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## The wood charcoal evidence from renewed excavations at Elands Bay Cave, South Africa

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### ABSTRACT

This article presents the results of the anatomical identification by scanning electron microscopy of wood charcoal from excavations in 2011 at Elands Bay Cave (EBC), South Africa. The samples are from Robberg Group D layers (18/19 ka cal BP); the Early Later Stone Age (LSA) Group F layers (22–24 ka cal BP), and the late Middle Stone Age (MSA) Group H-I-J layers (35–39ka cal BP). Noticeable differences in the vegetation are present in LSA layers, which have more diverse thicket elements represented in Groups D and F than in Group H-I-J layers—with their heavier reliance on Afromontane and mesic thicket taxa during the late MSA. Published charcoal results from previous excavations at EBC chart a progressive change over time from xeric thicket and asteraceous shrubland vegetation, through proteoid fynbos and general thicket to mesic thicket, riverine woodland and proteoid fynbos, ultimately to Afromontane forest. Climatic or soil moisture factors may have played a significant part and contributed to some or all of the taxa having very different phytogeographical distributions compared to their modern counterparts, but is also necessary to consider to what extent the people using EBC at different times might have collected (and selected) woody resources from a mosaic of vegetational communities, some local, some far away.

KEY WORDS: wood charcoal, scanning electron microscopy, Later Stone Age, Middle Stone Age, Robberg; vegetation, climate, Western Cape.

This article presents the results of the anatomical identification by scanning electron microscopy of wood charcoal from Robberg ‘Group D’, Early Later Stone Age (LSA) ‘Group F’ and late Middle Stone Age (MSA) ‘Group H-I-J’ within the renewed excavations in 2011 at Elands Bay Cave (EBC), South Africa. The purpose of the 2011 fieldwork season at EBC was to contextualize the lower LSA and MSA archaeological deposits excavated by John Parkington in 1972 and 1978 (Porraz et al. 2016 this issue). Present studies (Porraz et al. 2016 this issue; Tribolo et al. 2016 this issue) suggest that, unlike nearby Diepkloof Rock Shelter (DRS), no Still Bay, Howiesons Poort (HP) or post-HP occupation has yet been recorded at EBC.

Detailed analysis of charcoal from the 1970 excavations at EBC revealed new insights into late and terminal Pleistocene vegetational and climate change in the coastal area of the Western Cape (Cartwright & Parkington 1997; Cowling et al. 1999; Parkington et al. 2000; Cartwright et al. 2014). These charcoal assemblages from EBC at the Last Glacial Maximum (LGM) included Afromontane taxa which showed that the Western Cape coastal belt had higher soil moisture availability during the later and terminal Pleistocene, including at the LGM. We hypothesized, therefore, that during these time periods, westerly cyclonic fronts delivered sustained precipitation on the western slopes of the Cape Fold Belt mountains but decreased movement of moist unstable air across the restricted and possibly cooler Agulhas current left the eastern part of the biome more arid than it is today

(Cowling et al. 1999). Comparisons with charcoal samples from the LSA and MSA chronostratigraphic sequence at DRS are vital to all EBC analyses (Cartwright 2013), and this comparative research is on-going in terms of its wider palaeoenvironmental and archaeobotanical implications.

#### METHODS

For the earlier EBC charcoal analysis (Cartwright & Parkington 1997; Cartwright et al. 2014) collection of reference specimens essential for the identification of the archaeological charcoal commenced in the area around the site, and then extended to other locations in the south-western, north-western and southern Cape. In the field, 434 woody taxa were photographed, documented and collected. Some were professionally identified *in situ*, whilst others were brought back for identification at the Bolus Herbarium, Department of Botany, University of Cape Town or at Kirstenbosch National Botanical Garden, Cape Town. Collection was made from a range of substrata and topographical locations with a view to assessing possible microenvironmental variability. The collected woody taxa not only characterised the region around EBC (and DRS) today, but also provided a framework of reference for those represented in the vegetational changes through time evidenced by the archaeological charcoal assemblages (Cartwright et al. 2014). Integral to interpretation is the research currently in progress (under the direction of Richard M. Cowling) with regard to the characterisation of extant vegetational communities in their climatic and habitat envelopes covering steep gradients in temperature and rainfall regimes. Already, such characterisation has resulted in a broad set of available environmental correlates that were crucial to the interpretation of the 1970 EBC charcoal assemblages (Cowling et al. 1999), and it is anticipated that similar outcomes will be forthcoming for both the DRS and the 2011 EBC charcoal being reported here.

