Review of Palaeobotany and Palynology 329 (2024) 105172

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

A microfossil-based object biogeography of a set of stocks from the Rijksmuseum in Amsterdam

Hans Piena [a,b,c,*], Bas van Geel [d], Tom Hakbijl [e], Arie J. Kalis [f], Pim (W.O.) van der Knaap [d], Jacqueline F.N. van Leeuwen [d], Kees Nooren [g]

[a] *Vrije Universiteit; Amsterdam, the Netherlands*
[b] *Dutch Open Air Museum; Arnhem, the Netherlands*
[c] *Royal Historical Society; Amsterdam, the Netherlands*
[d] *University of Amsterdam; Amsterdam, the Netherlands*
[e] *Naturalis Biodiversity Center; Leiden, the Netherlands*
[f] *Goethe University; Frankfurt am Main, Germany*
[g] *Utrecht University; Utrecht, the Netherlands*

ARTICLE INFO

Keywords:
Museum object
Oak stocks
Palaeoecology
Microfossils
Biogeography
Western Iberian Peninsula
Early 19th century

ABSTRACT

In 2019 the Rijksmuseum in Amsterdam acquired a set of oak stocks about which little was known. Radiocarbon wiggle-matching revealed that the tree used to make the stocks was likely felled around 1800 C.E., while ancient DNA indicated the tree's growing zone to be Central Europe. The question remained where and how these stocks were used. To answer these questions, traces of former use at the surface of the stocks were studied and sediment from cracks and holes in the stocks was analyzed for pollen, fungal spores, diatoms and other algae, phytoliths, and insects. The biogeographical information of the recorded taxa shows that the stocks had been used in the western Iberian Peninsula. Although the sediments could have entered in various ways and at various moments, a dungeon seems the most likely context in which these stocks have been used.

1. Introduction

In 2019 the Rijksmuseum in Amsterdam acquired a set of oak stocks (Fig. 1). However, their age, provenance and former use were unclear. According to the donor, his grandfather had acquired the stocks in the 1970s from a farm in the Dutch province of Zeeland, but nothing more was known for certain. The Rijksmuseum presented the stocks in 2021 in a slavery exhibition within the context of Dutch plantations in Brazil, the Dutch Republic having had a colony there between 1630 and 1654. In 2023 these stocks were presented at the exhibition *Ten True Stories of Dutch Colonial Slavery* (27 February–30 March 2023) at the United Nations in New York. However, the writers of the exhibition catalog doubted whether the stocks had ever been shipped to Dutch Brazil (Sint Nicolaas and Smeulders, 2021). Radiocarbon wiggle-matching revealed that the tree used for the stocks had most likely been felled between 1791 and 1824 C.E. (Dominguez-Delmás et al., 2023). The stocks themselves were probably made in the first quarter of the 19th century. Ancient DNA indicated Central Europe to be the tree's growing zone, running from the north of Spain to southern Scandinavia. Stocks were used throughout this region in the past (de Win, 1991; Ramos Vazquez, 2007; Schild, 2010; Bernal Peña, 2016; d'Artagnan, 2017, 2019; Moore, 2022). Questions remained as to where these particular stocks had been used and who had been kept captive in them.

2. Approach

Establishing the provenance of objects can be aided by studying traces left through contact between the object and its former environment. One of the fields that can reconstruct past environments is palynology through the study of microfossils. While palynology and other disciplines are frequently used on samples from an archaeological context (Bryant and Holloway, 1983; van Geel et al., 1983), this is less common with museum objects. For the present study palaeoecologists from different sub-disciplines worked together to reconstruct the most likely 'picture of place'. Much of this work has parallels with forensic palynology which often compares pollen and spore records of a crime scene with microscopic entities on items retrieved from suspects and cadavers. Forensic palynologists use pollen grains to assist in solving

* Corresponding author.
E-mail address: H.Piena@openluchtmuseum.nl (H. Piena).

https://doi.org/10.1016/j.revpalbo.2024.105172
Received 2 July 2024; Received in revised form 6 August 2024; Accepted 6 August 2024
Available online 10 August 2024

Fig. 1. Oak stocks in the collection of the Rijksmuseum in Amsterdam (Inv.nr. NG.2019–502). Measurements: 265 × 37.5 × 23 cm (Photo: Rijksmuseum).

