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Pollen in fossil hyrax dung from Marine Isotope Stages 2 and 3 reveals past environments in Namibia

Louis Scott [a,*], Graciela Gil Romera [b,c], Eugene Marais [d], George A. Brook [e]

[a] Department of Plant Sciences, University of the Free State, Bloemfontein, 9300, South Africa
[b] Department of Geography and Earth Sciences, University of Aberystwyth, Penglais Campus, SY23 3DB, United Kingdom
[c] Pyrenean Institute of Ecology, CSIC. Avda. Montañana, 1005, 50159, Zaragoza, Spain
[d] National Museum of Namibia, PO Box 1203, Windhoek, Namibia
[e] Department of Geography, University of Georgia, Athens, GA, 30602, USA

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ABSTRACT

In view of a scarcity of terrestrial Quaternary pollen records relating to climate change in desert areas, we present new terrestrial sequences from hyrax middens in Namibia. While the few previously available pollen records are mainly Holocene, we present climate time series for Marine Isotope Stages 2 and 3 (MIS 2 and MIS 3). The data are from two sites in central Namibia that are surrounded by desert plains and close to the Namibian escarpment, viz., the Dâures Massif (Brandberg) and 200 km further south, the Mirabib Shelter located in a small inselberg. In the studied material, grass-rich pollen assemblages were more common at Mirabib where the vegetation is desert grassland, than at Brandberg with its mountain vegetation. Hyrax radiocarbon ages range from 21 ka to >50 ka, with inconsistencies in ages near the limit of effective radiocarbon dating. However, correlation of overlapping sequences supports the chronology we present. Despite chronological gaps in the available deposits, pollen assemblages from different middens indicate marked climate cycles, starting with moderately cool dry conditions with grassy karroid vegetation at Mirabib c. 50 ka. After a gap in the record, warmer conditions with savanna woodland are indicated at both Mirabib and Brandberg around 40 ka. Eventually, cool conditions supporting shrubby grassland with wild olives developed at Brandberg during MIS 2, c. 21 ka. Comparison with marine pollen data confirms earlier findings that terrestrial pollen assemblages differ markedly from South Atlantic Ocean marine pollen assemblages of the same age presumably due to mixing of pollen from wide source areas at the marine localities versus the more locally restricted terrestrial pollen sources trapped in hyrax dung. The results therefore add information for the interpretation of local vegetation shifts on land during the interval between 50 ka and 21 ka in Namibia.

1. Introduction

Climate changes in the Namib Desert region of southern Africa (Fig. 1 A, B and C), during past glacial/interglacial temperature cycles may have been induced by fluctuations in west coast winter-rains, or alternatively by variations in tropical summer-rains along the Congo Air Boundary (CAB) (Tyson, 1986). Changes in moisture presumably would have affected the vegetation of the arid coastal Namib Desert. A decline in moisture from either source would decrease the Namib Desert's cover of arid-adapted flora. Increased winter rainfall would facilitate range extension and expansion of floral elements of the Succulent Karoo or Fynbos Biomes (Mucina and Rutherford, 2006), with their distinctive pollen types, northwards towards the central Namib. In contrast, increased monsoonal summer rain would allow migration of species assemblages of the present-day savanna flora into the desert. Furthermore, it is likely that these changes would have been most notable along the interior margin of the Namib Desert where it presently grades into the semi-arid Nama Karoo Biome and trees and shrubs of the Savanna Biomes (Irish, 1994) (Fig. 1C). A primary aim of this paper is to outline the vegetation changes that are indicated by changing pollen assemblages in a series of Late Pleistocene hyrax middens and compare these with other palaeoclimatic records for the region.

Tracing detailed patterns of vegetation change on land in the dry desert and semi-desert of Namibia is difficult in the absence of

* Corresponding author.
E-mail address: scottl@ufs.ac.za (L. Scott).