In the laboratory each securely-identified woody reference collection specimen was halved; one portion was thin sectioned using standard microtome and staining techniques to provide transverse, radial longitudinal and tangential longitudinal (TS, RLS and TLS) sections of the wood, and the other half was converted to charcoal for anatomical comparative reference purposes (Cartwright & Parkington 1997). None of the taxa represented by woody reference collection specimens had already been described anatomically according to International Association of Wood Anatomists (IAWA) protocols (Wheeler et al. 1989). Thus, before any identification of archaeological charcoals could proceed, Cartwright carried out an intensive microscopical examination and compiled a computerised anatomical feature database and checklist for all the reference collection of woody taxa using the descriptions and features from the IAWA List of Features for Hardwood Identification (Wheeler et al. 1989; InsideWood 2004 onwards). The extremely useful on-line wood anatomy database InsideWood (Wheeler 2011) was not available at the commencement of the EBC (and DRS) projects. But even if it had been available, whilst it is an essential tool for the wood anatomist, and despite comprising 6996 modern wood descriptions and 43 005 modern wood thin section images at the time of writing (June 2016), InsideWood's geographical coverage (did not and) does not extend (at present) to the woody taxa of the western Cape of South Africa, it does not cover gymnosperm woods (softwoods), and it does not document charcoal. However, it still remains a key

resource for the wood anatomist and, with certain cautions, to the charcoal specialist as well (Cartwright 2015). Cartwright updated her original computerised anatomical feature database for Western Cape charcoal using the augmented IAWA feature checklist (InsideWood 2004 onwards) prior to the final phases of identification of Western Cape archaeological charcoal assemblages. Some of the descriptors on this data sheet required modification—particularly those reflecting size and dimension—to accommodate the effects of charring, as had been implemented for EBC 1970 charcoal on an earlier version (Cartwright & Parkington 1997).

The anatomical examination of all EBC 2011 archaeological charcoal was carried out using scanning electron microscopy (SEM). Because of the three-dimensional nature of wood anatomy, each piece of charcoal, irrespective of size, was fractured manually to show TS, RLS and TLS for examination (for full details, see Cartwright & Parkington 1997). Each TS, RLS and TLS charcoal sample was then mounted on an aluminium SEM stub for SEM examination. Charcoal fragments that were very small, in poor condition or from contexts lowest in the stratigraphical sequence were mounted using Leit-C Plast carbon cement (which is a proprietary brand of conductive material with low outgassing properties). After mounting, each stub with its charcoal sample was sputter-coated with gold or platinum to make it conductive in the high vacuum conditions of the Hitachi S4800 field emission (FE) SEM using the secondary electron (SE) detector (for technical details see Cartwright 2013). Although the 2011 EBC charcoal fragments are in remarkably good condition (considering their antiquity), they are often extremely small and so the FE-SEM ultra-resolution and increased range of magnification has proved particularly suitable for these charcoal samples. Well-preserved charcoal samples were mounted as described above and examined uncoated in the Hitachi S-3700N variable pressure (VP) SEM (for methodological and technical details see Cartwright 2013).

## RESULTS AND DISCUSSION

Excavations in 2011 at EBC were carried out in sedimentary units, rigorously following the slope of the strata. Hearths were excavated separately with charcoals and ash horizons being differentiated (Miller et al. 2016 this issue; Porraz et al. 2016 this issue). All deposits have been sorted using 3 mm and 1 mm mesh screens. The present study is based on the sorting of the 3 mm screen only.

Three main groups can be defined (Porraz et al. 2016 this issue):

- 1) The Robberg Group D layers (14C dated to 18/19 ka cal BP)
- 2) The Early LSA Group F layers (14C dated to 22–24 ka cal BP)
- 3) The late MSA Group H-I-J layers (14C dated to 34–36 ka cal BP).

Table 1 shows the results of the charcoal identifications presented according to these groups. The present-day distributions and characteristics of the taxa present in Table 1 serve as a framework of reference for interpretation of the archaeological charcoal, particularly with regard to palaeoenvironmental considerations.

