Absence of botanical European Palaeolithic cave art: what can it tell us about plant awareness disparity?

Received: 15 December 2022 | Revised: 8 March 2023 | Accepted: 2 April 2023

DOI: 10.1002/ppp3.10373

Plants People Planet PPP Open Access

BRIEF REPORT

Absence of botanical European Palaeolithic cave art: What can it tell us about plant awareness disparity?

Georgina Walton[1] | Jonathan Mitchley[2] | Geraldine Reid[3] | Sven Batke[1]

[1]Biology Department, Edge Hill University, Ormskirk, UK

[2]School of Biological Sciences, University of Reading, Reading, UK

[3]Botany, National Museums Liverpool, Liverpool, UK

Correspondence
Sven Batke, Biology Department, Edge Hill University, Ormskirk L39 4QP, UK.
Email: sven.batke@edgehill.ac.uk

Societal Impact Statement

Cave art has been an integral part of human history, providing a glimpse into the lives and cultures of our ancestors. Prehistoric botanical art is an important medium that can help us to redefine our intimate relationship with plants. The findings from our work provide some evidence from the European Palaeolithic period that modern plant awareness disparity (PAD) might be more deeply rooted in our past. By inspiring a deeper appreciation and understanding of the natural world, cave art can help people to reconnect with plants, thus tackling PAD.

KEYWORDS
animals, art, botany, cave, Palaeolithic, plant blindness, plant sciences

1 | INTRODUCTION

Plants are ubiquitous, accounting for over 80% of the world's biomass (Bar-On et al., 2018); they sustain life, provide food, shelter and medicine (Buhner, 2002). In addition, their role in global cycles is key to sustaining our climate (Purcell et al., 2018). The link between our survival and ability to flourish on earth is inexorably linked to the biology of plants and our ability to utilise their unique properties (Bar-On et al., 2018; Friesner et al., 2021; Jose et al., 2019). The recognition and appreciation of plants depends on people's frameworks with which they view plants, whether that is primarily driven by aesthetic or economic reasons (Mabey, 2016). The term 'plant blindness', or the more recently suggested alternative term, which we use in this paper, 'plant awareness disparity' (PAD) (Parsley, 2020), encompasses the idea that, compared with animals, there is a disparity of people that notice plants in their own environment (Wandersee & Schussler, 1999), resulting in the underappreciation or lack of recognition towards plants. PAD is thought to have arisen during the last century as a result of modernisation and urbanisation of many societies (Stagg & Dillon, 2022).

The concept of PAD can be found within scientific literature dating back over 100 years. However, in more recent years the discussion of PAD has been newly invigorated in the scientific literature (Brownlee et al., 2021; Stagg & Dillon, 2022). The fundamental skills evolving from an understanding and relationship with plants, impact the ability to categorise and identify individuals within or between plant species, protect global health, create food security and tackle the crisis of climate change (Batke et al., 2020). Narby (1999) writes of humans being selfish in the context of acknowledging plants—we see them as food and medicines, for example, rather than seeing beyond this.

The visualisation of plants in art may provide a more accessible way for people to notice plants, as well as educating individuals that have not necessarily had the opportunity to engage with plants during their life (Ben-Ari, 1999). Art has been an important part of human culture since prehistoric times, most formally through religious and/or spiritual scenes or portraits (Honour & Fleming, 2005). The depiction of plants in art falls under the term 'botanical art' and has been defined as the depiction of plants through colour and form, with its focus often being on the aesthetics and decorative purposes, or even for spiritual intentions between plants and humans (Meagher; Meagher, 2007). In comparison, botanical illustrations hold emphasis on the scientific and botanical accuracy through which scientific discovery can be made (Meagher, 2007).

The origin of botanical art follows a disjointed development across time. The exact date to which botanical art and illustration first

appeared, aside from documented art, cannot be stated with certainty due to a lack of surviving information. In this case, botanical art and illustrations may be limited to books and canvas due to issues with preservation (Ivanova et al., 2013; Lacanette et al., 2013), therefore art will be missing from history (Bahn & Bahn, 1998). This is often the case with prehistoric art, which is found most often in caves, on walls, ceilings, or cave floors (Lacanette et al., 2013). Some scant evidence exists depicting plants in prehistoric art. However, this has rarely been quantified and some interpretations are often disputed. For example, what some believe to depict a plant, others believe to be abstract symbols (Mabey, 2016; Von Petzinger, 2017). Von Petzinger (2017) emphasises this, noting the absence of plants in much European prehistoric art (EPCA) and the difficulty in unambiguously identifying a plant depiction.

Soon after the first modern humans reached Europe, they began to decorate the walls of caves with images of the world around them. Animals and geometric designs were common, but fish, birds and plants appear rarely. The appearance of plants in prehistoric art is speculative, particularly in Palaeolithic Europe (Newton, 2009; Tyldesley & Bahn, 1983; Von Petzinger, 2017). EPCA first appeared in nonfigurative forms around 64,000 BP, during the Palaeolithic on the Iberian Peninsula of Spain (Hoffmann et al., 2018), with different themes emerging throughout (Folgerø et al., 2021). These early drawings predate modern humans' arrival in Europe by 20,000 years and are presumed to be made by Neanderthals (*Homo neanderthalensis*). This art is found in caves and at open-air sites, for example, rock faces, on mobiliary items (items that are portable, e.g., rocks), or in the form of sculptures (Lawson, 2012). The art appears in the form of pigments painted onto a surface, as drawings using charcoal, or as engravings. There are many known locations of cave art across Europe, which have been dated back to around 66,000 BP (David, 2017; Hodgson & Brennand, 2006). The artists in EPCA used three main colours made from yellow ochre, red ochre or charcoal mixed with spit, water or animal fat. They used moss, reed or bone pipes, their fingers or brushes made of hair to apply the paint. Sometimes, they made stencils of their hands by blowing paint over them which aids in the interpretation of who was making the images, women or men, adults or children. Since the discovery of EPCA, research has been undertaken to understand and make speculations behind its meaning and evolution (White, 2006). However, much of the research surrounding EPCA focuses on the dating of the art and the semantics behind it, particularly the depiction of animals (Humphrey, 1998; Valladas et al., 2001). Themes that appear in EPCA vary across location and time; the depiction of animals dates back to 37,000 BP (Hodgson & Pettitt, 2018) with abstract symbols predating animals by 20,000 years (Fritz & Tosello, 2007). There has been no identified point in time to establish the origin of plants in EPCA (Von Petzinger, 2017).

