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Published in:
Dendrochronologia

DOI:
10.1016/j.dendro.2021.125861

2021

Document Version:
Publisher's PDF, also known as Version of record

Link to publication

Citation for published version (APA):
Hansson, A., Linderson, H., & Foley, B. (2021). The Danish royal flagship gribshunden: Dendrochronology on a late medieval carvel sunk in the Baltic Sea. *Dendrochronologia*, *68*, Article 125861. https://doi.org/10.1016/j.dendro.2021.125861

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Dendrochronologia 68 (2021) 125861

Contents lists available at ScienceDirect

Dendrochronologia

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

The Danish royal flagship *gribshunden* – Dendrochronology on a late medieval carvel sunk in the Baltic Sea

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ARTICLE INFO

Keywords:
Marine archaeology
Dendrochronology
Shipwreck
Medieval
Baltic Sea

ABSTRACT

The Royal flagship *Gribshunden* carried the Danish King Hans on its way to the city of Kalmar in Sweden when the ship sank in the summer of 1495. The ship caught fire while anchored north of the Stora Ekö Island and sank to the seafloor, where it lies to this day. The wreck was rediscovered in the 1970s and is remarkably well preserved. Since 2001, scientific investigations have been performed on the wreck by various organizations. In total, 13 dendrochronological samples from different parts of the ship construction have been collected and analyzed with standard dendrochronological methods with respect to age and provenance. The results show that all dated samples could have been felled during the winter season of 1482/83, although only one sample contains sapwood and waney edge. The highest correlations are obtained from reference chronologies that originate from the River Meuse drainage area, with correlations peaking around the city of Namur in Belgium. Most likely, the ship was constructed in a shipyard close to the mouth of the River Meuse in the southern Netherlands. It seems King Hans realized the potential of the new ship type represented by *Gribshunden*, but his shipwrights did not have the knowledge to build such a ship in Denmark. Instead, he purchased the ship from abroad. This study highlights late medieval economic and political connections throughout northern Europe.

1. Introduction

Dendrochronological studies of wood from Baltic Sea archaeological sites provide accurate and precise dating of the features, and often the provenance of the trees. Dendrochronology can be used by social scientists to expose patterns of cultural contact, economic transactions and even aspects of political power through time. The Baltic Sea is an exceptional preservative environment for wood primarily due to the absence of marine borers such as the shipworm, *Teredo navalis*, which cannot reproduce in this sea's low salinity. As a result, archaeological sites remain on the seafloor for hundreds or even thousands of years (Fors et al., 2012; Rönnby, 2001). It is estimated that the Baltic holds more than 100,000 underwater cultural heritage sites including Stone Age features, coastal fortifications, and particularly shipwrecks (Olsson, 2006; Eriksson and Rönnby, 2012).

One of the most important shipwrecks yet investigated in the Baltic Sea is the flagship of King Hans, who ruled Denmark 1481−1513. *Gribshunden* sank in 1495 north of Stora Ekö Island in the Blekinge archipelago (Eriksson, 2015) (Fig. 1). Recreational divers discovered the wreck during the 1970s, and around 2001 archaeologists under the auspices of Kalmar County Museum determined that the wreck was medieval. Maritime historians subsequently linked the wreck to written sources from Denmark and Lübeck, and identified it tentatively as *Griffen* or *Gribshunden* (Einarsson and Wallbom, 2001; Rönnby, 2015).

This ship appears in documents held in the Danish royal archives, with the first mention in a letter written by King Hans aboard the vessel in May 1486 (Sjöblom, 2015). *Gribshunden* quickly became an instrument to exercise Hans' political and military will; in 1487 *Gribshunden* helped suppress a potential revolt on the Danish-held island of Gotland. In the early summer of 1495 King Hans was on his way to the city of Kalmar, a Swedish city close to the then-border of Denmark and Sweden, where he was to meet the Swedish regent Sten Sture the Elder (ca 1440–1503). King Hans wanted to re-establish the Nordic Union between Denmark, Norway, and Sweden by being elected king of Sweden (Eriksson, 2020; Sjöblom, 2015). On his way to Kalmar, the king took shelter close to the city of Ronneby in the Blekinge archipelago, then Danish territory. While anchored north of Stora Ekö Island the ship caught fire and sank, with many casualties. King Hans had disembarked prior to the fire, and later continued his journey to Kalmar.