Table 1
List of samples and sample locations.

No.	Location	Description
1	Cavity around padlock eye	Cavity made to insert the padlock eye and probably as old as the stocks
2	Cavity around hinge	Cavity was made to insert the hinge and is probably as old as the stocks
3	Hole in the bottom	Hole is probably caused by later fungal attack
4	Crack in the end	Crack probably developed shortly after fabrication of the stocks
5	Hole in the top with sandy silt	Hole probably developed shortly after fabrication of the stocks
6A	Hole in the top with sandy silt	Top material is sampled
6B	Hole in the top with sandy silt	Material halfway is sampled
6C	Hole in the top with sandy silt	Near bottom material is sampled
6D	Hole in the top with sandy silt	Bottom material is sampled
6E	Hole in the top with sandy silt	Bottom material is sampled
7	Hole in the top with sandy silt	Bottom material is sampled for diatoms.
8	Crack in the end near the hinge	Crack probably developed shortly after fabrication of the stocks
9	Saw cuts in the ankle holes	Cuts were made to chisel out the ankle holes and are probably as old as the stocks

Fig. 2. The underside of one of the cross-braces, which is worn and shows traces of fungal and wood worm attack (Photo: Rijksmuseum).

Table 2
Relative abundance of diatoms identified in sample 7 from the stocks.

Diatom taxa	el. abun. (%)	Diatom taxa	rel. abun. (%)
Achnanthidium minutissimum (Kütz.) Czarn	32.0	*Navicula rhynchocephala* Kützing	1.2
Amphora sp.	0.3	*Neidium ampliatum* Krammer	< 0.3
Caloneis aerophila Bock	0.3	*Neidium affine* (Ehrenberg) Pfitzer	0.3
Cocconeis placentula Ehrenberg	11.5	*Nitzschia* sp.	1.2
Craticula cuspidata (Kützing) D.G. Mann	< 0.3	*Pinnularia borealis* Ehrenberg	4.9
Cyclostephanos dubius (Fricke) Round	< 0.3	*Pinnularia microstauron* (Ehrenberg) Cleve	0.6
Diadesmis confervaceae Kützing	0.3	*Pinnularia neomajor* Krammer	0.3
Encyonema sp.	1.2	*Pinnularia obscura* Krasske	1.7
Eunotia sp.	0.9	*Pinnularia rabenhorstii* (Grunow) Krammer	< 0.3
Fragilaria capucina Desmazières	16.7	*Pinnularia sinistra* Krammerr	0.3
Fragilaria gracilis Østrup	0.6	*Pinnularia* sp.	1.2
Fragilaria sp.	<0.3	*Pinnularia viridiformis* (Nitzsch) Ehrenberg	< 0.3
Gomphonema acuminatum Ehrenberg	0.9	*Placoneis* sp.	1.4
Gomphonema brebissonii Kützing	0.3	*Psammothidium* sp.	0.3
Gomphonema parvulum (Kützing) Grunow	7.5	*Sellaphora blackfordensis* Mann et Droop	0.6
Gyrosigma acuminatum (Kützing) Rabenhorst	<0.3	*Sellaphora laevissima* (Kützing) D.G. Mann	0.6
Hantzschia amphioxys (Ehrenberg) Grunow	2.6	*Sellaphora nigri*	1.4
Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin et Witkowski	0.3	*Sellaphora pupula* (Kützing) Mereschkowksy	0.3
Humidophila contenta (Grunow) Lowe, Kociolek, Johansen, Van de Vijver, Lange-Bertalot et Kopalová	0.3	*Stauroneis anceps* Ehrenberg	0.9
Karayevia laterostrata (Hustedt) Bukhtiyarova	0.3	*Stauroneis gracilis* Ehrenberg	0.3
Luticola mutica (Kützing) D.G. Mann	1.2	*Stauroneis obtusa* N. Lagerstedt	0.3
Luticola nivalis (Ehrenberg) D.G. Mann	0.3	*Stauroneis phoenicenteron* (Nitzsch) Ehrenberg	0.3
Mayamaea sp.	0.6	*Staurosira* sp.	1.2
Navicula cryptocephala Kützing	2.9	*Surirella* sp.	0.3
Navicula radiosa Kützing	<0.3	*Ulnaria* sp.	< 0.3

Fig. 3. *Por liberal?,* 1814–1823, by Francisco de Goya y Lucientes, showing a lady trapped in a horizontal type of stocks (Source: Museo del Prado, Inv. nr.: D004074.).

crimes. By examining pollen collected from a crime scene or person involved, it is possible to be specific about where a person or object has been.

