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Dendrochronological dating of the Kalaranna wreck from Tallinn

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INTRODUCTION

In spring 2020, an unknown wreck of a ship was discovered and excavated in a real estate development in Kalaranna St. 8, Tallinn (Vitismann 2020). This is a former shallow sea area that was filled with a mixture of soil, oil shale ash and construction waste from the 20th century. The thickness of the sediments reaches three metres. The wreck was found on a flat sea floor, one hundred metres from the current coastline, laying in a N – S direction. There were neither masts nor superstructure preserved in the wreck. As these seemed to be sawn, it can be assumed that the wreck was submerged on its location in the 20th century. Nevertheless, all necessary details existed for determining the ship type: the vertical stem post, strong framing and outer planking as well as the massive keelson with a mast-step. The stern of the ship was destroyed. There were no other finds related to the wreck. The dimensions of the wreck were 19 m in length and 4.5 m in width. The structure of the wreck helped to determine the ship type (Mäss 2020). As we have extensive experience in dendrochronological dating of old wrecks (Daly 2007; Roio *et al.* 2016a–b; Roio *et al.* 2017; Roio & Läänelaid 2019; Läänelaid *et al.* 2020), the archaeologist of the excavation initiated cooperation to date this wreck. Cross-sectional samples were collected from the wreck timbers for dendrochronological analysis. After investigations, the Kalaranna wreck was removed from its place and deposited in Tallinn Bay in 12 m deep waters, with coordinates 59°34.825´ N, 24°36.970´ E.

The vertical stem-post of this ship differs greatly from the traditional curved or sloping clipper-bow of Scandinavian ships and from the sloping or straight bow of Estonian ships. This was an unusual type of a sailing ship. The mast-step in the keelson showed the location of the main mast, while the mast-step of the mizzen-mast has been destroyed in the stern of the ship. This has been a very strong ship with dense oak framing. Carvel outer planking of

oak was attached with treenails to the framing, with single iron nails between them. Inner planking was preserved in a few square metres (Fig. 1; Mäss 2020). Such a ship belongs to the two-masted ketch type, being used as a fishing vessel for herring and mackerel in the North Sea (Fig. 2). This seaworthy ship type was widely in use by the English, French, Dutch, Danish and German fishermen in the 18th – 19th centuries. The ketch was generally equipped with a fore-and-aft rig, yet for better handling a four sided lug sail, bent to a yard and slung to the mast in fore-and-aft position was often used. In such cases, the ship was referred to as lugger. In the 19th century, luggers were built in great numbers on British coasts (Underhill 1958).

Fig. 1. *Kalaranna wreck* in situ. *There is massive keelson in the centre and starboard in the foreground.*
Jn 1. *Kalaranna laevavrakk leidmiskohas. Keskel on massiivne kiilson, esiplaanil on tüürpoord.*
Photo / Foto: Rivo Bernotas

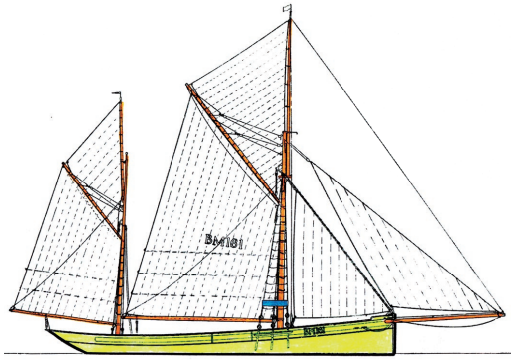

Fig. 2. *Gaff ketch, a widely used fishing ship in the North Sea in the 18th and 19th centuries.*
Jn 2. *Kahvelpurjestusega ketš, 18. ja 19. saj Põhjamerel laialdaselt kasutatud kalalaev.*
Figure / Joonis: Underhill 1958

MATERIAL AND METHODS

In March 2020, 14 sawn cross-sections of the ship timbers were brought to the dendrochronology laboratory of the University of Tartu for dating. 13 samples were taken from squared timbers, 12 from frames, one from the keelson, while one sample represented a tangential inner plank (Fig. 3).

