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Letter to the Editor

Paleoecology and paleoart: Landscapes of the Middle Pleistocene Neanderthals in Bolomor Cave, eastern iberia

During the last International Congress of Paleobotany and Palynology (Dublin, 2018), participants discussed *Paleoecology through the lens of Art and Science*. These talks identified an urgent need for a more synergistic interaction between the visual arts and the sciences. Importantly, such consilience could inform research. This is because, while fossils can capture the world of the biological past, art offers an interpretative window which, though not free from conjecture, can provide perspectives which can transform the unknown into the possible.

It is increasingly recognized that any research project financed with public funds needs to give back to the community and the citizens, preferably in a format that is both informative and engaging. The consilience of art and science, we would suggest, is key to this. In addition, students today unfortunately suffer from excessive bureaucracy and excessive reliance on technology. While complexity of the scientific fabric may be transformed into digestible segments in this way, it runs the risk of generating anodine conclusions which are unfulfilling for the student. The biological sciences should introduce students to multi-disciplinarity. It is, after all, the "Natural History" which produced Charles Darwin, among many others. Instead, excessive specialization leads to a level of reductionism that has effectively killed Natural History as a discipline. Introducing the visual arts into the study of Nature has the potential of encouraging holistic thinking. Art and science together could help reorientate neontological models that have become unsuitable for explaining phenomena, to the extent of correcting deficiencies in such areas as bio-conservation practice and natural resource management.

A specific case in point, acting as a case study, is that of the paucity of "paleoart" depicting vegetation. Most paleo-artists deal exclusively with animals, mostly dinosaurs and terrestrial mammals. Unfortunately, the botanical component is usually nothing more than a decorative element, a backdrop, which sometimes even lacks a scientific foundation.

In the accompanying artwork, we seek to reproduce the flora of the ancient habitat of the Neanderthals that occupied Bolomor Cave (Eastern Spain) from before 350.000 to after 120.000 years ago. It is based mainly on a detailed paleobotanical sequence that has recently been published (Ochando et al., 2019) (Fig. 1). The site is well-known among researchers for its abundance of fossils and lithics, as well as for offering one of the first evidence of controlled fire in form of combustion structures in the Iberian Peninsula, dated to approximately to ~230,000 years ago (Rosell and Blasco, 2019).

Ochando et al. (2019) found that the Neanderthals of Bolomor lived for hundreds of thousands of years in woodland which was numerically dominated by pines (*Pinus*) and oaks (*Quercus*). The palynological evidence pointed to an abundance of woody plants and, importantly, highlighted the presence of thermophilic plants. Together, the data suggest that the site may have been a significant refuge of plant diversity. The evidence runs counter to the long-established view of the Neanderthal as a cold-adapted hominin that occupied the steppe-tundra of northerly latitudes. It supports, instead, paleoecological evidence from the south (Finlayson, 2006; Finlayson and Carrión, 2007, Carrión et al., 2018) and the northeast of the peninsula (Ochando et al., 2020), which clearly situates the Neanderthals in a thermo- and meso-Mediterranean context (Finlayson, 2020). Recent anatomical and ecological studies on Neanderthal locomotion also fit into our more recent ideas of this historical landscape, suggesting that "hunting strategy was more likely to be encounter or ambush in style than pursuit hunting, which involves a power mode of locomotion such as sprinting" (Stewart et al., 2019). Paleofloristic data match the record of faunal and lithic diversity (Blasco and Fernández-Peris, 2012), which suggest a long human occupation in the Valldigna Valley, in the karst mountains of the Mondúver. The conditions are those of an ecotone between the Mediterranean littoral platforms, the Iberian Cordillera and the northern Betic Mountains. This leads us to suspect that there may be a close connection between ecological resilience, the permanence of human populations, adaptation processes and the high animal and plant biodiversity present in the region (Carrión et al., 2011, 2019a, b).

There is certainly an implicitly anthropological intentionality in our work, seeking to challenge the conventional image of Neanderthal hunters living under the challenges of a freezing climate in an open and desolate landscape. We see here (Fig. 1) a Bolomor hominin adult and a child, with a very "human" aspect (Finlayson, 2019; Spikins et al., 2019), naked, relaxed; the adult with a feather ornament on the head (Finlayson et al., 2012) eats hazelnuts; the child plays with a tortoise and there is evidence that they are being eaten (Blasco, 2008). We decided not to reflect scenes with large carnivores which, although locally present, and undoubtedly an eventual threat to survival, did not necessarily represent the daily life of Bolomor's hominins.

