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Pollen from Late Pleistocene hyena (*Crocuta crocuta spelaea*) coprolites: An interdisciplinary approach from two Italian sites

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ABSTRACT

Palynology of fossil faeces is still extremely rare and its contribution to the interpretation of the environment undervalued. In this paper we present the results of pollen analysis performed on cave hyena coprolites [*Crocuta crocuta spelaea* (Goldfuss, 1832)] from Marine Isotope Stage 3 (MIS 3) sites of Cava Muracci (Cisterna di Latina, central Italy) and Tana delle Iene (Ceglie Messapica, southern Italy). This study provides new insights into the vegetation of the Late Pleistocene of peninsular Italy, until now known only through long pollen records. It also shows how the content of coprolites, combined with faunal data and geochronological investigations, can represent a potential integrative source of palaeoclimatic proxy data. Our results indicate that the surroundings of both of the hyena dens were characterised by a patchy landscape with open lowlands dominated by steppe and grassland vegetation, while a few mesophilous and thermophilous trees were present in more humid areas, probably along the marine coast and inland. The harsh glacial climate appears to have been milder at Cava Muracci than at Tana delle Iene. This could be due either to the different environmental features of the two sites or to the high climatic variability that occurred during MIS3.

1. Introduction

The Last Glacial period (~112 ka to 11.8 ka) in Mediterranean Europe is featured by a marked climatic variability (Sanchez-Goñi et al., 2002), with extremes approaching, on one side, the dry and cold conditions of the Last Glacial Maximum and, on the other, the warm and humid conditions of a typical interglacial period (Allen et al., 2000). In particular, the period corresponding to Marine Isotope Stage 3 (MIS 3), spanning between ~58 ka and 28 ka (Railsback et al., 2015), can be seen as a paradigm of this variability, being the most unstable temporal interval of the Last Glacial period, punctuated by abrupt and short climate changes at sub-millennial to decennial-scales, i.e., not directly related to millennial-scale orbital changes considered to be the main drivers of the longer term glacial–interglacial variability (Moreno et al., 2014). Throughout the high- to mid-latitude regions of the northern hemisphere, ice, marine and terrestrial multi-proxy palaeoclimatic and palaeoenvironmental archives record the extreme climatic instability of MIS 3. They show (*i*) marked atmospheric temperature oscillations, e.g., the so-called Dansgaard–Oeschger (D-O) events in Greenland ice cores (Dansgaard et al., 1993), (*ii*) marine sea surface temperature changes and ice rafting events, i.e., Heinrich events (Birner et al., 2016; Broecker, 1994; Hemming, 2004), (*iii*) abrupt changes in rainfall regime, as revealed by speleothem (Luetscher et al., 2015) and pollen (Follieri et al., 1998; Allen et al., 2000; Margari et al., 2010) records, and other environmental changes (Moreno et al., 2014). Although a teleconnection between the climatic variability of the polar and mid-latitude regions of the boreal hemisphere has been recognised (Kandiano et al., 2014; Regattieri et al., 2015), a close and precise comparison of MIS 3 temporal series of different regions (e.g. North Atlantic and central Mediterranean) is sometimes limited by the inherent uncertainty in comparing records based on different dating methods and age models, the resolution of which is often lower than the frequency of the MIS 3 climatic variability itself. Interpretation is further complicated by possible, often undeterminable, lags in the responses of different environmental systems and proxies to the climatic changes.

The Last Glacial climate has been reconstructed in central and southern Italy using long lacustrine pollen records from the volcanic

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lakes of Basilicata and Latium. The records are, from North to South: Lagaccione (Magri, 1999); Lago di Vico (Magri and Sadori, 1999); Stracciacappa (Giardini, 2007); Valle di Castiglione (Follieri et al., 1988; Follieri et al., 1989) and Lago Grande di Monticchio (Allen et al., 2000; Watts et al., 2000). A pollen record of the Last Glacial age is also available from an intermontane valley of Abruzzi (Chiarini et al., 2007).

In all of these records montane, mesophilous and Mediterranean tree pollen oscillations characterise part of the glacial period corresponding to MIS 3. Follieri et al. (1995, 1998), comparing four lacustrine records of Latium, found seven main arboreal fluctuations, probably strictly related to North Atlantic events of MIS 3. An attempt to compare these slight tree expansions and contractions, mainly due to variations in humidity, to changes found in ice and marine cores of high boreal hemisphere latitudes, was carried out for the pollen record of Lago Grande di Monticchio (southern Italy) (Allen et al., 2000; Watts et al., 2000). It is worth highlighting that even between the relatively close sites of Latium it is possible to denote a discrepancy in the records, possibly due to different, local environmental conditions.

The central and southern Italian long lacustrine records offer a good general framework for palaeoenvironmental reconstruction carried out in specific sites. However, we have to consider that sites far from the above mentioned lakes could have quite different geographic and climatic features and could provide improved insights into regional variability. Analysis of local sources such as coprolites can be decisive in regions in which there are no available lacustrine archives for the period under investigation.