Gaining an understanding of cave art is essential to understanding prehistoric culture and its progression, for example, how did we develop from hunter-gatherers to domesticating plants and animals (Ahmad et al., 2020)? This visual articulation of humankind throughout Palaeolithic Europe may act as a source of communication, past and present, helping to provide insight into prehistoric life and culture (Blinkhorn et al., 2012; Soper, 1982). If we assess botanical art and its appearance in EPCA, we can gain a better understanding of the relationship between humans and plants, which might help us to better understand modern PAD (Schaal, 2019).

By identifying a link between the depiction of plants in EPCA and PAD, a historical and anthropological perspective can be taken to understand how this has affected plant–people relationships. Therefore, this study aims to quantify how often plants appear in EPCA compared with other depictions (e.g., humans, animals etc.) and to discuss the relevance of these findings in terms of PAD.

2 | MATERIALS AND METHODS

The Emile Cartailhac Prehistoric Art Research and Study Centre holds a database of over 16,000 images of cave art from 369 caves from over 580 Palaeolithic digs (http://creap.fr/). All the images from EPCA have been digitised, creating the largest Palaeolithic database of cave art. However, due to technical challenges (pers. com. CNRS research director C. Fritz), the database cannot be used for the unforeseeable future due to technical issues. We therefore made use of the European Prehistoric Art database (EPAD) (http://www.europreart.net/index.htm), which contains data from different art features across 807 sites in Europe (e.g., Denmark, France, Ireland, Italy, Portugal, Spain and Sweden). For each of these sites, various information was available including the period and type of rock art for each depiction. The 807 sites were filtered using a predefined search criterion, limiting the number to sites that only included cave art. Of the 141 remaining sites, we further excluded sites that contained art from other periods, for example, mesolithic, or art that did not fit under the definition of cave art, such as mobiliary art. Following these exclusions, 113 sites were retained (Figure 1).

A total of 5786 depictions from the 113 sites were scored based on the absence and presence of different categories. These categories included 'plants', 'anthropomorphs', 'animals' and 'abstract symbols' (Haskell, 1993). In some cases, the interpretation of the image and the categorisation was ambiguous; these were subsequently included into 'abstract symbol' category. Figure 2 shows an example of a cave image from La Grotte de Marsoulas, France, that featured polychrome representations of bison and horses. The middle and lower section also show penniform structures that were scored by the authors as ambiguous and there was included in the 'abstract symbol' category. In cases were ambiguity existed, two people scored the image independently. However, this was only the case for a small number (<10) of images. In addition, the database also had predetermined picture identification information, which helped validate our interpretation following our own scoring.

Undetermined features were not included in the analysis, as some were speculated to be claw marks from animals and therefore not intentional cave art markings (Von Petzinger, 2017). In addition, sexual symbols were categorised into the 'abstract symbol' rather than 'anthropomorph' category, as their status under the definition of anthropomorph is subjective (Rice & Paterson, 1988).

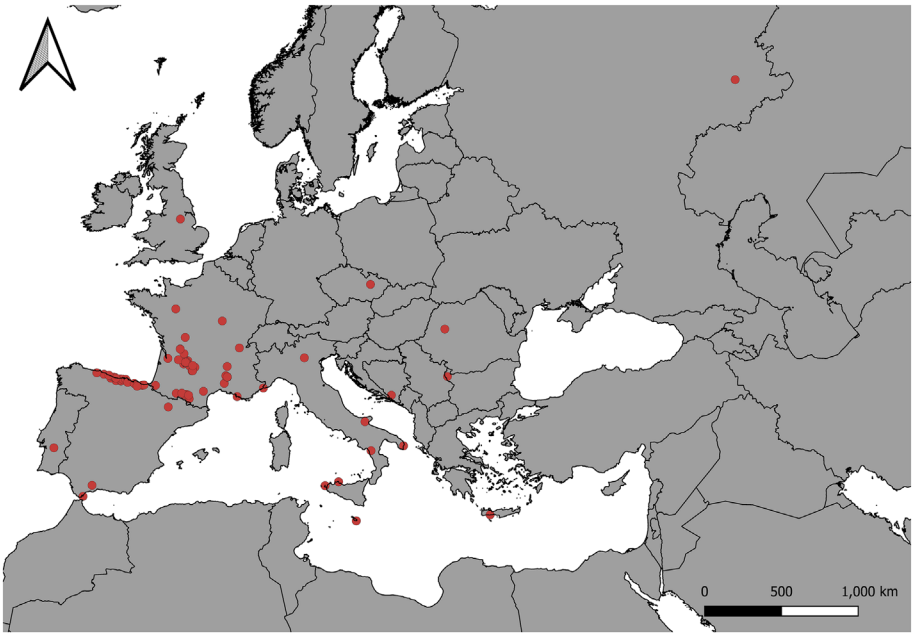

FIGURE 1 Map showing the location of caves that were included in this study. Red dots show individual Palaeolithic sites ($n = 113$) from across Europe.