Mindful of the very different present-day vegetation of Elands Bay—with low xeric (very dry) scrub and asteraceous shrubs—and also the previous published charcoal results from EBC which chart a progressive change over time from xeric thicket and asteraceous shrubland vegetation, through proteoid fynbos and general thicket to mesic

TABLE 1  
Charcoal identifications from groups D, F and H-I-J of EBC 2011 excavations.  
Numbers = weight in grams.

	<b>Group D</b> dated to 18/19 ka cal BP	<b>Group F</b> dated to 22–24 ka cal BP	<b>Group H-I-J</b> dated to 3–39 ka cal BP
<b>General thicket taxa</b>			
<i>Searsia lucida</i> (formerly <i>Rhus lucida</i> )	10	7	
<i>Searsia tomentosa</i> (formerly <i>Rhus tomentosa</i> )	11	9	6
<i>Searsia undulata</i> (formerly <i>Rhus undulata</i> )	15	6	4
<b>Mesic thicket taxa</b>			
<i>Cassine peragua</i>	6	10	12
<i>Cassine schinoides</i> (formerly <i>Hartogiella schinoides</i> )	5	8	16
<i>Diospyros glabra</i>	6	8	22
<i>Dodonaea viscosa</i> subsp. <i>angustifolia</i> (formerly <i>Dodonaea angustifolia</i> )	7	7	28
<i>Gymnosporia buxifolia</i> (formerly <i>Maytenus heterophylla</i> )	4	8	14
<i>Heeria argentea</i>	6	12	14
<i>Maytenus oleoides</i>	6	11	10
<i>Olea europaea</i> subsp. <i>africana</i>	4	8	30
<b>Afromontane forest taxa</b>			
<i>Celtis africana</i>	2	2	15
<i>Halleria lucida</i>	2	2	17
<i>Kiggelaria africana</i>	3	5	22
<i>Myrsine africana</i>			8
<i>Podocarpus elongatus</i>	4	4	26

thicket, riverine woodland and proteoid fynbos, ultimately to Afromontane forest (Cartwright & Parkington 1997), we can consider the charcoal taxa represented in the 2011 EBC record in more detail.

Group D layers show distinct use of general thicket taxa; Group F layers also to some extent but Group H-I-J layers less so. *Searsia lucida* (waxy-leaved bush) can be classified as a general thicket taxon, though may also be found on edges of forests and on rocky hill-slopes. *S. lucida* shows a preference (although not exclusively so) for wetter locations, including Olifants Alluvium Fynbos, Graafwater Sandstone Fynbos in wetter areas in hills, Leipoldtville Sand Fynbos, Graafwater Flats Strandveld, Kobee Succulent Shrubland, CitrusdalVygieveld (Helme 2007), sandstone fynbos valley bottom/depression wetlands, sandstone fynbos depressions/mountain seeps and alluvial floodplain wetlands (Job et al. 2008). Other thicket taxa include *Searsia tomentosa* (wild currant), which can be found in Renosterveld, on rocky mountain slopes and



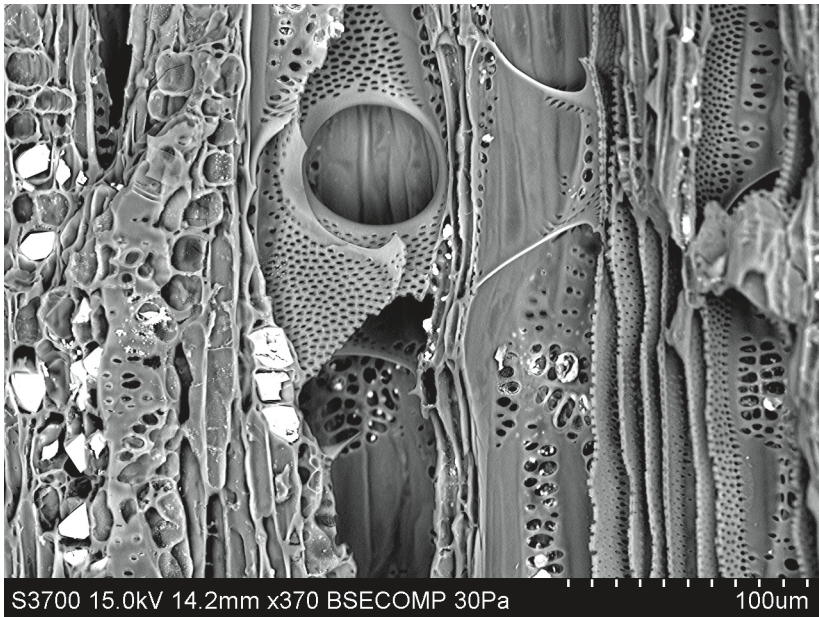


Fig. 1. Variable pressure scanning electron microscope image of *Searsia undulata* (Namaqua kuni-bush) charcoal in radial longitudinal section. Image: Caroline R. Cartwright.