Four investigation campaigns during 2001, 2002, 2006 and 2012

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https://doi.org/10.1016/j.dendro.2021.125861
Received 13 April 2021; Received in revised form 22 June 2021; Accepted 22 June 2021
Available online 25 June 2021

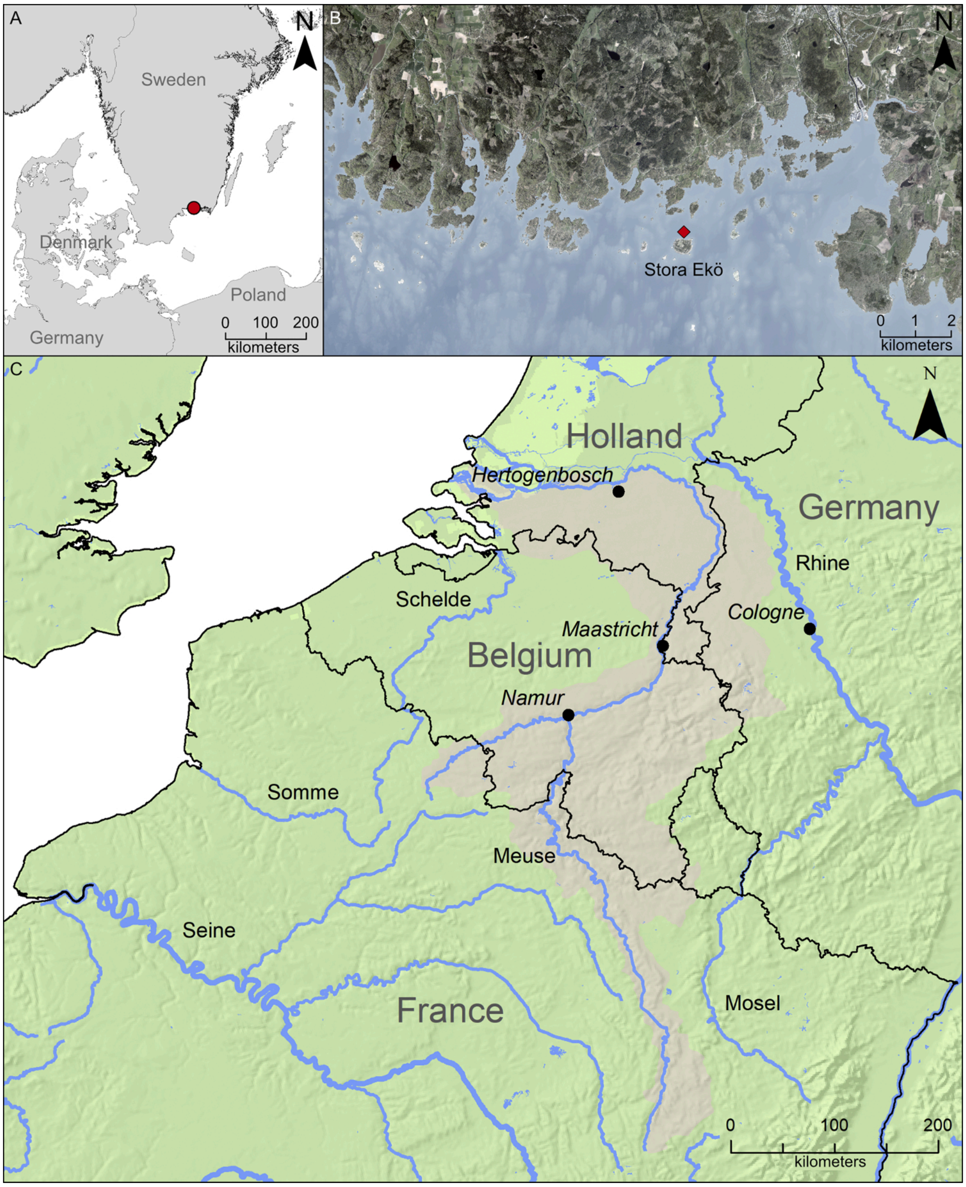

Fig. 1. Map of the locations discussed in this paper. (A) A map showing the position of the *Gribshunden* shipwreck position (red circle) in southeastern Sweden. Basemap © EuroGeographics. (B) Location of the Stora Ekön Island and the *Gribshunden* shipwreck, marked by the red rhomb, north of the Island. Topography data © Lantmäteriet. (C) Map over parts of northwestern Europe. Cities are marked by black circles and names in italics. Names of rivers in the area are marked by normal letters. The beige area represents the drainage area of the River Meuse. Basemap © EuroGeographics.

resulted in recovery of wooden gun carriages, dendrochronological samples, and hundreds of individual artifacts (Einarsson and Wallbom, 2001, 2002; Einarsson and Gainsford, 2007; Einarsson, 2012). Between 2013 and 2015 *Gribshunden* was part of the Södertörn University project 'Ships at War', resulting in the recovery of the ship's wooden figurehead (Eriksson, 2020; Rönnby, 2015). During the summer of 2019 a new effort involving Lund University, Blekinge Museum, and Södertörn University excavated a trench amidships to reveal the hull construction and to assess the archaeological potential of the site (Fig. 2).

This dendrochronological study is part of a multi-disciplinary effort on the *Gribshunden* shipwreck aiming at a better understanding of late medieval ship construction, life aboard a royal ship, and everyday commodity use practices in late medieval Scandinavia. The specific aims with this dendrochronological study are to determine the time of felling and source area of the timber used to build the ship. This will aid understanding of political, military, and economic connections throughout Europe in the later medieval period. Specifically, it will provide insight into Hans' connections across Europe, and the development of ships like *Gribshunden*: the first purpose-built warships capable of carrying naval artillery.