FIGURE 2 An example of a cave image from La Grotte de Marsoulas, France, that depicted ochre penniform images that appeared to look like plant forms but was scored in our analysis as ambiguous. The image also featured polychrome representations of bison and horses (image courtesy of Ralph Frenken, Le Parc de la Préhistoire de Tarascon-sur-Ariège).

3 | RESULTS

One hundred and thirteen Palaeolithic cave art sites across Europe contained a total of 5786 depictions in which only four featured plants. These were reported from four sites in France, namely, Ariège, Grotte du Tuc d'Audoubert ($n = 1$); Lot, Grotte de Sainte-Eulalie ($n = 1$); Lot, Grotte des Escabasses and Seine-Maritime ($n = 1$); and Grotte de Gouy, ou grotte du Cheval ($n = 1$). All the depictions of plants used red ochre or charcoal as a medium. Across all sites, animal depictions (53.7%) were more represented than all other categories. Abstract symbols were the next most common depiction on cave walls (43.3%), with anthropomorphs (2.9%) and plants (0.07%) being represented extremely rarely 0.07%.

4 | DISCUSSION

Of the 5786 depictions identified across 113 European Palaeolithic caves, only 0.07% featured plants. Animals and abstract symbols appeared more frequently, 53.7% and 43.3% respectively. The identification of plants from drawings was somewhat ambiguous due to a lack of detail in some images, making interpretation of images difficult in some cases (Mabey, 2016; Tyldesley & Bahn, 1983; Von Petzinger, 2017).

Interestingly, the underrepresentation of plants in cave art during the Palaeolithic has been reported from other sites outside Europe (Masao, 1990). For example, Hodgson and Pettitt (2018) found that Australian Kimberley rock art mostly depicted animals (75%), with plant images being found less frequent (~25%). Similarly, Tyldesley and Bahn (1983) analysed cave art at Lascaux, France, and found that only 11% of the available images at this site depicted plants. However, they emphasised that all these depictions were on mobiliary art and not rock art. Within societies where plants are more central to existence (including food, medicine and spiritual use), such as early aboriginal communities, plants were shown with a higher proportion than found in European rock art. Up to 25% of sites in Australia of Kimberley rock art contain plant depictions, which date to at least 16,000 years (Veth et al., 2018). Interestingly, here, they also

appeared within anthropomorphic depictions as plant human forms, phyto-anthropomorphs, suggesting plants as integral to human identity (Ouzman et al., 2017). Anthropomorphs in our analysis were also underrepresented compared with animals and abstract art (2.9%). Levine (1968) found similar proportions of anthropomorphs (3% to 4%) on upper Palaeolithic cave walls (also see Rice and Paterson (1988)). It is interesting to observe that both plants and human-like features are underrepresented categories in EPCA, with animals taking precedence.

The importance of the higher proportion of animals in cave art may lie in the significance of animals to the survival of the genus *Homo*. This evolutionary survival link could have led to the priming of the brain for distinguishing and encoding animal-like outlines when hunting (Hodgson & Watson, 2015). The visual experience of humans during the Palaeolithic is likely to be dominated by objects that evoked strong emotions such as fear and survival. For example, being able to identify animals that could cause immediate risk or increase survival because of its high nutritional value, might have evoked a stronger emotional identification with animals over plants (Alcock, 2009; Hodgson & Pettitt, 2018). Hodgson and Watson (2015) suggested that indigenous communities from different geographical locations may also have comparable visual brain biases towards attending particular forms. However, this has only been assessed for animals. It has also been suggested that this emphasis towards animal depiction might be because of a misconception that plants are 'less alive' compared with animals and the perception that plants move less (Nantawanit et al., 2011). Similar ideas have been discussed in more recent work that aimed to identify the underlying cause of PAD (Allen, 2003). However, this does not explain why nonfigurative art predates animal depictions. One suggestion is that the progression from Neanderthal to modern humans reflects a change in brain development (Gunz et al., 2010). Fossil evidence suggests a difference in size of the prefrontal cortex between Neanderthals and *Homo sapiens*, which may explain the advance from nonfigurative art to more commonly recognised animal depictions (Miyagawa et al., 2018). With that said, abstract symbols continue to appear across time even with the dominance of modern humans (Von Petzinger, 2017).

The investigation of art features represented in EPCA gives insight into early humans, their cognition and their early cultures. While our analysis suggests little artistic representation of plants, there may have been a practical awareness surrounding plants conveyed through other means of art that did not survive (Marshack, 1991). For example, it has been noted that plants seem to be depicted more often on mobiliary art (Tyldesley & Bahn, 1983). Mobile art would have been more frequently used for daily activities (e.g., preparation of food) and would have allowed it to be moved during migrations. There is evidence that our ancestors lived a nomadic and migratory lifestyle (French, 2021) and mobiliary art depicting plants could have played more important educational purposes during daily activities compared with wall art. Identifying the depiction of plants in cave art during Palaeolithic times does not recognise the extension of plants to other uses during that time but it is likely that the appreciation of plants in wall art was less pronounced because of the frequent use of plants during daily activities (Power et al., 2014). Encounters with animals are likely to have been less frequent or more memorable due to physiological fight and flight responses. Even if plants were not featured as frequently in wall art, it has been suggested that they most certainly played an important role during the cave paintings due to their hallucinogenic properties (Helvenston et al., 2003; Layton, 2000).