on the edges of low thicket or scrub, and *Searsia undulata* (Namaqua kuni-bush, Fig. 1) *S. undulata* seems to prefer the drier vegetational communities such as Nieuwoudtville-Roggeveld Dolerite Renosterveld (Manning & Goldblatt 1997), Doringrivier Quartzite Karoo, Kobee Succulent Shrubland and Citrusdal Vygieveld (Helme 2007). It occurs alongside *Cassine peragua* (forest spoonwood), *Dodonaea viscosa* var. *angustifolia* (sand-olive), *Heeria argentea* (rockwood/kliphout), *Olea europaea* subsp. *africana* (wild olive), *Maytenus oleoides* (mountain maytenus/rock candlewood), *Diospyros glabra* (blueberry bush) and *S. lucida* in thicket vegetation on rocky slopes and in forest margins and it is of significance that the association of these taxa is clear in Groups D and F layers, and to some extent in Group H-I-J layers (Table 1).

Group D layers exploit the mesic thicket category, Group F layers even more so and Group H-I-J layers show a marked reliance on these taxa. *Cassine* species can be found at the present day in mesic thicket as well as in Afrotropical forest and its margins and on riverine fringes; Groups D and F layers, and particularly those in Group H-I-J show consistent selection of *C. peragua* (see Cartwright 2013 for a detailed taxonomic discussion) and *C. schinoides* (spoonwood) is present in an altitude range of 100 to 1800 m in Afrotropical forest, on rocky mountain slopes, in wooded kloofs (ravines) and in thicket. *D. glabra* sometimes forms part of general thicket vegetation and sometimes within mesic thicket at forest-margins and on rocky hill-slopes. It has been recorded in pockets of Afrotropical vegetation in mountain kloofs as well as in Olifants Alluvium Fynbos, Graafwater Sandstone Fynbos and Vanrhynsdorp Shale Renosterveld, and on alluvial floodplain wetlands (Low et al. 2004; Helme 2007; Job et al. 2008). *D. viscosa* var. *angustifolia*, *O. europaea* subsp. *africana* and *H. argentea* can also be found in association within Graafwater Sandstone Fynbos in kloofs (Low et

al. 2004). *O. europaea* subsp. *africana*, in addition to occurring in thicket and woodland (where it may attain a height of 12 m), can also be found in riverine valley bottom wetland sandstone fynbos vegetation. *Gymnosporia buxifolia* (spike-thorn) occurs in a variety of thicket, fynbos and strandveld vegetation, including Hopefield Sand Fynbos, Leipoldtville Sand Fynbos, Namaqualand Sand Fynbos, Swartland Shale Renosterveld, Saldanha Flats Strandveld, West Coast Strandveld, Langebaan Fynbos/Thicket Mosaic, Graafwater Flats Strandveld and Namaqualand Strandveld (Helme 2007). *H. argentea* is recorded as being common in thicket patches of Graafwater Sandstone Fynbos, but on the west coast, only one example of *H. argentea* forest has survived in the Lambert's Bay area on a sandstone inselberg "a remnant from long ago, perhaps when sea levels were further out and the climate was much wetter than it is now ... the nearest patch is now at least 25 km inland, in more mesic habitats" (Helme 2007: 67 and Plate 32). *M. oleoides* occurs in Graafwater Sandstone Fynbos (Helme 2007) on rocky slopes and at forest margins.

Maps (some interactive) of these different vegetation zones at the present day (mentioned above) can be found on the Biodiversity GIS (BGIS) South African National Biodiversity Institute (SANBI) websites at <http://bgis.sanbi.org/gcbc/vegetationTypes.asp> and [http://bgis.sanbi.org/vegmap/map2009\\_2012.asp](http://bgis.sanbi.org/vegmap/map2009_2012.asp).