In some cases, the most plausible crime scene is reconstructed purely from pollen on the suspect (Wiltshire, 2009, 2014, 2015). In this project, a similar line was followed, the stocks themselves being approached as an exhibit associated with a suspect. Sediment from cracks and holes was sampled. The sediment was scraped loose with a clean preparation needle and transferred with a clean spatula into numbered sealable plastic bags (Table 1). Pollen, fungal spores, diatoms and other algae, phytoliths and insects were recorded. In addition, traces of use on the stocks' surface were analyzed.

3. Traces of use and typology

The oak stocks consists of two beams resting on two cross-braces (Fig. 1). Along the inner face both beams have nine corresponding semi-circular holes. These ankle holes have a shiny inner surface, which indicates frequent use. The stocks open on one side with an iron hinge and have an obliquely worn padlock eye on the other side. The top of the stocks has a smooth surface as though scrubbed with sand, with cracks and small holes filled with sediment. In addition, the top has many marks from repetitive chopping and cutting, sometimes in an irregular checkerboard pattern. The underside is clean, not sanded and hardly shows any wear. No sediment is present in the cracks and holes in the underside and in the space between the cross-braces and the oak beams. Pencil lines and scratch marks from the maker are preserved on the underside, but not on the top. The two wooden cross-braces serve as feet, the underside of which are worn and show traces of fungal and wood worm attack (Fig. 2). At the slavery exhibitions in Amsterdam and New York these stocks were erroneously exhibited on their edge with the feet pointing sideward (Sint Nicolaas and Smeulders, 2021). The number '22' is written in blue chalk on top of the stocks. Until the twentieth century chalk crayon only appeared in a limited color palette, which includes blue (Ellis and Yeh, 1998). The fact that the chalk writing is still preserved suggests that the stocks were no longer in use after this number was applied. The writing may therefore indicate that the stocks have been part of an inventory or auction.

4. Diatoms and other siliceous microfossils

To gain insight into the environment in which the stocks have been, siliceous microfossils were studied in a sample from a hole in the upper side of the stocks filled with sediment (Sample 7 in Table 1). Samples were prepared conform the method outlined by Battarbee (1973), and Naphrax was used as mounting medium. The siliceous microfossils encountered include diatoms, phytoliths and stomatocysts. The sample contained on average 500,000 diatoms per gram sediment. Diatom identification and ecological preferences are largely based on Cantonati et al. (2017), supplemented by the expertise of Dr. B. van de Vijver (pers. com.). An extensive count revealed 50 different diatom species (Table 2), which are characteristic for mesotrophic freshwater, probably a gently flowing stream or ditch. The epiphytic diatom *Cocconeis placentula* indicate the presence of aquatic plants or macroalgae. Diatoms living in brackish to marine waters were absent. The encountered phytoliths mainly originate from grasses but not from palms. Particularly striking is the abundance of stomatocysts of Chrysophyceae (golden-brown algae), about 460,000 per gram sediment. These algae also mainly occur in freshwater systems. Other sediment samples from the same hole yielded the freshwater alga *Spirogyra* and pollen of the freshwater plant *Myriophyllum alterniflorum*. The encountered diatom species are cosmopolitan and can be found in temperate to tropical freshwater systems. There is no indication that the sediment would have been deposited under brackish to marine conditions.