Whether we look at botanical art or the use of plants in Palaeolithic Europe, we can still make inferences on the evolution of humans and their relationship with plants during this time (Marshack, 1991). Although it has been found that plants do not appear often in EPCA, it does not mean they were not important. Evidence of modern indigenous communities, for example, suggest that the interaction between human and plants are related to where they live and how oral based knowledge is transferred to the next generations (Haq et al., 2022). For example, a recent literature review showed that communities in urbanised and wealthier societies are less plant aware compared with communities that live closer to nature (Pilgrim et al., 2008; Stagg & Dillon, 2022). It has been suggested that rapidly changing climates during the Palaeolithic would have resulted in subsequent vegetation changes (Bertran et al., 2013; Finlayson & Carrión, 2007; Gómez-Olivencia et al., 2015; Jones et al., 2021), indicating to have caused population migrations (Kondo et al., 2018) to refugia (Jones et al., 2020) and biomes that offered more diverse environmental opportunities (Gavashelishvili & Tarkhnishvili, 2016). Therefore, living in environments where plants are major feature of the landscape can help to foster plant awareness. It is therefore reasonable to suggest that in geographic areas where plant diversity was higher, communities would have had more access to diverse plant-based sources and thus would have built a stronger awareness towards plants. Although little cave art exists from the Palaeolithic in many regions across world, partly because of absence of human amongst other reasons, there is still a rich collection of prehistoric art from later periods. For example, in countries such as Brazil during the pre-Columbian, several examples of rock art exist and include petroglyphs and pictographs that were created by indigenous peoples, such as the Sambaqui and Guarani, who inhabited the region prior to European colonisation (Bahn et al., 2021). The Sambaqui people, who lived along the coast of Brazil between 6000 and 1000 years ago, created petroglyphs that depicted a variety of plant and animal species. Some of the plants that appear in their rock art include palm trees, vines and trees with distinctive leaf shapes. The Guarani people on the other hand, who lived in Brazil and other parts of South America for thousands of years prior to European colonisation, created pictographs that depict a range of plant species, including cassava, tobacco and cotton. These plants were of great cultural and economic importance to the Guarani, and their depictions in rock art may have served as a way of conveying knowledge about their use and cultivation. In north-eastern Brazil, there are several examples of pre-Columbian rock art that depict plants in a more abstract or stylised form. These include spiral-shaped designs that are thought to represent snails or seashells, as well as circular patterns that may represent the sun or other celestial bodies. In addition, many indigenous peoples in Brazil have strong relationships

with the natural world and consider plants to be sacred and powerful beings. Botanical art could have had different meanings, including medicinal properties, symbolic significance, ritual and practical uses such as for fibre and construction materials (Bahn et al., 2021).

The idea that our ancestors are more likely to depict plants in art form when they lived in very high floristic regions (e.g., Brazil), compared with areas where plant life was less diverse such as Palaeolithic Europe, can also be translated into the relationship and awareness of humans to plants in modern communities. Although we lack a global quantitative assessment of this, it is interesting to note that plant awareness seems to be higher in modern communities that are in geographical areas that also have a higher number of edible plants (e.g., see Antonelli et al., 2020—State of the World's Plants and Fungi report—fig. 3). However, it is also likely that for communities that did not migrate to more prosperous lands, the relationship with animals could have been stronger (Alcock, 2009), thus promoting animal over plant art in many forms during the Palaeolithic in Europe. Alternative explanations why we find more animals compared with plants in cave art may come from the idea that plants had lower energy nutritional value compared with animals as a food source. This meant animals were more sought after for food to improve survival (Veth et al., 2018). However, the latter is disputed as the animals depicted in EPCA are not thought to be species that formed large parts of the European Palaeolithic diet (Guthrie, 2005). Moreover, there is evidence to suggest that plants made up a larger proportion of the European Palaeolithic diet compared with meat (Pryor et al., 2013).

The factors that determined plant–people relationships are still very speculative. Interestingly, research on PAD in modern society has suggested that past relationships between early humans and plants could be one of the underlying reasons why PAD is even more enhanced in our modern and urbanised societies (Wyner & Doherty, 2022). It may be that we have lost touch with plants due to a reliance on the modern world. While there is evidence of plants appearing more on art during the 16th century (Ben-Ari, 1999; Blunt & Stearn, 1994; Dominiczak, 2016; Honour & Fleming, 2005; Mabey, 2016), this may have been essential for survival during this period, as access to meat was limited to certain societal classes. Much of the botanical art seen in the 16th century was for pharmaceutical and medical purposes (Dominiczak, 2016; Sillasoo, 2006), which suggests that people were more aware of the uses and importance of plants as well as using art as a means of communicating scientific information (Hodgson & Pettitt, 2018; Janick, 2003). In addition, this acknowledgment declined following the 17th and 18th Century (Ben-Ari, 1999).

With the modernisation of society, there is less of a need for individuals to utilise plants and have an awareness of them (Abelson, 1990). Resources that enhance our survival are very accessible (Balick & Cox, 2020) and thus less value is placed on knowing about plant resources (Apffel-Marglin et al., 2004). However, this is not representative of all societies across the globe, but it has been suggested to be a particular industrialised issue (Amprazis & Papadopoulou, 2020; Stagg & Dillon, 2022). Narby (1999), for example, pointed out that indigenous communities have a greater awareness of plants. Additionally, there are communities that still rely on plants to sustain themselves, as well as dietary diversification between cultures and societies both impacting on plant–people perceptions and relationships (Balick & Cox, 2020). However, the challenge remains to understand whether PAD is a result of our ancient past (Soga & Gaston, 2018), as we can never know how and in what context humans during the Palaeolithic interacted with plants or whether artistic interpretation of plants on cave art contributed to the knowledge transfer of plants.