2. Methods

The samples, all of oak, were collected by divers during several field campaigns at the wreck site. Samples 55236–55245, consisting of available loose parts of the hull in direct vicinity of the wreck on the seafloor, were collected in the late summer of 2001 (Einarsson and Wallbom, 2001). The exact find spots were not recorded. Samples 55609–55610, found disarticulated on the seafloor 2.5 and 9.8 m either side of the absolute stern of the wreck, were collected in the autumn of 2011 (Einarsson, 2012). Sample 55,881 was sampled in the summer of 2019 and consists of a section of hull plank sawn from the intact hull 1 m below the sediment surface in an excavation trench located starboard amidships (Rönnby, 2020) (Fig. 2).

The samples were analyzed at the National Laboratory of Wood Anatomy and Dendrochronology at the Department of Geology, Lund University. The samples were prepared by cutting the surface with an industrial razor blade to make the rings clearly visible. Chalk was applied to better distinguish the earlywood-latewood border. The tree ring-widths were measured with a precision of 0.01 mm using a stereo microscope and the CATRAS software (Aniol, 1983). Between two and four radii for each sample were measured, in order to detect missing

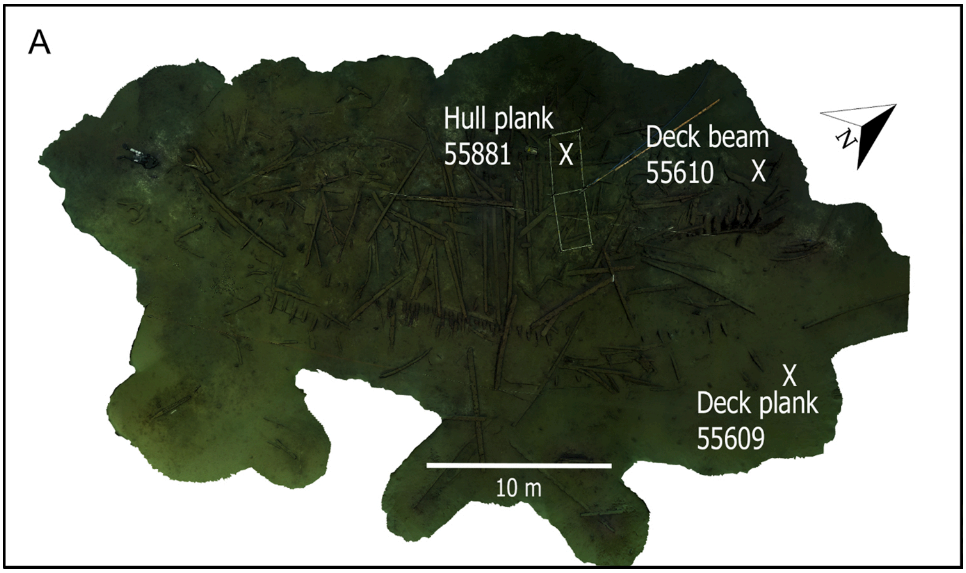

Fig. 2. A. Photogrammetric site plan of the Gribshunden ship wreck produced during the field campaign of 2019. The position of the three latest dendrochronological samples are marked. The square around the hull plank sample position is the outline of the excavation trench, see Fig. 2B. B. Archaeological excavation in a trench located starboard amidships during the field campaign of 2019.

Table 1
Sample characteristics and calendar year dating. The calculated year of felling is calculated based on the normal amount of sapwood rings in (older than 100 years) oak from Belgium (11-37 rings) (Haneca et al., 2009).

Sample number	Type	Radii	Amount of rings	Sapwood; Waney edge	Date of outermost ring	Calculated year of felling
55236	Futtock	2	84	No; No	No dating	No dating
55237	Knee	2	101	No; No	No dating	No dating
55238	Futtock	2	83	No; No	1450	After 1461
55239	Futtock	2	108	No; No	1463	After 1474
55240	Knee	2	52	No; No	1420	After 1431
55241	Knee	4	70	15; W	1482	Winter 1482/83
55242	Plank	2	22	No; No	No dating	No dating
55243	Plank	2	84	No; No	1456	After 1467
55244	Plank	4	60	No; No	1418	After 1429
55245	Plank	4	60	No; No	1418	After 1429
55609	Plank	5	71	No; No	No dating	No dating
55610	Beam	6	91	No; No	1446	After 1457
55881	Plank	3	96	No; No	1454	After 1465

rings or possible measurement errors, and merged into tree-ring width series. Comparisons between the tree-ring series were performed by statistical and visual methods (Pilcher, 1990), in order to construct tree-ring width chronologies. The ring-width measurements and chronologies were quality controlled using the COFECHA software (Holmes, 1983). In order to obtain calendar ages and to determine the provenance of the wood, the ring-width chronologies, and the individual samples, were matched against the vast network of reference chronologies representing different geographical areas across Europe harbored at the National Laboratory of Wood Anatomy and Dendrochronology. The matching was performed in the TSAPWin software (Rinn, 2003) using the Baillie-Pilcher *t*-value (Baillie and Pilcher, 1973) and the *gleichläufigkeit* (glk) (*, ** or *** representing 95 %, 99 % or 99.9 % significance, respectively) (Schweingruber, 1988) statistical parameters, as well as visual inspection of the chronology cross correlation.