5. Pollen and spores

Pollen and spores were studied in twelve samples of sediment taken from eight different cracks and holes either thought to be as old as the stocks themselves or developed later (Table 1). Five separate samples were taken stratigraphically from a single large hole in upper surface filled with sediment. Sample preparation followed Faegri and Iversen (1989). The samples were less than 0.5 cc. Identification of pollen and fern spores was based on Faegri and Iversen (1989), Punt (1976), Punt and Clarke (1980, 1981, 1984), Punt et al. (1988, 1995), Punt and Blackmore (1991), Punt and Hoen (2009), Reille (1992, 1995, 1998), and Moore et al. (1991). Fungal spores were identified based on Van Geel and Aptroot (2006). Pollen preservation was excellent and the samples were quite uniform and rich in pollen, both in quantity and variety. From a total of 7106 microfossils, 142 pollen and spore taxa were identified: 18 trees, 21 shrubs, 91 herbs, 5 ferns, and 7 types of fungi, algae, and moss spores (Fig. 4).

5.1. Regionality

The pollen record as a whole has a very low proportion of tree and shrub pollen and a large variety of herb pollen (Fig. 4), which may suggest an open agricultural landscape with a low nutrient status (e.g., modest proportions of *Urtica* and Chenopodiaceae-type pollen) and not including salt marshes (e.g., modest proportions of Chenopodiaceae-type and *Plantago maritima*-type pollen). Although many of the taxa have a wide distribution, pollen from *Armeria,* Cistaceae, *Erica arborea*, *Lavandula, Nerium oleander*, *Olea*, *Pinus pinaster, Quercus ilex*, *Urtica*