The numbered samples were washed of mud and sand and the tree-ring widths were measured in 0.01 mm units using a stereo-microscope Leica S4E and measuring device Lintab (Rinntech). All samples are of oak (*Quercus sp.*). A stripe of sapwood was preserved in two samples. When comparing the ring width series with each other it appeared that several of them had rather low correlation. As we suspected that this was because of measurement mistakes due to poorly distinguishable narrow rings, we prepared the surface of some samples anew with razor blades and re-measured their ring series several times. The wood surface was moistened with water and treated with white chalk.

For analysing the ring-width series TSAP-Win program was used (Rinntech). Based on the similarity of the tree-ring series of the wreck, seven sample series were averaged into a

mean with a code *2eqklr02*, with length of 167 years. Synchronizing this mean with about 40 European oak chronologies Alar Läänelaid did not succeed in finding any reliable similarities. The mean series was similar neither with Estonian nor Baltic oak chronologies in any position (Läänelaid *et al*. 2001; Läänelaid *et al*. 2008; Sohar & Läänelaid 2009; Sohar *et al*. 2012). The wreck series were then sent to dendrochronologist Aoife Daly in Copenhagen, a specialist in dating wrecked ships (Daly 2007). Now, through cross-matching using Student's *t*-test (Baillie & Pilcher 1973) a group of nine samples formed a cross-matching group and an average of these nine (*2eqklr03*) was made (highlighted in blue in Table 1).

Fig. 3. *Location of the wood samples taken from the wreck, with sample numbers.*
Jn 3. *Kohad, kus vrakist võeti puiduproovid. Numbrid näitavad proovinumbreid.*
Photo / Foto: Rivo Bernotas

Table 1. *Similarity (Baillie-Pilcher t-values) between the single ring-width series of the samples. The highest values are indicated by darker background. The blue highlights the nine samples that form a group.*
Tabel 1. *Kalaranna vrakiproovide aastarõngaridade omavaheline sarnasus (Baillie-Pilcheri t-väärtus). Kõrgemad sarnasusnäitaja väärtused on tumedamal taustal. Sinise taustaga on üheksa sama grupi proovi.*
Compiled by / Koostanud: Aoife Daly

	0eqklr3d	0eqklr07	0eqklr13b	0eqkl10a	0eqklr12b	0eqklr14	0eqklr1d	0eqklr08	0eqklr2b	0eqklr4b	0eqklr9c	0eqklr5c
0eqklr3d	*	1.12	-	0.66	0.8	0.30	-	0.42	-	-	1.20	1.82
0eqklr07	1.12	*	1.28	1.8	0.48	1.96	1.07	\	\	\	0.93	2.6
0eqklr13b	-	1.28	*	2.22	0.29	0.11	0.27	-	1.11	0.2	0.96	2.84
0eqkl10a	0.66	1.8	2.22	*	5.99	3.1	5.38	5.38	3.15	4.23	2.93	1.61
0eqklr12b	0.8	0.48	0.29	5.99	*	3.32	7.3	4.68	3.68	3.85	1.24	2.24
0eqklr14	0.30	1.96	0.11	3.1	3.32	*	7.43	\	\	\	3.78	2.86
0eqklr1d	-	1.07	0.27	5.38	7.3	7.43	*	4.46	5.54	4.87	2.49	4.2
0eqklr08	0.42	\	-	5.38	4.68	\	4.46	*	6.3	6.81	4.72	0.10
0eqklr2b	-	\	1.11	3.15	3.68	\	5.54	6.3	*	6.87	2.48	1.78
0eqklr4b	-	\	0.2	4.23	3.85	\	4.87	6.81	6.87	*	4.61	0.96
0eqklr9c	1.20	0.93	0.96	2.93	1.24	3.78	2.49	4.72	2.48	4.61	*	-
0eqklr5c	1.82	2.6	2.84	1.61	2.24	2.86	4.2	0.10	1.78	0.96	-	*

RESULTS

Aoife Daly found that the mean series *2eqklr03* was reliably similar to several oak chronologies from northern Germany in the position, where the last ring of the group series corresponds to AD 1826 (Table 2). Apart from this mean, it was possible to date three other series independently.