3. Results

The oak samples are from deck and hull planks, knees, deck beam, and futtocks of the ship. The number of rings in each sample varies from 22 to 108, with a mean ring width ranging from 1.1–4.5 mm. Only one sample has sapwood and/or waney edge preserved (Table 1). Two ring-width chronologies, 20552384 and 20552415, were constructed based on the internal correlations of the samples (Table 2). The 20552384 chronology consists of four samples and the 20552415 chronology consists of five samples. One sample, 55,241, occurs in both chronologies, whereas sample 55239 does not belong to any of the chronologies. Furthermore, a third ring-width chronology, 20552389, containing all nine dated samples was constructed.

The results show that the 20552389 chronology is dated to 1482 (Fig. 3). Statistical matches between the three *Gribshunden* chronologies, with and without a valid time series of ring 1−100, and the highest correlating reference chronologies are presented in Table 3. Of the thirteen measured samples, nine could be confidently dated to a calendar year, while four have not been possible to date. One sample, 55,241, has preserved sapwood and waney edge and is dated to the winter season of 1482/83. The other dated samples lack sapwood, and therefore a number of years have been added to the outermost ring to determine the oldest possible year of felling, a so-called *terminus post quem* dating (Table 1).

4. Discussion

4.1. Dating of the Gribshunden timber

The 20552389 chronology is dated to 1482 (Table 3). The best

Table 2
Statistical correlations between the Gribshunden samples. The statistics are presented as *t*-value; *gleichläufigkeit* with *, ** or *** representing 95 %, 99 % or 99.9 % significance, respectively. Sample matches forming chronology 20552384 are coloured in orange, while sample matches forming chronology 20552415 are coloured in blue. Note that sample 55,241 is included in both chronologies and is therefore coloured blue on the horizontal axis and orange on the vertical axis.

	55236	55237	55238	55239	55240	55241	55243	55244	55245	55609	55610	55881
55236												
55237	--------											
55238	--------	--------										
55239	4,4; 66**	--------	--------									
55240	--------	--------	5,0; 75***	--------								
55241	--------	--------	6,8; 78***	--------	--------							
55243	--------	4,6; 63*	--------	--------	--------	5,6; 79***						
55244	--------	--------	--------	3,2; 67**	--------	4,4; 75***	--------					
55245	--------	--------	--------	--------	--------	5,1; 74**	--------	6,0; 81***				
55609	--------	--------	4,1; 65**	3,8; 58*	--------	--------	--------	--------	--------			
55610	--------	--------	3,9; 67**	3,7; 59*	--------	4,6; 71**	4,3; 65**	4,1; 73***	4,0; 67**	--------		
55881	--------	3,1; 69**	5,6; 74***	--------	3,5; 73***	--------	--------	--------	3,4; 65**	--------	4,5; 71***	

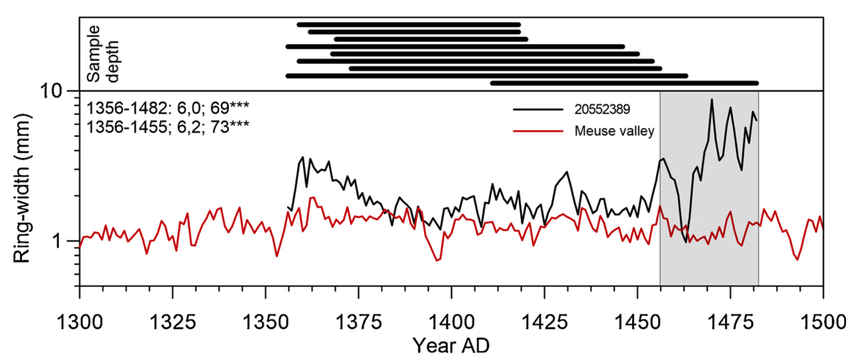

Fig. 3. Visual and statistical correlation between the 20552389 chronology (black curve) and the BBMEUSE2 chronology (red curve). The grey box represents the area omitted from the valid time span when correlating with the reference chronology. The sample depth of the 20552389 chronology is presented in the top of the figure.

Table 3
Statistical correlation parameters between Gribshunden chronologies and reference chronologies for the year 1482 CE. *t*-value; *gleichläufigkeit* with *, ** or *** representing 95 %, 99 % or 99.9 % significance, respectively. The reference chronologies are sorted by the *t*-value of the '20552389' chronology.