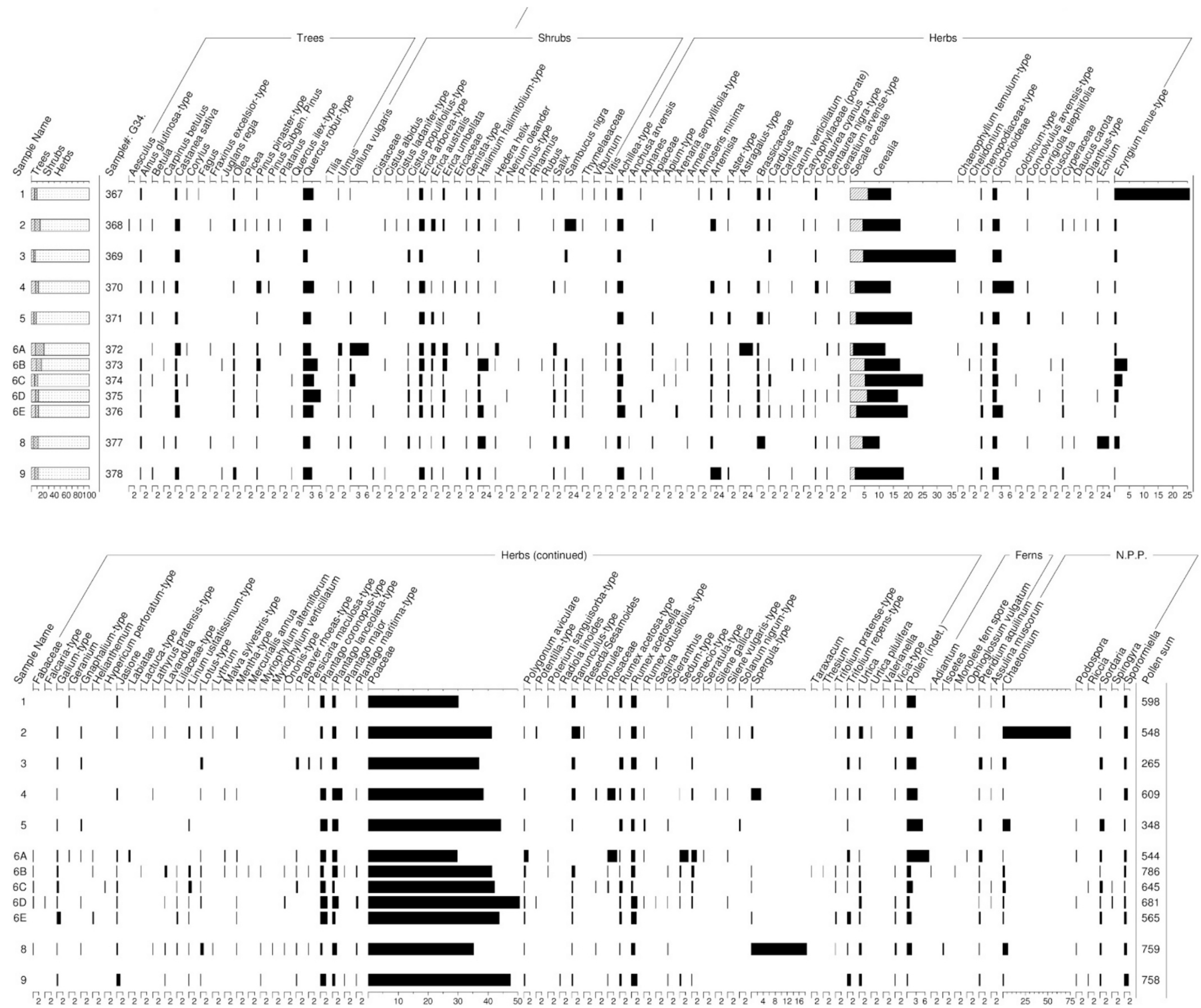

Fig. 4. Microfossil diagram showing pollen and spores of taxa identified in the sediment samples from the stocks.

pilulifera, Eryngium tenue, Corrigiola telephiifolia, and *Vitis vinifera* are characteristic for the Mediterranean. The geographical origin can be narrowed down on the basis of pollen types that are typical for the western Iberian Peninsula and Northwest Africa (*Erica australis*, *Erica umbellata*, *Cistus albidus*, *Cistus populifolius, Cistus ladanifer*, and *Halimium halimifolium*) (Flora Iberica, 1986–2001; Flora Europaea, 1964–1993). No pollen was encountered that would exclude Portugal or Spain. We did not encounter pollen of *Cedrus* or *Chamaerops*, which occurs in most samples from Northwest Africa up to a few centuries old (Ballouche, 1986).

5.2. Cereal pollen

In our analysis, Cerealia pollen is characterized by a large size (> 35 μ diameter), a large pore (8–20 μ, including the annulus), and a thick annulus which is broader than the pore diameter and is clearly delimited towards the surrounding exine. With this combination of features it differs from other grasses with large pollen such as *Glyceria fluitans* and several *Bromus* species. The fourth author (A.J. Kalis) noticed that the walls of many cereal pollen grains in the pollen samples were thickened. This kind of deformation was first published by Andersen (1988). Based on his test results, Andersen attributed it to heating. An explanation is that the intine, which normally disappears with fossilization, is preserved by heating as a thick layer below the nexine, and the distinction between sexine and nexine disappears. Kalis carried out similar tests, with the same result. Since then, Kalis has observed this deformation of cereal pollen in medieval cesspits, probably caused by the heating of cereals for the production of porridge or bread. Similar observations were made by Pini et al. (2018).

6. Insects

The stocks show insect damage and the samples taken for microfossil analysis contained also some insect remains. The insect damage is of two types. The first consists of a wide and flat tunneling in the cambium zone under the now missing bark, which can be attributed to beetle larvae of Buprestids or Cerambycids. The second type consists of small boreholes that are similar to those of *Anobium punctatum*, which is in Europe the most common small wood borer found in historic beams and wooden objects. It lives predominantly indoors, preferring a humid environment (Heinze, 1983). The insects concern the beetles *Ptinus fur/P. clavipes, Latridius minutus, Adistemia watsoni*, and two species of Corticariinae. A mite belonging to the Macrochelidae was also recorded. The tiny species *Adistemia watsoni* is of South American origin, but had spread to Europe at least as early as the 19th century (Haghebaert, 1986). This beetle was the only specimen that was almost intact, suggesting that it had entered the stocks in a later period of its existence. Other non-European taxa were not encountered. The *Ptinus* species mostly live in indoor situations, feeding on human food and other remains of plant or animal origin (Heinze, 1983). The combination of recovered species is typically found in indoor environments with various kinds of moldy remains and litter or hay mixed with excrements (Koch, 1989a, 1989b, 1992). They are also frequently found as archaeological remains (van den Bos et al., 2014; Schelvis and Ervynck, 1992). No remains of the multitude of possible outdoor arthropods were found.