Table 2. *Similarity (Baillie-Pilcher t-values) of the average ring-width series of the Kalaranna wreck 2eqklr03 (9 sample series) with European oak chronologies, in the position AD 1660–1826. The grey tones highlight higher correlation values.*

Tabel 2. *Kalaranna vraki keskmise aastarõngarea 2eqklr03 (9 proovirea keskmine) sarnasus (Baillie-Pilcheri t-väärtus) Euroopa tammekronoloogiatega positsioonis AD 1660–1826. Kõrgemad sarnasusnäitaja väärtused on tumedamal taustal.*

Compiled by / Koostanud: Aoife Daly

Filenames	-	-	2eqklr03	
-	start	dates	AD1660	
-	dates	end	AD1826	
E_German	AD1343	AD1968	7.63	East Germany Climate project sites 339 timbers (Daly unpubl)
DM200006	AD914	AD1873	7.01	Lüneburger Heide (Göttingen Uni)
DM200005	AD915	AD1873	6.86	Niedersachsen Nord (Göttingen Uni)
POL_DSLA	AD1319	AD1994	6.68	SW Poland Dolny Slask (M Krapiec pers comm)
GO12IZ02	AD1644	AD1823	6.59	Schwerin 6 timbers (Göttingen Uni revised Daly 2007)
G360AZ01	AD1644	AD1810	6.46	Neustadt 5 timbers (Göttingen Uni revised Daly 2007)
G341DZ02	AD1654	AD1785	6.20	Braunschweig 3 timbers (Göttingen Uni revised Daly 2007)
G330FZ02	AD1689	AD1826	5.97	Stadthagen 5 timbers (Göttingen Uni revised Daly 2007)
FIN.itrdb.001	AD1590	AD1984	5.74	Ilomanti Sivakkovaara (Matti Eronen ITRDB)
G342ZZ01	AD1643	AD1890	5.57	Gadenstedt 5 timbers (Göttingen Uni revised Daly 2007)
G3532Z01	AD1656	AD1815	5.57	Linden 2 timbers (Göttingen Uni revised Daly 2007)
GOC01Z01	AD1684	AD1835	5.57	Nordhausen 10 timbers (Göttingen Uni revised Daly 2007)
G341AZ03	AD1694	AD1828	5.56	Wolfenbüttel 6 timbers (Göttingen Uni revised Daly 2007)
G340KZ01	AD1655	AD1809	5.51	Wolfenbüttel 7 timbers (Göttingen Uni revised Daly 2007)
G340BZ01	AD1655	AD1763	5.44	Neustadt am Rübenberge 4 timbers (Göttingen Uni revised Daly 2007)
GO605Z01	AD1660	AD1968	5.40	Colbitz 5 timbers (Göttingen Uni revised Daly 2007)
G3525Z01	AD1599	AD1774	5.37	Suderburg 4 timbers (Göttingen Uni revised Daly 2007)
G3608Z01	AD1704	AD1809	5.36	Schinna 2 timbers (Göttingen Uni revised Daly 2007)
DM200001	AD1082	AD1972	5.33	Nieders. Kuestenraum (Göttingen Uni)
JemGrp05	AD1684	AD1901	5.29	London Westminster 107 Jermyn Street (C Tyers pers comm)
FMP0004A	AD1375	AD1984	5.23	Finland North Karelia (Zetterberg pers comm)
G360DZ03	AD1711	AD1832	5.08	Isernhagen 6 timbers (Göttingen Uni revised Daly 2007)
G340NZ01	AD1716	AD1873	5.05	Braunschweig 4 timbers (Göttingen Uni revised Daly 2007)
germ6	AD1376	AD1972	5.04	Oldenburg 138 timber (Eckstein ITRDB)
G330BZ03	AD1588	AD1811	5.02	Melle 18 timbers (Göttingen Uni revised Daly 2007)
G3510Z01	AD1701	AD1839	5.01	Lüneburg 6 timbers (Göttingen Uni revised Daly 2007)
G390AZ01	AD1568	AD1783	4.99	Quakenbrück 13 timbers (Göttingen Uni revised Daly 2007)
G3122Z01	AD1421	AD1817	4.93	Göttingen 17 timbers (Göttingen Uni revised Daly 2007)
G3172Z01	AD1631	AD1856	4.91	Jühnde 16 timbers (Göttingen Uni revised Daly 2007)
DM200004	30BC	AD1960	4.87	G Weser (Göttingen Uni)
PP143M01	AD1667	AD1763	4.84	PL Pomorska 9 timbers (Wazny pers comm revised Daly 2007)
H11IKM01	AD1652	AD1719	4.79	HL-Marlesgrube 42 3 timbers (Hamburg Uni revised Daly 2007)
H115KM01	AD1733	AD1786	4.78	Lauenbg. Hohler Weg 2 timbers (Hamburg Uni revised Daly 2007)