Ref. chronology	Year AD	Location	20552384	20552384 VT 1−100	20552415	20552415 VT 1−100	20552389	20552389 VT 1−100
BBMEUSE2	674−1989	Meuse Valley	6,1; 67***	5,4; 69***	5,8; 71***	5,4; 74***	6,0; 69***	6,2; 73***
BBDBHSTD	1311−1550	Hertogenbosch	5,2; 63**	4,9; 64**	5,9; 65***	6,0: 67***	5,8; 63**	6,3; 65**
00000081	822−1964	Western Germany	4,0; 64**	3,3; 65**	5,0; 67***	4,7; 71***	5,1; 67***	5,3; 72***
ENGQ0001	413−1899	South East England	5,7; 68***	4,4; 65**	4,2; 61**	3,7; 63**	5,1; 66***	3,9; 64**
BBMJKSTD	1191−1457	Maastricht	4,3; 69***	5,2; 69***	4,2; 69***	4,7; 70***	4,9; 69***	5,5; 70***
BBNAMUR1	1363−1638	Namur	4,8; 63**	3,7; 63**	4,1; 69***	3,5: 72***	4,7; 67***	4,7; 70***
00000084	1322−1973	Mosel Valley	3,9; 65***	3,9; 63**	4,6; 66***	3,5; 65**	4,3; 66***	3,6; 66***
BBARDEN2	1120−1986	The Ardennes	3,7; 55*	3,9; 58*	3,7; 57*	4,3; 65**	4,0; 55*	4,9; 60*
00000078	1036−1972	Holland	3,0; 63**	3,9; 64**	2,6; 58*	4,0; 66***	3,1; 63**	4,6; 64**
0M010006	1000−1655	Cologne	2,7; 59*	3,3; 64**	3,4; 60*	4,2; 61*	3,3; 59*	4,7; 60*

correlation is to the Meuse Valley chronology with a *t*-value of 6,0 and a glk of 69***. However, the sample depth of the 20552389 chronology decreases and the ring-width curve starts to vary greatly after 1455 and the visual match against the reference chronology is low (Fig. 3). In order to get a more representative chronology and a better statistical match, the years 1456–1482 were subsequently left out of further statistical analysis. This led to an increase in both *t*-value and glk with most reference chronologies, with the South East England chronology being

Table 4
Correlations between the reference chronologies used in this study without valid time spans applied.

	BBMEUSE2	BBDBHSTD	00000081	ENGQ0001	BBMJKSTD	BBNAMUR1	00000084	BBARDEN2	00000078	0M010006
BBMEUSE2		13.5; 78***	25.4; 72***	12.9; 73***	7.7; 73***	14.6; 79***	17.0; 73***	42.3; 82***	14.9; 69***	9.5; 68***
BBDBHSTD	13.5; 78***		9.4; 73***	6.5; 67***	6.5; 70***	8.5; 73***	9.6; 74***	11.0; 75***	9.3; 74***	8.4; 68***
00000081	25.4; 72***	9.4; 73***		13.0; 63***	6.0; 67***	6.0; 66***	18.7; 71***	19.2; 69***	17.4; 71***	11.0; 68***
ENGQ0001	12.9; 73***	6.5; 67***	13.0; 63***		4.9; 61***	4.5; 61***	7.4; 62***	9.4; 62***	10.3; 64***	7.2; 62***
BBMJKSTD	7.7; 73***	6.5; 70***	6.0; 67***	4.9; 61***		3.4; 74***	3.5; 66***	5.4; 63***	6.0; 62***	7.5; 68***
BBNAMUR1	14.6; 79***	8.5; 73***	6.0; 66***	4.5; 61***	3.4; 74***		5.8; 70***	7.4; 64***	7.6; 65***	5.0; 65***
00000084	17.0; 73***	9.6; 74***	18.7; 71***	7.4; 62***	3.5; 66***	5.8; 70***		15.3; 70***	12.9; 71***	9.0; 68***
BBARDEN2	42.3; 82***	11.0; 75***	19.2; 69***	9.4; 62***	5.4; 63***	7.4; 64***	15.3; 70***		14.8; 65***	9.7; 64***
00000078	14.9; 69***	9.3; 74***	17.4; 71***	10.3; 64***	6.0; 62***	7.6; 65***	12.9; 71***	14.8; 65***		7.5; 66***
0M010006	9.5; 68***	8.4; 68***	11.0; 68***	7.2; 62***	7.5; 68***	5.0; 65***	9.0; 68***	9.7; 64***	7.5; 66***	

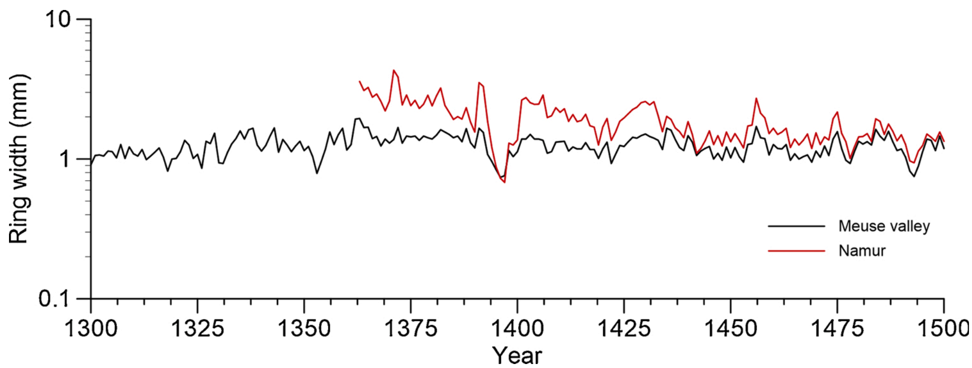

Fig. 4. Visual correlation between the Meuse valley and Namur chronologies for the 1356-1500 time span.

the notable exception (Table 3).