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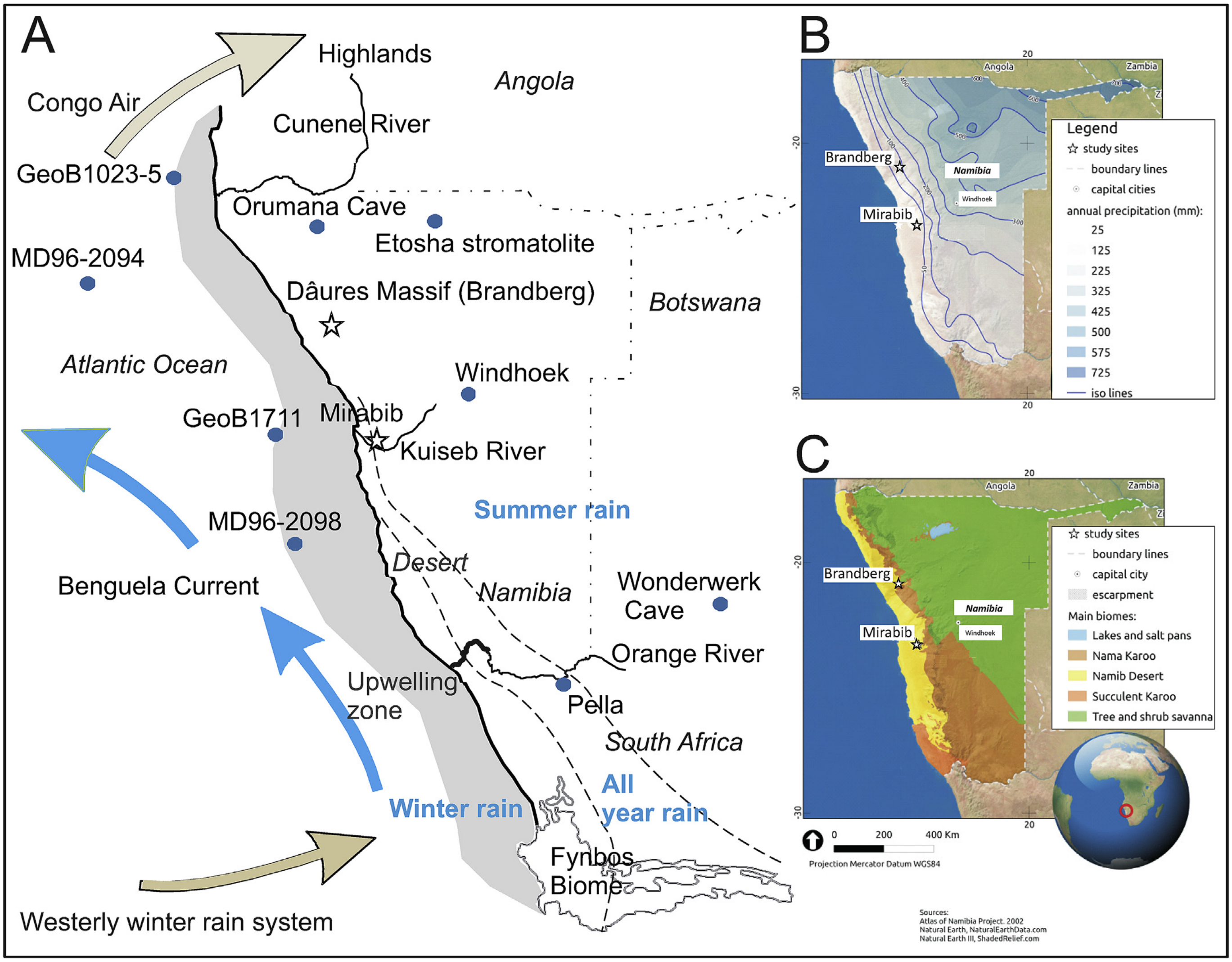

Fig. 1. A, Locality map of southwestern Africa. The dashed line is the approximate boundary between the winter rainfall zone to the west and the all season or summer rainfall regions to the east. The location and extent of the Fynbos Biome relative to our study sites is shown. B, Variations in annual rainfall, C, Relevant Namibian biomes adapted after Irish (1994).

suitable water-deposited materials that preserve pollen. Therefore, information on past vegetation and climate in this region has come largely from interpretations of marine pollen sequences (Shi et al., 1998, 2000, 2001; Dupont et al., 2008; Urrego et al., 2015). Scott et al. (2004) observed an apparent difference between land and ocean pollen records that could be due to a more local signature in the former and mixing of pollen from widely diverse sources in the latter. Therefore, a second aim of this paper is to examine any differences between our terrestrial hyrax pollen data and marine pollen records and discuss their implications for shifts in ranges of some plant taxa in southern Africa during the Quaternary. A problem with comparing land and sea pollen assemblages is that the available terrestrial records are mostly of a younger Holocene age (Scott, 1996; Gil Romera et al., 2006, 2007; Quick et al., 2011; Valsecchi et al., 2013; Chase et al., 2009, 2010, 2011, 2012; Scott and Woodborne, 2007a, b; Scott, 1990) while the above-mentioned marine records generally extend into the Late Pleistocene. Longer terrestrial records like that of Lim et al. (2016) are as yet scarce, so a third aim of the research is to contribute new land palaeoclimatic information for the region dating to the Late Pleistocene.

In the absence of more conventional sources of pollen in Namibia, and the limited age of those that are available, fossil hyrax dung provides a viable alternative source of pollen and has potential for future studies. Here we present pollen records from Brandberg and Mirabib (Fig. 1), two inselbergs west of the Namibian escarpment. The pollen data we present are the oldest from hyrax dung deposits currently available; they extend present records into the Pleistocene. They document vegetation responses to environmental changes, information that is needed to record past vegetation shifts on the continent. In addition, we compare our reliable terrestrial records with marine data to adjust possible biases in reconstructions of biome and habitat changes on land based on data from distant offshore sites (e.g., Urrego et al., 2015).

There are Late Holocene palaeobotanical records for Namibia based on analysis of rare lake, swamp and cave guano sequences (e.g. Marais et al., 2015; Scott et al., 1991) but most information has been obtained by pollen (Scott, 1996; Gil Romera et al., 2006, 2007) and isotopic (Chase et al., 2009, 2010, 2011) analysis of hyrax dung. Apart from marine pollen data and except for some preliminary findings (Scott et al., 2004), very little or nothing is known about mainland vegetation changes in Namibia during pre-Holocene

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