We have already noted that the charcoal evidence from the 1970 excavations at EBC indicated a predominance of Afrotropical taxa which suggested that the Western Cape coastal belt had higher soil moisture availability during the later and terminal Pleistocene, including at the LGM (Cartwright & Parkington 1997; Cowling et al. 1999; Parkington et al. 2000; Cartwright et al. 2014). Charcoal from Group H-I-J layers of the 2011 excavations at EBC show a more marked dependence on such taxa than in Groups D and F layers. *Celtis africana* (white stinkwood), Figure 2, and *Podocarpus elongatus* (Breede River yellowwood), Figure 3, are found today in Southern and Eastern Cape Afrotropical woodlands in sheltered mountain gorges alongside taxa such as *Cassine* (Cowling et al. 1997). *C. africana* is usually associated with higher rainfall or moister places (Cowling et al. 1999) and can be found in rocky outcrops (in small and scrubby form) as well as full-grown in Afrotropical forests. The phenotypic plasticity of *P. elongatus* has already been noted (Cowling & Homes 1992; Cowling et al. 1999; Cartwright et al. 2014) but it is worth reiterating this adaptive capacity for plants and trees to survive in changed environments and in a variety of vegetational communities, as it is directly relevant to their presence at EBC and the processes whereby they arrived at the site over time. *P. elongatus*, for example, whilst often to be found in pockets of Afrotropical/Afrotropical forests in kloofs, along rivers and adjacent to wetlands, can also occur in the wetter areas of different types of fynbos including Graafwater Sandstone Fynbos (in hills) and Olifants Alluvium Fynbos (Cowling & Homes 1992; Low et al. 2004; Helme 2007). The fact that *Podocarpus* is useful source of resin might account for its sustained presence in the archaeological record at EBC (and other sites in the Western Cape, such as DRS).

*Halleria lucida* (tree fuchsia) has a mostly eastern distribution at the present day in coastal and karroid scrub, at forest and river margins and on rocky slopes. Helme (2007) does not record *H. lucida* for the Strandveld of the Western Cape, but does note the presence of the shrubby *H. ovata* along stream banks in the Citrusdal region and in fynbos locations in the Olifants River Mountains (Helme & Raimondo 2007;

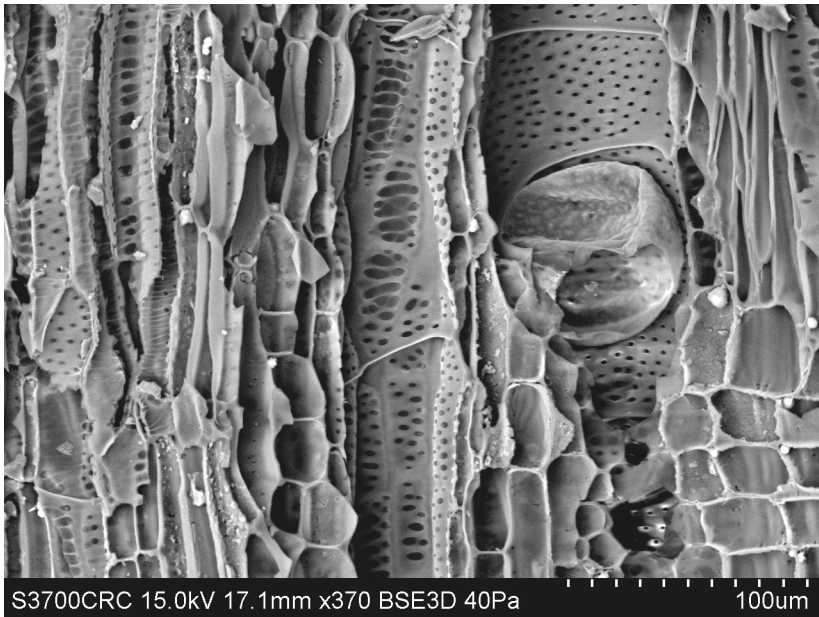


Fig. 2. Variable pressure scanning electron microscope image of *Celtis africana* (white stinkwood) charcoal in radial longitudinal section. Image: Caroline R. Cartwright.