One sample, 55,241, has been possible to date to the winter season of 1482/83. The growth season of an oak tree starts in late April to early May and continues until the end of August, hence the term winter season is defined as September to April. The dating of the individual timber shows eight *terminus post quem* dates. Based on the presumed felling in the winter season of 1482/83, all dated timber was at least 100 years old when it was cut down. The normal amount of sapwood rings in oak from Belgium older than 100 years is 11–37 (95 % confidence interval), the minimum of which should be added to the outermost dated ring in order to obtain the oldest possible felling year (Haneca et al., 2009).

Since all *terminus post quem* dates are older than sample 55,241, it is possible that the wood was felled during one event during the winter season of 1482/83. Due to the high correlation between the dated samples, it is most probable that the timber is sourced from one general area, which further strengthens the proposition that all timber was cut down during one season, namely the winter season of 1482/83.

The two ring-width chronologies 20552384 and 20552415 have a good statistical and visual correlation, even when removing the common sample 55241 from either of the chronologies. Possibly, the grouping of the samples could be explained by the different type of timber needed for the respective ship part. The 20552384 chronology contains one futtock, two knees, and one plank and the 20552415 chronology contains four plank samples and one beam sample. Probably, the straight trunk of a tree was used for planks and the knees were sourced from the crown timber, more suited to the knee measurements. Another possibility is that factors such as soil moisture and micro-topography within a stand enable straight and crooked trees to co-exist where trees with similar growth situations within the stand statistically correlate better with each other.

4.2. Provenance of the reference chronologies

The reference chronologies used for the dating and provenance have not been constructed by the laboratory at Lund University and therefore the origin of the samples which were used in the chronologies is unclear. For chronologies which have descriptions of cities in their data header, it is assumed that the trees grew in the vicinity of that city. However, some chronologies have descriptions that make the determination of the source area harder to determine, such as the Western Germany chronology.

By statistically comparing the reference chronologies with each other (Table 4), both by their full age span and during the valid period of 1300–1500, the time span when the *Gribshunden* trees grew, it is possible

Table 5
Correlations between the reference chronologies used in this study within the time span 1300-1500.

	BBMEUSE2	BBDBHSTD	00000081	ENGQ0001	BBMJKSTD	BBNAMUR1	00000084	BBARDEN2	00000078	0M010006
BBMEUSE2		12.5; 75***	12.5; 79***	7.5; 67***	7.7; 79***	18.0; 89***	10.3; 74***	14.1; 72***	119; 72***	10.6; 72***
BBDBHSTD	12.5; 75***		8.6; 72***	6.0; 65***	6.5; 70***	7.2; 71***	8.8; 72***	10.0; 73***	8.7; 74***	8.0; 66***
00000081	12.5; 79***	8.6; 72***		5.0; 62***	6.4; 71***	6.3; 70***	8.3; 69***	8.4; 67***	10.3; 73***	9.6; 66***
ENGQ0001	7.5; 67***	6.0; 65***	5.0; 62***		3.5; 58*	4.0; 67***	3.9; 63***	4.9; 59**	3.8; 63***	5.1; 59**
BBMJKSTD	7.7; 79***	6.5; 70***	6.4; 71***	3.5; 58*		3.4; 74***	3.5; 66***	5.0; 65***	5.5; 62**	8.7; 71***
BBNAMUR1	18.0; 89***	7.2; 71***	6.3; 70***	4.0; 67***	3.4; 74***		6.4; 77***	7.8; 66***	7.5; 68***	5.0; 71***
00000084	10.3; 74***	8.8; 72***	8.3; 69***	3.9; 63***	3.5; 66***	6.4; 77***		8.0; 70***	8.8; 75***	7.5; 69***
BBARDEN2	14.1; 72***	10.0; 73***	8.4; 67***	4.9; 59**	5.0; 65***	7.8; 66***	8.0; 70***		10.2; 72***	7.8; 63***
00000078	11.9; 72***	8.7; 74***	10.3; 73***	3.8; 63***	5.5; 62**	7.5; 68***	8.8; 75***	10.2; 72***		8.9; 64***
0M010006	10.6; 72***	8.0; 66***	9.6; 66***	5.1; 59**	8.7; 71***	5.0; 71***	7.5; 69***	7.8; 63***	8.9; 64***	