The findings of our research are speculative, but there appears to be evidence from cave art that suggests of ancestrally derived PAD. However, wall art is only one form of art used during the Palaeolithic, and many of the 400 European Palaeolithic cave art sites (Mabey, 2016) have yet to be fully integrated into a global database. Similarly, mobile art seems to play a much more important role in the depiction of plants, but the reasons for that are speculative and more research is required (Newton, 2009; Ruiz-Redondo et al., 2020; Tyldesley & Bahn, 1983; Von Petzinger, 2017). For example, data used from the EPAD website for image analysis was published around the year 2000 and has not been updated in over 22 years (Bahn et al., 2003). Conversely, art may be degrading or has already been lost (Lorblanchet et al., 1973).

Without plants, humans would cease to exist, and so their importance needs to be emphasised wherever possible. By making this historical link, an insight into human attitudes towards plants can be speculated upon thus aiding research and practice into the process of educating people on plants. Although the experience of cave dweller compared with the modern human is vastly different, the knowledge of our ancestors can still be utilised to improve and protect plant–people connections (Beckwith et al., 2022). It may be that we can only tentatively make the inference that PAD is ancestrally derived, however it is interesting to note the lack of plants in cave art. Although anthropomorphs are similarly underrepresented, this may be because we identify with beings that share our human form, which did not impact on threats to survival during prehistoric times (Mabey, 2016).

There are different opinions when trying to understand the meaning of EPCA. For example, Clottes (2016) stated that seeking meaning in cave art may be senseless as the context of the art is difficult to elucidate. Ouzman et al. (2017) on the other hand indicated that there are underresearched areas, particularly those involving plant depictions in prehistoric art, but it still warrants scientific interpretation and investigation. It may be that modernisation and urbanisation have created the issue of modern PAD, or it may be that our brains are hardwired to notice other features over plants, which might be argued when seeing the low number of plants featured on cave wall art. Certainly, there are some periods related different for PAD between Palaeolithic and modern societies, as the social context and structures have changed. However, Palaeolithic-derived PAD appears to have manifested itself into modern PAD. Acknowledging our ancestral hold on our modern perception and awareness of plants can thus better help us to tackle modern PAD, by using arts as a form to communicate the beauty and important of plants.

AUTHOR CONTRIBUTIONS

Georgina Walton and Sven Batke contributed to the study conception and design. Material preparation, data curation and analysis were performed by Georgina Walton, Geraldine Reid and Sven Batke, with support from Jonathan Mitchley. The first draft of the manuscript was written by Georgina Walton and Sven Batke, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

We thank Ralph Frenken and the Le Parc de la Préhistoire de Tarascon-sur-Ariège for giving us permission to use the cave image from La Grotte de Marsoulas, France.

CONFLICT OF INTEREST STATEMENT

The authors have no relevant financial or nonfinancial interests to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in http://www.europreart.net/index.htm.

ORCID

Jonathan Mitchley https://orcid.org/0000-0002-0558-7547
Geraldine Reid https://orcid.org/0000-0002-2477-2174
Sven Batke https://orcid.org/0000-0002-1938-3625

REFERENCES

Abelson, P. H. (1990). Medicine from plants. *Science*, *247*(4942), 513. https://doi.org/10.1126/science.2300807

Ahmad, H. I., Ahmad, M. J., Jabbir, F., Ahmar, S., Ahmad, N., Elokil, A. A., & Chen, J. (2020). The domestication makeup: Evolution, survival, and challenges. *Frontiers in Ecology and Evolution*, *8*, 103. https://doi.org/10.3389/fevo.2020.00103

Alcock, J. (2009). *Animal behavior: An evolutionary approach*. Sinauer Associates.

Allen, W. (2003). Plant blindness. *Bioscience*, *53*(10), 926. https://doi.org/10.1641/0006-3568%282003%29053%5B0926:PB%5D2.0.CO;2

Amprazis, A., & Papadopoulou, P. (2020). Plant blindness: A faddish research interest or a substantive impediment to achieve sustainable development goals? *Environmental Education Research*, *26*(8), 1065–1087. https://doi.org/10.1080/13504622.2020.1768225

Antonelli, A., Smith, R. J., Fry, C., Simmonds, M. S., Kersey, P. J., Pritchard, H. W., Abbo, M. S., Acedo, C., Adams, J., Ainsworth, A. M., & Allkin, B. (2020). *State of the world's plants and fungi* [Doctoral dissertation, Royal Botanic Gardens (Kew)]. Sfumato Foundation.

Apffel-Marglin, F., Marglin, S., & Sen, A. (2004). Culture, poverty, and external intervention. In *Culture and Public Action* (Vol. 185). Stanford University Press.

Bahn, P., & Bahn, P. G. (1998). *The Cambridge illustrated history of prehistoric art*. Cambridge University Press.

Bahn, P. G., Pettitt, P., & Ripoll, S. (2003). Discovery of Palaeolithic cave art in Britain. *Antiquity*, *77*(296), 227–231. https://doi.org/10.1017/S0003598X0009222X

Bahn, P. G., Strecker, M., & Franklin, N. (2021). *Rock art studies: News of the world VI*. Archaeopress.