The chronological position of the dated ring-width series of the Kalaranna wreck is shown in Fig. 4. The outermost preserved tree-ring from the wreck was formed in AD 1844 (sample no 13). This is one of the three dated samples that does not belong with the main group. Dendrochronological dating of the outermost preserved ring in the main group of nine samples (coloured blue in Fig. 4), *2eqklr03*, is AD 1826. None of the nine samples in the group have sapwood preserved. Taking into account the missing sapwood rings, the oaks of the main group for the Kalaranna ship were probably cut after AD 1836 (See Discussion below). The separately dated samples with a portion of preserved sapwood reveal their cutting time in AD 1841–1852 (sample no 3) and AD 1852–1867 (sample no 13), while the oak of sample no 7 was cut probably after AD 1847. The overlap of all these dates is in AD 1852.

The dendrochronological dates of the wreck samples thus show that the main group of oaks used for building the Kalaranna ship were felled after AD 1836 and the other oaks were most probably felled around AD 1852.

The greatest similarity of the ring-width series of the Kalaranna wreck with a number of oak chronologies from northern Germany implies that the building timber for this ship originates from that region. As high similarity is revealed with several chronologies, it is not possible to specify the region in northern Germany, but we might suggest the source is the region around the south-west Baltic Sea. Two native oak species grow in this region, pedunculate oak (*Quercus robur*) and sessile oak (*Q. petraea*). Wood of these two oak species is indistinguishable from each other anatomically, therefore the ship can have been made of both of these.

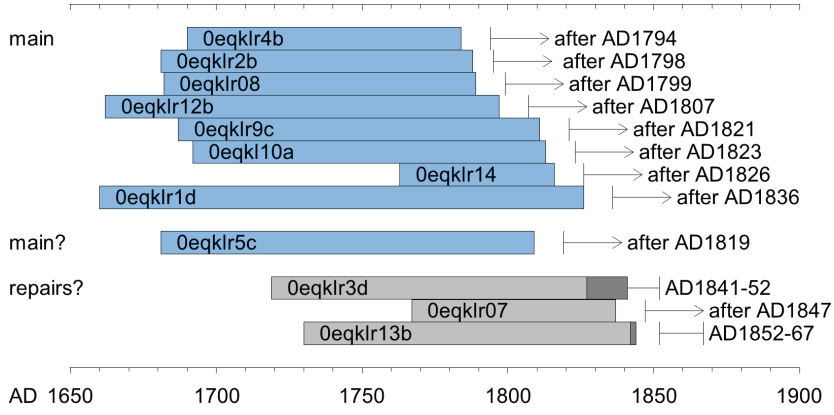

Fig. 4. *Chronological span of the dated ring-width series (with sample codes indicated in the bars) of Kalaranna wreck and the probable cutting time of the oaks. The blue bars correspond to the correlating group of nine samples 2eqklr03. The darker colour denotes sapwood. Calendar years are shown on the scale.*