In this paper we present the results of pollen analysis of hyena coprolites from the karst caves of the Latium coast, central Italy, and the Apulia hinterland, southern Italy (Fig. 1) with the aim of exploring the temporally and regionally highly variable MIS 3 climate, and adding new information on the palaeoenvironmental mosaic. The present study also has the methodological purpose of testing the potential of pollen from hyena coprolites to provide local environmental reconstructions – i.e., within a radius of 50 km from the hyena dens, in contrast to the more typical use of pollen data in interpretations of larger regional areas (Scott, 1987; Yll et al., 2006) – and thus as an additional source of palaeoenvironmental data to complement the longer and more continuous pollen records from lacustrine successions.

The potential contribution of fossil faeces to palaeoecological information has been known for a long time (Bryant and Holloway, 1983; Leroi-Gourhan, 1966; Martin et al., 1961; Moe, 1983), but is nevertheless rarely exploited or treated as of marginal usefulness.

Well preserved coprolites, due to their hardness and durability (Bearder, 1977; Larkin et al., 2000), can insulate organic matter, including pollen, preventing oxidation of the granules (Scott et al., 2003). Therefore, pollen contained in coprolites is often well preserved and closely identifiable with the associated sediments (Carrion et al., 2001; Scott, 1987; Scott et al., 2003). All these reasons make the coprolites a valuable resource, especially for those contexts in which typical pollen traps such as lakes and swamps do not occur (González-Sampériz et al., 2003; Scott, 2000).

Pollen analysis has been carried out elsewhere on coprolites of extinct giant birds (Wood et al., 2008) and herbivores (Carrion et al., 1999, 2000; Yll Aguirre et al., 2001). The amount of pollen in coprolites is extremely variable and may be affected by a number of factors, such as the age of the samples, seasonality of deposition, sediment conditions, gastric action, diet and behaviour of carnivores and their prey and other differential preservation processes. However, although pollen concentration in herbivore coprolites is usually higher (González-Sampériz et al., 2003), palaeoecological analyses of carnivore coprolites, such as hyena, have been successfully achieved on samples with low pollen concentration (Argant and Dimitrijevic, 2007; Carrion et al., 2001; Scott et al., 2003; Yll et al., 2006). The reliability of the pollen data from hyena coprolites and vegetation reconstructions based on them is also confirmed by comparisons with pollen spectra from other archives (Argant and Dimitrijevic, 2007; Carrion et al., 2001; González-Sampériz et al., 2003; Scott et al., 2003; Yll et al., 2006).

2. Study sites

2.1. Present day setting

The two selected sites are Cisterna di Latina (Latium, central Italy) and to Ceglie Messapica (Apulia, southern Italy) (Fig. 1).

The current climate of central and southern Italy consists of warm summers and wet conditions in autumn and winter. The climate is typically Mediterranean along the coast while temperature and rainfall vary greatly in the hills and mountains of the Apennines, where the sub-Alpine climate provides cold and snowy winters and cool summers. Cisterna di Latina is situated in the mesomediterranean thermotype class, with a high average annual temperature and long warm, dry summers. Winters are never harsh and temperatures rarely reach 0 °C. The position of the small plain between the sea and the mountains makes the botanical framework extremely varied and complex, causing

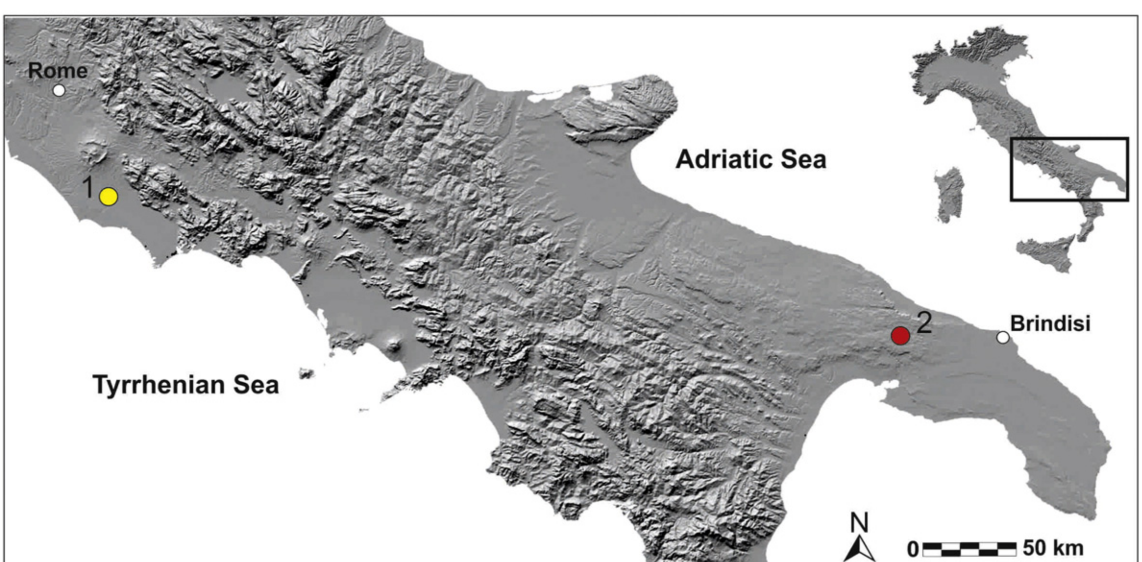

Fig. 1. Location of the investigated successions. 1 – Cava Muracci Cave, Cisterna di Latina; 2 – Tana delle Iene site, Ceglie Messapica.