7. Discussion

7.1. Hypotheses regarding the stock's history

From their moment of construction onwards, artifacts can accumulate pollen, spores, and other small biological and mineralogical particulates. These traces can provide evidence of the environment with which the object has had contact; this was the case with the stocks from the Rijksmuseum in Amsterdam. From the data collected, there is no evidence that the stocks have ever been in Brazil. And, although the donor indicated that his grandfather found the object in Zeeland, the microfossils do not point that way either.

DNA indicates that the geographical distribution of the oak tree used to make these stocks runs through Central Europe from North Spain up to Southern Scandinavia (Dominguez-Delmás et al., 2023). It is however unlikely that the wood from this trunk was transported over long distances. Wood transported over long distances generally had market value. As a rule it is straight-grained and without knots. These stocks, on the contrary, are made of wood with an irregular grain and knots, which is generally of local origin that had to meet few requirements. Woodworking techniques that are common for green wood have been used in the manufacture of these stocks (Dominguez-Delmás et al., 2023). The low quality wood and the woodworking techniques together make it likely that the place of felling of the trunk and manufacture of the stocks were in proximity.

The stocks examined here, are of the horizontal type (holes on top). This model is much less common than the vertical type (holes on the sides). However, as is described below, on the Iberian Peninsula several examples of this horizontal model have survived and there is even iconographic evidence for the use of this horizontal type in the early 19th century. Based on the model, it is therefore likely that these stocks were made and used on the Iberian Peninsula.

Samples were taken from locations as old as the stocks themselves, and from cracks that developed later. The sampling locations at the bottom and the ends of the stocks contained more dust than sand. On top of the stocks however, the sediment in the sampling locations was more sandy. One location was sampled stratigraphically (Table 1. no. 6 A to E). All these sample locations, different in age and sediment, however yielded more or less the same pollen spectra (Fig. 4). It therefore appears that these stocks have always been in the same type of environment.

Some of the plant taxa found in the stocks as pollen are limited to Northwest Africa and the western Iberian Peninsula, whereas pollen of trees that are highly characteristic of Northwest Africa was not encountered. The western Iberian Peninsula is thus the most likely origin of the encountered pollen. Although neighboring each other, the inferred geographical distributions of the oak tree used and the pollen do not overlap. This leaves us with two hypotheses. Possibly, the distribution of the oak as suggested by DNA and that of the pollen types typical for the western Iberian Peninsula were in reality closer together. Otherwise the tree used could have been felled in North Spain and transported to where the stocks were used, somewhere in the western Iberian Peninsula.

The insect species found indicate that the stocks have been in a humid indoor environment. The pollen suggests the presence of wild grasses and cereals, while the good preservation and lack of corrosion of the diatoms and pollen indicate that the analyzed sediment was not exposed to moist air conditions for a long period of time. Within these constraints, there are two possible scenarios for the microfossils to have entered these stocks, and these might have happened consecutively.

7.1.1. Agricultural environment

The sediment entered the cavities in the stocks post-use, when it was thrown in a low-energy stream or ditch, in an open agricultural landscape with intensive cultivation of rye (*Secale*), a crop found on poor soils such as the Iberian peninsula during the 19th century (Ballesteros-Arias, 2019). Arguments that support this scenario are the good preservation of diatoms and pollen, the fine texture of the sediment, and the relative low abundance of fungal spores. An argument against this scenario is the presence of sediment on the upper side of the stocks contrasting with absence on the lower side or in the cavities between the beams and the cross-braces.

7.1.2. Humid indoor environment

The majority of the encountered pollen derives from wild grasses (Poaceae). The second largest group is that of cereals (Cerealia, part of which could be identified as rye (*Secale cereale*)). Most cereal species are self-pollinating and shed their pollen during threshing. Rye, however, is wind-pollinated and its pollen must either have entered the deposit directly through the air (in an agricultural environment), or was captured by the rye straw and grass used as litter. Four fungal taxa characterize the direct environment of the stocks: *Chaetomium* associated with cellulosic materials including plant debris, cotton and linen fabric and paper; *Podospora* and *Sordaria* thriving on decaying plant matter as well as herbivore dung (Willemsen et al., 1996; Raposeiro et al., 2021; Weijdema et al., 2021); and *Sordaria* (You et al., 2021; Szóstak et al., 2023) and *Sporormiella* (Hamad et al., 2017) primarily known to occur on human and animal feces. From all this it is possible that the stocks were used in a humid environment with decaying plant material (straw and hay) and feces of humans and/or herbivores.