Jn 4. *Kalaranna vraki dateeritud puiduproovide (identifitseerimiskoodid lintidel) aastarõngaridade ajaline paiknemine ja puude tõenäolised raiumisajad. Sinised lindid tähistavad üheksat omavahel korreleeruvat proovirida keskmises 2eqklr03. Tumedam värvus märgib maltspuitu. Rõhtteljel on kalendriaastad.*

Compiled by / Koostanud: Aoife Daly

DISCUSSION

The dendrochronological date of the Kalaranna wreck was found from an average of 9 single samples' tree-ring series, *3epklr03* (outermost ring 1826). As there was no sapwood preserved in these samples, the actual waney edge of these samples might be at least ca. 10 sapwood rings later, in this case after 1836 (*terminus post quem*). To estimate the felling dates of the oak trees a sapwood average of ca. 10–25 sapwood rings was used. Several calculations of the average sapwood in oaks in different regions in Northern Europe have been published, and as the provenance of the oak for the Kalaranna ship points towards northeast Germany, we have here chosen to use a combination of the estimate for northern Germany (ca. 20 sapwood years (-5 +10) (Hollstein 1980)) and for northern Poland (15 years (-6 +9) (Ważny 1990)).

Fig. 5. *Sample no 3 with 14 sapwood rings in the top right corner.*
Jn 5. *Proov nr 3 maltspuidu 14 aastarõngaga ülal paremal nurgas.*
Photo / Foto: Alar Läänelaid

In addition, the ring-width series of three samples, nos 3, 7 and 13, do not strongly cross-match the main group (Table 1). Nevertheless, the outermost rings on these samples were dated to 1841, 1837 and 1844 respectively. When we look at the location of these three samples in the wreck we see that no 3 represents a frame in the stern part of the wreck, no 7 is a frame in the middle of the wreck and no 13 has been taken from the keelson in the fore part of the ship, just afore of the mast step. While repairs of ships were common, it seems unlikely that the two framing timbers placed so far apart from each other represent repairs. Taking into account the partially preserved sapwood in sample no 3 (Fig. 5) and adding the probable missing sapwood rings gives dates AD 1841–1852. In the case of the tree-ring series of the 9 sample group, all with only heartwood preserved, we actually do not know how many annual rings are missing from the waney edge. In other words, the waney edge of these timbers can also have been within the dates AD 1841–1852.

Sample no 13, from the keelson, stands a little apart. The two frames (samples nos 3 and 7) show weak similarity with chronologies from northern Germany, but the keelson sample is achieving the highest correlations with eastern Danish datasets (Zealand and Funen islands). So this timber is from an oak that might have grown in a different location than the others used in the ship. It is possible that this timber is a later repair or addition to the ship structure. Allowing for missing sapwood the estimated felling of this tree can be placed at AD 1852–1867.

From this consideration it seems likely that the ship was built within the period AD 1841–1852 and repairs to the keelson took place AD 1852–1867, with a timber of a slightly different provenance to the others.

The broken stern of the ship refers to a shipwreck in these complicated navigation circumstances. We can assume that the old ship was sold to local sea people for dismantling and after removing all valuable items (including masts and rigging) the wreck was abandoned at Kalaranna beach. It is possible that the fate of this ship was recorded in the Clayhills freight office in Tallinn, however, finding the data requires further investigation.

CONCLUSIONS

The Kalaranna wreck found in Tallinn represents a two-masted ketch, a typical fishing vessel used in the North Sea region around the 18th–19th centuries. The results of the dendrochronological investigation show that it was made of oak wood felled around 1841–1852, and thus was probably built in the middle of the 19th century. The oaks for making this ship had been growing in northern Germany. An additional timber from a different source, used to repair the keelson, was felled slightly later, AD 1852–1867.