Balick, M. J., & Cox, P. A. (2020). *Plants, people, and culture: The science of ethnobotany*. Garland Science. https://doi.org/10.4324/9781003049074

Bar-On, Y. M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences*, *115*(25), 6506–6511. https://doi.org/10.1073/pnas.1711842115

Batke, S., Dallimore, T., & Bostock, J. (2020). Understanding plant blindness—Students' inherent interest of plants in higher education. *Journal of Plant Sciences*, *8*(4), 98–105. https://doi.org/10.11648/j.jps.20200804.14

Beckwith, B. R., Johansson, E. M., & Huff, V. J. (2022). Connecting people, plants and place: A native plant society's journey towards a community of practice. *People and Nature*, *4*, 1414–1425. https://doi.org/10.1002/pan3.10368

Ben-Ari, E. T. (1999). Better than a thousand words: Botanical artists blend science and aesthetics. *Bioscience*, *49*(8), 602–608. https://doi.org/10.2307/1313435

Bertran, P., Sitzia, L., Banks, W. E., Bateman, M. D., Demars, P.-Y., Hernandez, M., Lenoir, M., Mercier, N., & Prodeo, F. (2013). The Landes de Gascogne (southwest France): Periglacial desert and cultural frontier during the Palaeolithic. *Journal of Archaeological Science*, *40*(5), 2274–2285. https://doi.org/10.1016/j.jas.2013.01.012

Blinkhorn, J., Boivin, N., Taçon, P. S., & Petraglia, M. D. (2012). Rock art research in India: Historical approaches and recent theoretical directions. In *A companion to rock art* (pp. 179–196). Wiley Online Library. https://doi.org/10.1002/9781118253892.ch11

Blunt, W., & Stearn, W. T. (1994). *The art of botanical illustration: An illustrated history*. Courier Corporation.

Brownlee, K., Parsley, K. M., & Sabel, J. L. (2021). An Analysis of plant awareness disparity within introductory Biology textbook images. *Journal of Biological Education*. https://doi.org/10.1080/00219266.2021.1920301

Buhner, S. H. (2002). *The lost language of plants: The ecological importance of plant medicines to life on Earth*. Chelsea Green Publishing.

Clottes, J. (2016). *What is Paleolithic art? Cave paintings and the dawn of human creativity*. University of Chicago Press. https://doi.org/10.7208/chicago/9780226188065.001.0001

David, B. (2017). *Cave art*. Thames & Hudson.

Dominiczak, M. H. (2016). Botanical books, taxonomy, and the art of Georgia O'Keeffe. *Clinical Chemistry*, *62*(10), 1420–1421. https://doi.org/10.1373/clinchem.2015.253138

Finlayson, C., & Carrión, J. S. (2007). Rapid ecological turnover and its impact on Neanderthal and other human populations. *Trends in Ecology & Evolution*, *22*(4), 213–222. https://doi.org/10.1016/j.tree.2007.02.001

Folgerø, P. O., Johansson, C., & Stokkedal, L. H. (2021). The superior visual perception hypothesis: Neuroaesthetics of cave art. *Behavioral Science*, *11*(6), 81. https://doi.org/10.3390/bs11060081

French, J. C. (2021). *Palaeolithic Europe: A demographic and social prehistory*. Cambridge University Press. https://doi.org/10.1017/9781108590891

Friesner, J., Colón-Carmona, A., Schnoes, A. M., Stepanova, A., Mason, G. A., Macintosh, G. C., Ullah, H., Baxter, I., Callis, J., & Sierra-Cajas, K. (2021). Broadening the impact of plant science through innovative, integrative, and inclusive outreach. *Plant Direct*, *5*(4), e00316. https://doi.org/10.1002/pld3.316

Fritz, C., & Tosello, G. (2007). The hidden meaning of forms: Methods of recording Paleolithic parietal art. *Journal of Archaeological Method and Theory*, *14*(1), 48–80. https://doi.org/10.1007/s10816-007-9027-3

Gavashelishvili, A., & Tarkhnishvili, D. (2016). Biomes and human distribution during the last ice age. *Global Ecology and Biogeography*, *25*, 563–574. https://doi.org/10.1111/geb.12437

Gómez-Olivencia, A., Sala, N., Arceredillo, D., García, N., Martínez-Pillado, V., Rios-Garaizar, J., Garate, D., Solar, G., & Libano, I. (2015). The Punta Lucero quarry site (Zierbena, Bizkaia): A window into the middle Pleistocene in the Northern Iberian Peninsula. *Quaternary Science Reviews*, *121*, 52–74. https://doi.org/10.1016/j.quascirev.2015.05.001

Gunz, P., Neubauer, S., Maureille, B., & Hublin, J.-J. (2010). Brain development after birth differs between Neanderthals and modern humans. *Current Biology*, *20*(21), 921–922. https://doi.org/10.1016/j.cub.2010.10.018

Guthrie, R. D. (2005). *The nature of Paleolithic art*. University of Chicago Press.

Haq, S. M., Hassan, M., Bussmann, R. W., Calixto, E. S., Rahman, I. U., Sakhi, S., Ijaz, F., Hashem, A., Al-Arjani, A. B. F., Almutairi, K. F., & Abd-Allah, E. F. (2022). A cross-cultural analysis of plant resources among five ethnic groups in the Western Himalayan region of Jammu and Kashmir. *Biology*, *11*, 491–528. https://doi.org/10.3390/biology11040491

Haskell, F. (1993). *History and its images: Art and the interpretation of the past*. Yale University Press.