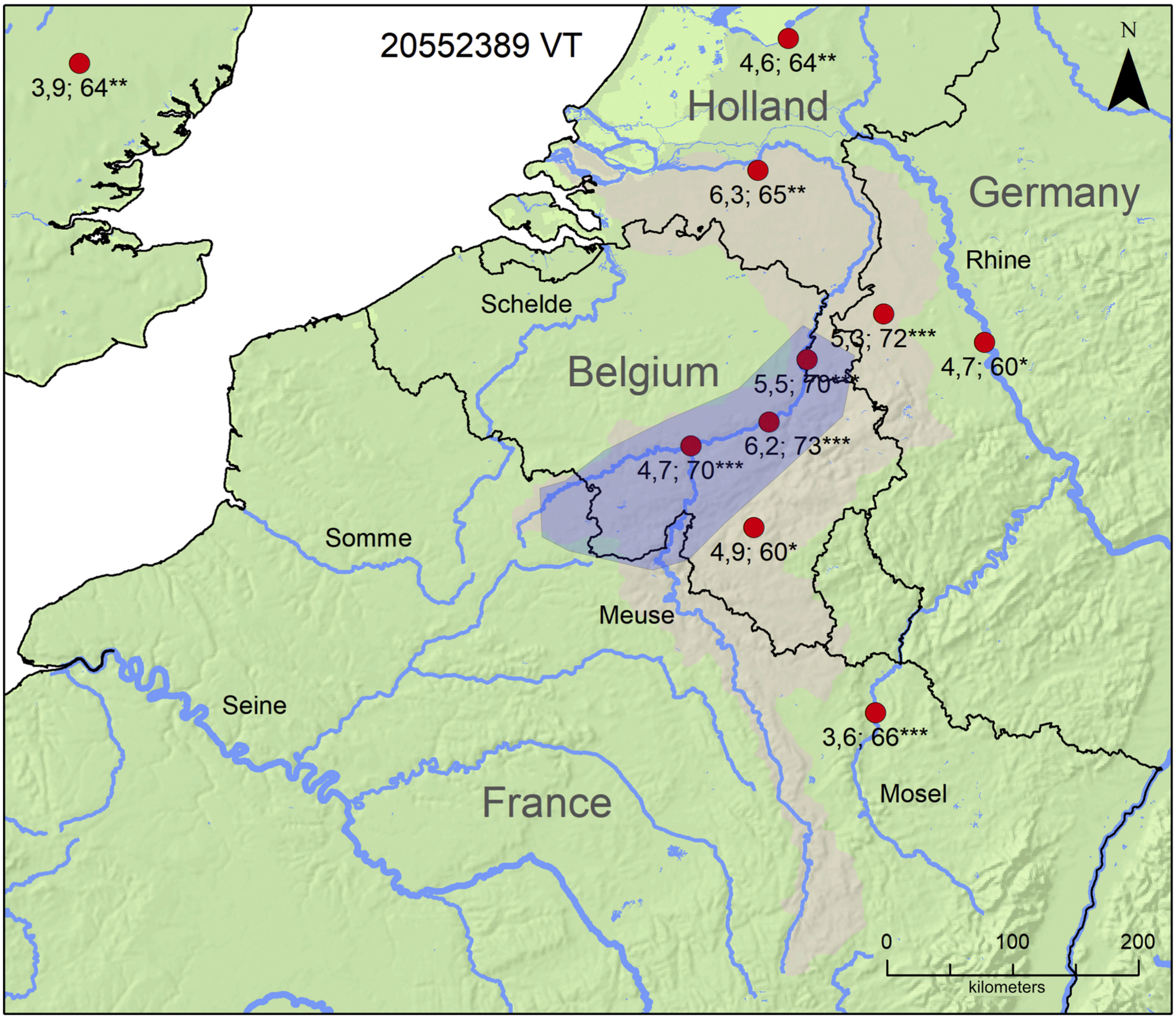

Fig. 5. Statistical matches between the 20552389 chronology with the valid time span and reference chronologies from northwestern Europe, represented by red circles followed by *t*-value and *gleichläufigkeit*. The location of the red circles represents the midpoint of the best estimate of the source area for each reference chronology. The River Meuse drainage area is represented by the beige outline. The provenance of the Gribshunden timber is in the Meuse River drainage area within the blue area in Belgium and northernmost France.

to better determine the source area of the respective reference chronology. The Namur, Hertogenbosch, and Maastricht chronologies are assumed to contain timber which grew close to the respective city. The Meuse Valley chronology potentially contains samples from a large area. However, the Meuse Valley chronology has a high similarity to the Namur chronology for the time span of 1363–1500 (Table 4), suggesting that they share several samples and therefore the Meuse Valley chronology could represent a source area close to the city of Namur (Fig. 4)

The Western Germany chronology correlates well with the Holland, Cologne, Meuse Valley, and Hertogenbosch chronologies, suggesting that the Western Germany chronology contains samples from many localities. However, the highest correlation is to the Meuse Valley chronology, especially with regards to glk, possibly indicating that the borderland to Belgium and Holland is a good provenance for the Western Germany chronology (Table 5).

The South East England chronology correlated very well with reference chronologies from the European mainland and this raised the possibility that the South East England chronology might contain timber from the European Mainland. However, the *t*-value is sensitive to the length of the overlapping chronologies (Baillie and Pilcher, 1973). When correlating only the 1300–1500 window, the correlation between the South East England and the European mainland chronologies decreases considerably indicating that the timber from the South East England chronology, at least for the time period 1300–1500, is sourced from England. Another aspect to consider when comparing chronologies is that during its construction a chronology might have been dependent on already existing chronologies that could explain some similarity.

