction, deforestation, burning and increase release of fossil fuel emissions.

2. Material and methods

2.1. Study area

The studied pollen material was collected from thawing lakes of Fildes Peninsula (62°08′-62°14′S; 59°02′-58°51′W) of southwestern King George Island, Antarctica (Fig. 1). At present, six scientific research stations are installed on Fildes Peninsula (Braun et al., 2012), and in the summer months, tourism is common (IAATO, 2015). Located in the northern region of the peninsula are the Collins Glacier and an area of permafrost, which together possess 100 thawing lakes (Peter et al., 2008), of which ten were sampled for the present study (Table 1).

2.2. Sampling

Samples were collected in the summer of 2012–2013 by researchers from the Laboratório de Radioecologia e Mudanças Globais (Laboratory of Radioecology and Global Changes) and members of the Instituto Nacional de Ciência e Tecnologia da Criosfera (National Institute of Science and Technology of the Cryosphere). One liter of surface water was sampled from each of the ten thawing lakes on Fildes Peninsula and stored separately in plastic bottles previously washed with ultrapure water (Milli-Q) and dried in a laminar flow chamber in the laboratory.

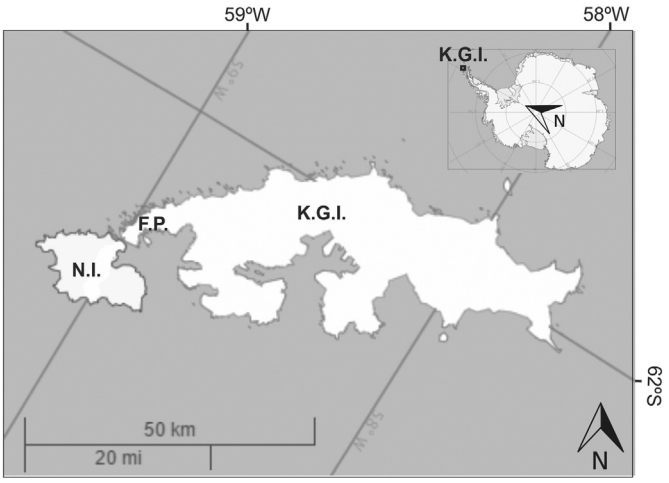

Fig. 1. Map of King George Island with the Antarctic, highlighting the geographic location of Fildes Peninsula. Where: KGI (King George Island), FP (Fildes Peninsula). Source: Centro Polar e Climático (Polar and Climate Center).

Table 1
Geographic location (latitude-longitude) of the thawing lakes sampled in the Fildes Peninsula.

Collection points	Latitude	Longitude
Point 1	−62.197502	−58.992633
Point 2	−62.221145	−58.957624
Point 3	−62.205922	−58.964835
Point 4	−62.202071	−58.966681
Point 5	−62.228434	−58.983330
Point 6	−62.227899	−58.969580
Point 7	−62.193788	−58.960217
Point 8	−62.192076	−58.940921
Point 9	−62.187465	−58.916477
Point 10	−62.183865	−58.910343

2.3. Preparation of the material

Sample preparation took place in a particulate free environment. Cleaning consisted of unidirectional mechanical removal of residues on the surfaces and bulkheads with the aid of disposable papers and alcohol, in addition to using laboratory material reserved for each sample.

Samples were submitted to fractionation methods in 40-ml Falcon tubes and sieving with a 6-μm mesh, as described by Rodrigues (2016). After this procedure, palynological slides were mounted (Kisser, 1935 *apud* Erdtman, 1952). The slides were analyzed under a white-light microscope (Zeiss Axiostar plus) with magnification of 400× and 1000×. When necessary, the slides were reheated and the palynomorphs rotated through mechanical movements with the ends of a forceps to facilitate better visualization of their characteristics.

The pollen descriptions followed the sequence proposed by Barth and Melhem (1988) and the terminology proposed by Punt et al. (2007). The pollen grains and spores were identified and associated with botanical groups with pollen morphology already described in the literature. The taxonomic classification used was based on that of The Angiosperm Phylogeny Group, 2009 (APG III).

3. Results and discussion

The palynological analysis recorded 25 palynomorphs of which 8 were indeterminate and 17 of the families: Gleicheniaceae, Cyperaceae, Apocynaceae, Asteraceae, Malpighiaceae, Meliaceae, Leguminosae, Polygalaceae, Ranunculaceae, Rubiaceae, Ruscaceae and Urticaceae. The taxa found in the samples possess pantropical, subtropical and subcosmopolitan distributions, with small palynomorphs with ornate exines being predominant (Table 2).

Monophyle
Order: Gleicheniales
Family: Gleicheniaceae C.B. Presl. (Fig. 2A)
Genus: *Gleichenia* sp.

Pollen description: Monolete spore, medium (32.5 μm), bilateral, heteropolar, elliptical in polar view and convex plane in equatorial view, monolete. Microreticulate perine.

Previous reference: Cassino and Meyer (2011); Roubik and Moreno (1991).

General occurrence data: The genus has 110 species distributed mostly in tropical regions but some species occur in extra-tropical regions. They occur in open areas near riverbanks or in ravines on sterile soils (Tryon and Tryon, 1982).

Monocotyledone
Order: Poales
Family: Cyperaceae Juss.
Type 1: (Fig. 2B).

Pollen description: Pollen grains in monads, medium (35 μm), bilateral, heteropolar, subtriangular in equatorial view, showing rounded distal pole and conical proximal pole. It has 1 poroid in the distal pole of indistinct contour. Scabrate exine.

Type 2: (Fig. 2C).