Helvenston, P. A., Bahn, P. G., Bradshaw, J. L., & Chippindale, C. (2003). Testing the 'three stages of trance' model. *Cambridge Archaeological Journal*, *13*(2), 213–224. https://doi.org/10.1017/S0959774303000131

Hodgson, D., & Pettitt, P. (2018). The origins of iconic depictions: A falsifiable model derived from the visual science of Palaeolithic cave art and world rock art. *Cambridge Archaeological Journal*, *28*(4), 591–612. https://doi.org/10.1017/S0959774318000227

Hodgson, D., & Watson, B. (2015). The visual brain and the early depiction of animals in Europe and Southeast Asia. *World Archaeology*, *47*, 776–791. https://doi.org/10.1080/00438243.2015.1074871

Hodgson, J., & Brennand, M. (2006). Prehistoric period resource assessment. The archaeology of North West England, an archaeological research framework for North West England. *Archaeoloy North West*, *8*(18), 23–58.

Hoffmann, D. L., Standish, C. D., García-Diez, M., Pettitt, P. B., Milton, J. A., Zilhão, J., Alcolea-González, J. J., Cantalejo-Duarte, P., Collado, H., & De Balbín, R. (2018). U-Th dating of carbonate crusts reveals Neandertal origin of Iberian cave art. *Science*, *359*(6378), 912–915. https://doi.org/10.1126/science.aap7778

Honour, H., & Fleming, J. (2005). *A world history of art*. Laurence King Publishing.

Humphrey, N. (1998). Cave art, autism, and the evolution of the human mind. *Cambridge Archaeological Journal*, *8*(2), 165–191. https://doi.org/10.1017/S0959774300001827

Ivanova, V., Tomova, I., Kamburov, A., Tomova, A., Vasileva-Tonkova, E., & Kambourova, M. (2013). High phylogenetic diversity of bacteria in the area of prehistoric paintings in Magura Cave, Bulgaria. *Journal of Cave & Karst Studies*, *75*(3), 218–228. https://doi.org/10.4311/2012MB0279

Janick, J. (2003). Herbals: The connection between horticulture and medicine. *HortTechnology*, *13*(2), 229–238. https://doi.org/10.21273/HORTTECH.13.2.0229

Jones, J. R., Marín-Arroyo, A. B., Rodríguez, M. C., & Richards, M. P. (2021). After the Last Glacial Maximum in the refugium of northern Iberia: Environmental shifts, demographic pressure and changing economic strategies at Las Caldas Cave (Asturias, Spain). *Quaternary Science Reviews*, *262*, 106931. https://doi.org/10.1016/j.quascirev.2021.106931

Jones, J. R., Marín-Arroyo, A. B., Straus, L. G., & Richards, M. P. (2020). Adaptability, resilience and environmental buffering in European Refugia during the Late Pleistocene: Insights from La Riera cave (Asturias, Cantabria, Spain). *Scientific Reports*, *10*, 1217–1234. https://doi.org/10.1038/s41598-020-57715-2

Jose, S. B., Wu, C. H., & Kamoun, S. (2019). Overcoming plant blindness in science, education, and society. *Plants, People, Planet*, *1*(3), 169–172. https://doi.org/10.1002/ppp3.51

Kondo, Y., Sano, K., Omori, T., Abe-Ouchi, A., Chan, W.-L., Kadowaki, S., Naganuma, M., O'ishi, R., Oguchi, T., & Nishiaki, Y. (2018). Ecological niche and least-cost path analyses to estimate optimal migration routes of initial Upper Palaeolithic populations to Eurasia. In *The Middle and Upper Paleolithic archeology of the Levant and beyond* (pp. 199–212). Springer. https://doi.org/10.1007/978-981-10-6826-3_13

Lacanette, D., Large, D., Ferrier, C., Aujoulat, N., Bastian, F., Denis, A., Jurado, V., Kervazo, B., Konik, S., & Lastennet, R. (2013). A laboratory cave for the study of wall degradation in rock art caves: An implementation in the Vézère area. *Journal of Archaeological Science*, *40*(2), 894–903. https://doi.org/10.1016/j.jas.2012.10.012

Lawson, A. J. (2012). *Painted caves: Palaeolithic rock art in Western Europe*. Oxford University Press. https://doi.org/10.1093/acprof:osobl/9780199698226.001.0001

Layton, R. (2000). Shamanism, totemism and rock art: Les chamanes de la préhistoire in the context of rock art research. *Cambridge Archaeological Journal*, *10*(1), 169–186. https://doi.org/10.1017/S0959774300000068

Levine, M. H. (1968). Reinterpretation of the earliest art: Treasures of prehistoric art. André Leroi-Gourhan. Translated from the French by Norbert Guterman (1967): Abrams, New York. *Science*, *161*(3837), 150–152.

Lorblanchet, M., Delpech, F., Renault, P., & Andrieux, C. (1973). La grotte de Sainte-Eulalie à Espagnac (Lot). *Gallia Préhistoire*, *16*(1), 3–62. https://doi.org/10.3406/galip.1973.1436

Mabey, R. (2016). *The cabaret of plants: Forty thousand years of plant life and the human imagination*. WW Norton & Company.

Marshack, A. (1991). *The roots of civilization: The cognitive beginnings of man's first art, symbol and notation*. Moyer Bell Limited.

Masao, F. (1990). Possible meaning of the rock art of central Tanzania. *Paideuma*, *36*, 189–199.

Meagher, J. (2007). Botanical imagery in European painting. In *Heilbrunn timeline of art history*. The Metropolitan Museum of Art.