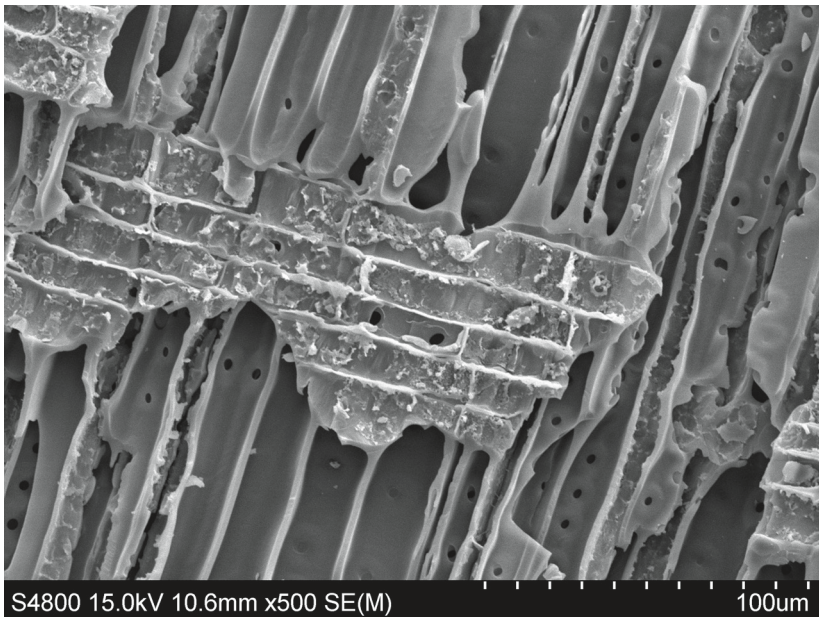


Fig. 3. Field emission scanning electron microscope image of *Podocarpus elongatus* (Breede River yellowwood) charcoal in radial longitudinal section. Image: Caroline R. Cartwright.





Fig. 4. Variable pressure scanning electron microscope image of *Myrsine africana* (Cape myrtle) charcoal in transverse section. Image: Caroline R. Cartwright.

Raimondo et al. 2009). *Kiggelaria africana* (wild peach) is widely distributed in (mostly southern, eastern and north-eastern) coastal and inland Afrotropical forests, along streams and on rocky hillsides. *Myrsine africana* (Cape myrtle), Figure 4, also has a wide distribution and can be found in forests, rocky hill-tops and fynbos.

The charcoal from the 2011 excavations at EBC contributes further evidence of the nature of vegetation change prompted by climatic variability during the LGM in the Western Cape. Comparing such evidence from the charcoal on West Coast sites to the broader picture of LGM change more widely in South Africa is far more complex, not least because the vegetation across South Africa is extremely diverse, and far more archaeological sites yielding well-stratified sequences containing identifiable charcoal need to be excavated and analysed. More meaningful than comparisons of individual taxa across South Africa in general will be comparisons on a region-by-region basis where the changes of vegetational communities as attested from the evidence of well-dated sequences of archaeological charcoal can be interpreted against the framework of present-day vegetation for that biogeographical region. Furthermore, patterns of vegetation and vegetational changes over time have been influenced and shaped by climatic controls that are fundamentally different on the east coast of South Africa compared to that of the west coast. Consequently, we have held back at this stage from making unsubstantiated comparisons over wide areas. It is crucial to understand west coast variability fully before attempting inter-regional reconstructions, particularly as the non-woody plant material (seeds and fruits) from EBC is not yet processed and available for study. Adding this dimension of evidence could significantly alter our reconstruction of vegetational communities over time, as well as providing enhanced information about resource selection and availability.

## CONCLUSIONS

The 2011 EBC charcoal evidence (Table 1) shows some noticeable differences in the vegetation present in LSA layers, which have more diverse thicket elements represented in Groups D and F than in Group H-I-J layers—with their heavier reliance on Afromontane and mesic thicket taxa during the late MSA. The published charcoal results from previous excavations at EBC chart a progressive change over time from xeric thicket and asteraceous shrubland vegetation, through proteoid fynbos and general thicket to mesic thicket, riverine woodland and proteoid fynbos, ultimately to Afromontane forest. As has been seen for these results (e.g. Cowling et al. 1999), whilst climatic or soil moisture factors may have played a significant part and contributed to some or all of the taxa having very different phytogeographical distributions compared to their modern counterparts, it is also necessary to consider to what extent the people using EBC at different times might have collected (and selected) woody and other botanical resources from a mosaic of vegetational communities, some local, some far away (see Charrié-Duhaut et al. 2016 this issue).

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