The diversity and physiographic complexity of the mountainous environment, which is reflected in the artwork was considered important and worthy of highlighting. The Bolomor area includes valleys, plains and flooded areas (fresh water sources), as well as potentially edible plants such as *Corylus avellana* (hazelnut), *Castanea sativa* (chestnut), *Celtis australis* (Mediterranean hackberry), *Arbutus unedo* (strawberry tree), *Ceratonia siliqua* (carob tree), *Quercus ilex* (holly oak), *Olea europaea* (olive), *Sambucus* (elderberry), perhaps *Pinus pinea* (stone pine) and others). The work

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Fig. 1. Free artistic view of the prehistoric habitat of the Neanderthals that occupied Bolomor Cave (Eastern Spain) during the Middle Pleistocene and early Upper Pleistocene, based on paleobotanical data (Ochando et al., 2019). (a) General aspect of Valldigna Valley in Mondúver Mountains; (b) Cave surroundings. Original paintings by Gabriela Amorós (color pencils). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

1. Bolomor Cave, entrance
2. *Quercus ilex/rotundifolia* (holm oak)
3. *Pinus* cf. *nigra* (Austrian pine)
4. *Betula* (birch)
5. *Quercus* cf. *faginea* (deciduous oaks)
6. *Castanea sativa* (chestnut)
7. *Pinus* cf. *halepensis* (Aleppo pine)
8. *Juniperus* (juniper)
9. *Corylus avellana* (hazel)
10. *Rhododendron* cf. *ponticum* (rhododendron)
11. *Arbutus unedo* (strawberry tree)
12. *Erica* (heather)
13. *Pistacia lentiscus* (lentisk)
14. *Artemisia* (sagebrush)
15. *Poaceae* (grasses)
16. *Myrtus communis* (myrtle)
17. *Chamaerops humilis* (palmetto)
18. *Helianthemum/Fumana* (rockroses)
19. *Dama dama* (fallow deer)
20. Neanderthal male eating hazelnuts
21. Neanderthal child watching tortoise (*Testudo hermanni*)
22. *Pinus* cf. *pinaster* (maritime pine)
23. *Taxus baccata* (yew)
24. *Hedera helix* (common ivy)
25. Pine forest with oaks
26. Asteraceae
27. *Sideritis* (ironwort)
28. *Saxifraga* (saxifrages)
29. *Quercus coccifera* (kermes oaks)
30. *Celtis australis* (Mediterranean hackberry)
31. *Ceratonia siliqua* (carob)

Fig. 1. (continued)

reflects the fact that plants are distributed according to their ecology, with gymnosperms in the highest and most exposed areas, where there is more abiotic stress, and angiosperm trees occupying the deepest soils and sheltered biotopes.

There is also a focus on taxonomic detail evident in this work, which sheds light on the species that no longer grow in the region (*Rhododendron* cf. *ponticum, Taxus baccata, Betula* cf. *celtiberica, Corylus avellana, Castanea sativa*), as well as those whose autochthonous character in the Iberian Peninsula could be considered controversial (*Pinus pinaster, Ceratonia siliqua, Celtis australis*) but for which there is clear evidence of their presence.

Finally, we found it conceptually relevant to combine the thermophytic component (*Olea*, evergreen *Quercus, Pistacia, Myrtus, Fraxinus, Salix, Castanea, Ceratonia*) with the cryophilous (*Pinus nigra, Juniperus* cf. thurifera), the phreatophilous (*Corylus, Quercus faginea, Salix*) and the xerophilous (*Artemisia,* Asteraceae, Poaceae) in order to give the image of a glacial refugium and a meeting point of species with different ecological requirements. It is also worth noting the link between human presence and the taxonomic and structural component of the vegetation. Bolomor is, without doubt, a very important site for the study of evolution of the first European Neanderthals (Blasco and Fernández-Peris, 2012). Carrión et al. (2011) postulated that the territories of maximum evolutionary innovation in hominids coincided with biodiversity hotspots and, to a smaller scale, with refugial areas. Bolomor seems therefore particularly well-suited to illustrate this pattern.

In short, these drawings represent what we now think of as the typical habitat of Iberian Neanderthals (Finlayson, 2006). This may not be the only habitat they occupied but, through this work, we have aimed to add value to the knowledge granted to us through paleodata. By creating these drawings, we have sought to move beyond the methodological paradigm that restricts us to the search for general or definitive trends. With this artistic execution, new scientific questions arise. For example, what is the spatial scale of the signals derived from the frequencies, concentrations and assemblages of fossil plants? how to reconcile the focus on taxonomic traits of the species with the differences in the times of flowering, fruiting, foliation and marcescence? how to represent the plant development and growth habit taking into account that many species have today a morphology highly conditioned by human management of ecosystems? In general, these issues need a decision making, setting a priority. In our case, facilitate taxonomic recognition.

It is important that we continue to encourage the creation of art based on, and inspired by, region-specific paleodata. Visual language has an enormous power to interpret reality and has the potential to become an important tool in the formal curriculum. We hope that this short article will serve as inspiration to continue breaking down the barriers between the arts, humanities and experimental sciences. Our corollary is that the introduction of scientific complexity into the artistic experience is helpful to our understanding of the past and, equally, ensures that the visual arts become integral to scientific practice.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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