Miyagawa, S., Lesure, C., & Nóbrega, V. A. (2018). Cross-modality information transfer: A hypothesis about the relationship among prehistoric cave paintings, symbolic thinking, and the emergence of language. *Frontiers in Psychology*, *9*, 115. https://doi.org/10.3389/fpsyg.2018.00115

Nantawanit, N., Panijpan, B., & Ruenwongsa, P. (2011). Studying how plants defend themselves: A chemical weapon produced by chilli fruit. *Journal of Biological Education*, *45*, 244–250. https://doi.org/10.1080/00219266.2011.553685

Narby, J. (1999). *The cosmic serpent: DNA and the origins of knowledge*. Phoenix/Orion Books.

Newton, J. (2009). *The roots of civilisation: Plants that changed the world*. Murdoch Books.

Ouzman, S., Veth, P., Myers, C., Heaney, P., & Kenneally, K. (2017). *Plants before animals?: Aboriginal rock art as evidence of ecoscaping in Australia's Kimberley*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190607357.013.31

Parsley, K. M. (2020). Plant awareness disparity: A case for renaming plant blindness. *Plants, People, Planet*, *2*(6), 598–601. https://doi.org/10.1002/ppp3.10153

Pilgrim, S. E., Cullen, L. C., Smith, D. J., & Pretty, J. (2008). Ecological knowledge is lost in wealthier communities and countries. *Environmental Science & Technology*, *42*, 1–6. https://doi.org/10.1021/es070837v

Power, R. C., Rosen, A. M., & Nadel, D. (2014). The economic and ritual utilization of plants at the Raqefet Cave Natufian site: The evidence from phytoliths. *Journal of Anthropological Archaeology*, *33*, 49–65. https://doi.org/10.1016/j.jaa.2013.11.002

Pryor, A. J., Steele, M., Jones, M. K., Svoboda, J., & Beresford-Jones, D. G. (2013). Plant foods in the Upper Palaeolithic at Dolní V stonice? Parenchyma redux. *Antiquity*, *87*(338), 971–984. https://doi.org/10.1017/S0003598X00049802

Purcell, C., Batke, S., Yiotis, C., Caballero, R., Soh, W., Murray, M., & McElwain, J. C. (2018). Increasing stomatal conductance in response to rising atmospheric CO_2. *Annals of Botany*, *121*(6), 1137–1149. https://doi.org/10.1093/aob/mcy023

Rice, P. C., & Paterson, A. L. (1988). Anthropomorphs in cave art: An empirical assessment. *American Anthropologist*, *90*(3), 664–674. https://doi.org/10.1525/aa.1988.90.3.02a00090

Ruiz-Redondo, A., Garate, D., González-Morales, M. R., Janković, I., Jaubert, J., Karavanić, I., Komšo, D., Kuhn, S. L., Mihailović, D., & Moro-Abadia, O. (2020). Beyond the bounds of western Europe: Paleolithic art in the Balkan Peninsula. *Journal of World Prehistory*, *33*(4), 425–455. https://doi.org/10.1007/s10963-020-09147-z

Schaal, B. (2019). Plants and people: Our shared history and future. *Plants, People, Planet*, *1*(1), 14–19. https://doi.org/10.1002/ppp3.12

Sillasoo, Ü. (2006). Medieval plant depictions as a source for archaeobotanical research. *Vegetation History and Archaeobotany*, *16*(1), 61–70. https://doi.org/10.1007/s00334-006-0036-z

Soga, M., & Gaston, K. J. (2018). Shifting baseline syndrome: Causes, consequences, and implications. *Frontiers in Ecology and the Environment*, *16*(4), 222–230. https://doi.org/10.1002/fee.1794

Soper, R. (1982). The later Stone Age and the rock paintings of Central Tanzania. *Canadian Journal of African Studies*, *15*, 1–511.

Stagg, B. C., & Dillon, J. (2022). Plant awareness is linked to plant relevance: A review of educational and ethnobiological literature (1998–2020). *Plants, People, Planet*, *4*(6), 579–592. https://doi.org/10.1002/ppp3.10323

Tyldesley, J. A., & Bahn, P. G. (1983). Use of plants in the European Palaeolithic: A review of the evidence. *Quaternary Science Reviews*, *2*(1), 53–81. https://doi.org/10.1016/0277-3791(83)90004-5

Valladas, H., Clottes, J., Geneste, J.-M., Garcia, M. A., Arnold, M., Cachier, H., & Tisnérat-Laborde, N. (2001). Evolution of prehistoric cave art. *Nature*, *413*(6855), 479. https://doi.org/10.1038/35097160

Veth, P., Myers, C., Heaney, P., & Ouzman, S. (2018). Plants before farming: The deep history of plant-use and representation in the rock art of Australia's Kimberley region. *Quaternary International*, *489*, 26–45. https://doi.org/10.1016/j.quaint.2016.08.036

Von Petzinger, G. (2017). *The first signs: Unlocking the mysteries of the world's oldest symbols*. Simon and Schuster.

Wandersee, J. H., & Schussler, E. E. (1999). Preventing plant blindness. *The American Biology Teacher*, *61*(2), 82–86. https://doi.org/10.2307/4450624

White, R. (2006). Looking for biological meaning in cave art. *American Scientist*, *94*(4), 371–373. https://doi.org/10.1511/2006.60.371

Wyner, Y., & Doherty, J. H. (2022). Caring to know a name: An examination of New York City student attitudes towards knowing a tree's name. *Plants, People, Planet*, *4*(3), 283–302. https://doi.org/10.1002/ppp3.10249

How to cite this article: Walton, G., Mitchley, J., Reid, G., & Batke, S. (2023). Absence of botanical European Palaeolithic cave art: What can it tell us about plant awareness disparity? *Plants, People, Planet*, 1–8. https://doi.org/10.1002/ppp3.10373