The latter idea is supported by the extensive damage from fungal decay and wood worm in the stocks themselves. This agrees with use in a dungeon or stable with a moist floor covered with straw and hay. In accordance with its function, the stocks were more likely to be used in a dungeon than a stable. The inferred heat deformation of much cereal pollen suggests food processing. This may have been animal or human food. In this context, however, it is more likely that the captives ate bread or porridge and had to deposit their feces on the stocks while being restrained. The sanded upper surface with cracks and holes filled with sediment might indicate regular scrubbing and cleaning. Scrubbing of wooden objects with sand was common practice in Spain (see illustration in La Ilustracion Española y Americana 1870 p. 140–142). A feasible scenario for the presence of the observed freshwater microfossils is the scrubbing of the upper side of the stocks with sand and water from freshwater sources, which then got mixed with the dirt on the stocks and was pressed into the cracks and holes. This might also explain the presence of sediment on the upper side but its absence on the (not scrubbed) lower side. This scenario combines the inferred outdoor origin of the studied sediments in scenario 1 with the indications for indoor use.

The more common type of stocks was positioned on its side, which allowed the captives to lay down, and was used throughout the world, including Europe (de Win, 1991; Ramos Vazquez, 2007; Schild, 2010; Bernal Peña, 2016; d'Artagnan, 2017, 2019; Moore, 2022). The stocks in the Rijksmuseum collection studied here, however, are of a flat horizontal type, with vertical holes restraining the captive's ankles, which is far less common. This type forced the captives to stand up straight, often with their necks fixed to the back wall. Many local Spanish prisons were equipped with such stocks and our stocks could have served in that context. Another possible historical context during which the flat horizontal type of stocks was used, is that of the violent early 19th century, when both the Peninsular War (1807–1814) and the Spanish War of Independence (1808–1814) took place, characterized by atrocities between the two sides, spearheaded by Carlos IV and his son Fernando VII. This is illustrated in the work titled *Por liberal?* (1814–1823) by Francisco de Goya y Lucientes (Fig. 3). Other flat stocks were combined with a bench, enabling the captives to sit. One such example, combined with a latrine bench with holes, is preserved to this day in the former dungeon at the Town Hall of Mazaleón (Spain) (Benavente Serrano et al., 2001; Benavente, 2012).

8. Conclusion

Little or nothing was known with certainty about the origin of a pair of wooden stocks exhibited in the Rijksmuseum, Amsterdam. The stocks are said to have been found in the Dutch province of Zeeland. The makers of the exhibition considered a relationship with Brazil plausible, where the Dutch had a colony from the year 1630 to 1654. However, ancient DNA indicated that the tree's growing zone was Central Europe and radiocarbon dating indicated that the tree for the stocks was likely felled around 1800 C.E. Archaeological methods proved to be very fruitful in reconstructing a picture of place of the use of the stocks. Samples taken from the cracks and holes in the stocks, turned out to contain a wealth of microbiological elements: pollen, fungal spores, diatoms and other algae, phytoliths, and insect remains. The diatoms found indicate that the sediments are initially from a freshwater environment. The spectrum of pollen made a fairly accurate regional delineation possible: the western Iberian Peninsula. The insect remains in the stocks and the fungal and wood worm attack indicated a moist indoor environment. Although the sediments might have entered in various ways and at various moments, a dungeon seems the most likely context in which these stocks have been used.

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.

The author is a Guest Editor for The Review of Palaeobotany and Palynology and was not involved in the editorial review or the decision to publish this article.

Data availability

Data will be made available on request.

Acknowledgements

Annemarie Philip kindly prepared the pollen samples. Dr. Bart van de Vijver helped identifying the diatoms. Prof. Patricia E.J. Wiltshire, Dr. Kate van Lookeren Campagne-Nuttall and Julian Parker commented on the draft version of this paper.

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