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KALARANNA VRAKI DENDROKRONOLOOGILINE DATEERIMINE

Alar Läänelaid, Aoife Daly, Rivo Bernotas ja Vello Mäss

2020. a kevadel leiti Tallinnas Kalaranna tn 8 kinnisvara arendusel kaevandist kolme meetri sügavuselt laevavrakk. Piirkond on endine madal mereala, mida täideti 20. sajandil pinnase, põlevkivituha ja ehitusprahi seguga. Umbes põhja–lõuna sihis paiknev vrakk lebas tasasel merepõhjal praegusest kaldajoonest sada meetrit kaugemal. Laevast oli säilinud suurem osa tugevat kaarestikku ja välisplangutust ning osa siseplangutusest, laeva ahter on hävinud. Siiski sai säilinud osade järgi teha kindlaks laevatüübi ja mastide arvu – laevajäänused kuulusid lüüger-tüüpi kahemastilisele Põhjamere kalalaevale. Vraki pikkus oli 19 m ja laius 4,5 m. Muid leide vraki juurest ei avastatud.

Vraki dendrokronoloogiliseks dateerimiseks saeti vrakipuidust 14 proovi: 12 proovi kaartest, üks kiilsonist ja üks siseplangust. Nummerdatud puiduproovid puhastati mudast ja liivast ning nende ristlõikepinnal siluti pikem raadius aastarõngalaiuste mõõtmiseks. Aastarõngaste laiused mõõdeti 0,01 mm täpsusega stereomikroskoobi Leica S4E ja mõõtmisaparaadi Lintab abil (Rinntech). Kitsaste aastarõngaste halva eristatavuse tõttu mõõdeti mitme proovi aastarõngad mitu korda. Kõik proovid osutusid tammepuiduks. Kahes proovis oli säilinud maltspuitu.

Vraki aastarõngalaiuste ridu analüüsiti programmis TSAPWin (Rinntech). Kuna Eestis kättesaadavate tamme referentskronoloogiatega sarnasust ei tuvastatud, saadeti aastarõngaste read vrakke uurivale dendrokronoloogile Aoife Dalyle Kopenhaagenisse. A. Daly dateeris Kalaranna vraki aastarõngalaiuste rea (välja arvatud kiilsoni) aastaga 1826 (see on hiliseima säilinud aastarõnga moodustumise kalendriaasta). Kalaranna vraki aastarõngalaiuste read osutusid kõige sarnasemaks mitme Põhja-Saksamaa tammekronoloogiaga. Erandiks oli kiilson, mille aastarõngarida oli sarnasem Taani idaosa tammekronoloogiaga. Kuna tüve koorealust puidupinda vrakiproovidel ei ole säilinud, siis sai täpsemaks dateerimiseks oluliseks maltspuiduriba kahe proovi välispinnal. Maltspuidu aastarõngaste arvu järgi saab järeldada, et vrakipuitudeks tarvitatud tammed olid raiutud pärast 1836. aastat. Võimalik, et kiilsoni proov kujutab endast hilisemat, laeva paranduseks kasutatud teise päritoluga tammepuitu. Kokkuvõttes saame dendrokronoloogilise uuringu tulemuste põhjal järeldada, et uuritud Kalaranna laev ehitati tõenäoliselt ajavahemikus 1841–1852 ning kiilsoni remont tehti veidi hiljem, ajavahemikus 1852–1867.

Laevavraki ülevaatus leiukohas annab alust oletada, et meresõidul tugevalt kahjustatud laev müüdi kohalikule mererahvale, kes realiseeris kõik väärtusliku, kaasa arvatud mastid ja taglase, ning jättis vraki Kalaranda maha. Kaldatäitest avastatud vrakk uputati pärast dendrokronoloogiliste proovide võtmist ja fotografeerimist Tallinna lahte.