4.3. Provenance of the Gribshunden timber

Where did the *Gribshunden* timber grow? The highest correlations were found in the northwestern part of Mainland Europe (Fig. 5). The highest correlation to the 20552389 chronology was with the Meuse Valley, followed by the Hertogenbosch, Western Germany, and South East England chronologies. The high correlation with the South East England chronology posed a problem due to the distance from England to the other reference locations. But by excluding the outermost 27 rings the correlation with the South East England chronology markedly decreased, clearly indicating that the source of the *Gribshunden* timber was not England. A similar decrease can be seen in the correlation to the Mosel valley chronology, excluding that source area as well.

An increased correlation when applying the valid time span can be seen in all the reference chronologies in the Meuse River drainage area. Matching ring-width extremes and long overlaps increases the *t*-value, whereas the glk is less sensitive to these factors. Therefore, correlations with a high *t*-value but a low glk should be used with caution when determining provenance. For instance, despite the high *t*-value the *Gribshunden* timber is unlikely to have been sourced close to the city of Hertogenbosch. Instead, the most likely source area is further upstream along the Meuse valley, where we find reference chronologies with both high *t*-value and glk. An area west and north of the Ardennes Mountains, limited by the city of Maastricht to the north and its southern limit somewhere south of the city of Namur represents the most likely source area for the *Gribshunden* timber (Fig. 5). Possibly the source area could stretch as far south as northernmost France, but the limited possibility to float timber through the Ardennes should also limit the source area.

The mean ring width of the trees stretches from 1.1–3.1 mm with an average mean ring width of 1.8 mm, excluding sample 55242 containing only 22 extremely wide rings. The mean ring widths suggest a relatively fast growth rate indicative of a more open woodland, without much competition for light and water among the trees. Comparatively, mean ring widths in the region of 1 mm or lower are indicative of a more closed forest where the competition for light and water is fiercer (Domínguez-Delmás et al., 2013). The *Gribshunden* timber can be compared with mean ring widths of other shipwrecks from the Netherlands and northwest Germany. A compilation of mean ring widths from five shipwrecks dated from the 14th to the 17th century show ring widths around 1.5–2 mm, similar to *Gribshunden*, whereas three ships show ring widths of around 2.8 mm and one ship 1.3 mm (Von Arbin and Daly, 2012; Lemée, 2006). Together the data indicate that the relatively open forest type the *Gribshunden* timber originated from was common in northwest mainland Europe, suggesting that these forests had already been thinned out by this time. Consistently, the inflow by the 14th century of southern Baltic timber into Europe, found in e.g. ships and panel paintings, further indicates the lack of local timber resources (Von Arbin and Daly, 2012).

4.4. Ship construction site and Danish procurement

Gribshunden represents the first generation of a vessel type that Iberian shipbuilders developed in the 15th century. It was an amalgamation of Mediterranean and Northern European styles, featuring a "balanced rig" combined with a carvel hull capable of carrying a heavy deck load including artillery (Adams, 2013). It is possible that King Hans recognized the advantages this ship type offered, but despite having forests of suitable timber in his realm, he did not have the requisite construction expertise in his own shipyards to build this new ship. This is supported by large sample volumes of 15th century oak from churches from the then-Danish province of Scania harbored at the National Laboratory of Wood Anatomy and Dendrochronology, suggesting that timber was readily available for ship construction within King Hans' dominion.

As a remedy, he purchased the ship from a builder in Belgium or the Netherlands. Information about the shipyard location has not been preserved through history, but with the timber provenance we can suggest the shipyard's construction locality. Assuming that the timber was floated down the River Meuse towards the Rhine-Meuse-Scheldt delta in present-day Netherlands, towns such as Rotterdam and Antwerp could be possible construction locations for *Gribshunden*.

Hans was likely the first and only owner of the ship. If the trees were felled in the winter of 1482/83, they would have been "seasoned" and allowed to dry for a year or more before construction commenced. Building and fitting-out would have taken perhaps another year, making 1485 the earliest year of delivery. Hans possessed the ship at least as early as May 1486, as evidenced by a letter he wrote while aboard the vessel (Etting et al., 2020).

5. Conclusions

Gribshunden is a remarkably well-preserved and historically significant shipwreck. Written accounts provide the date and circumstances of the sinking, providing a *terminus ante quem* for the dendrochronological analysis described here. The possibility that this new ship type was Dutch-built suggests that Hans not only sought technological advantage but had the trans-European political and economic connections to obtain the vessel. Continued excavation will reveal details of the construction. Additional elements of the ship will be the subject of future dendrochronogical studies, to trace ship usage and repair. Combined with the authors' studies now underway of wooden barrels contained in the hold, dendrochronological analysis will provide new views of the medieval economy and political connections in the late medieval period.

Declaration of Competing Interest

The authors report no declarations of interest.

Acknowledgements

This research was supported by funds from Crafood Foundation [grant number 20190008] and from the Swordspoint Foundation, USA. We acknowledge archaeologists Lars Einarsson, Johan Rönnby, and Niklas Eriksson for their research activities on the *Gribshunden* shipwreck.

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