

Wood identification

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Identifikacija drva

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Tijekom dviju istraživačkih kampanja, u 2011. i u 2013., na olupini je prikupljeno ukupno 28 uzoraka drva. Oni su analizirani radi identifikacije vrste drva koje je bilo upotrijebljeno za izradu različitih dijelova brodske konstrukcije.

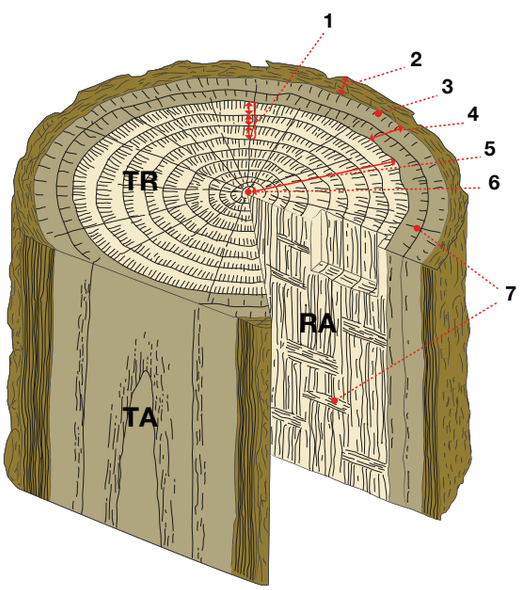
A total of 28 wood samples were taken from the Zambratija wreck during the two excavation seasons in 2011 and 2013. The samples have been analysed to identify the wood species used for different parts of the boat's structure.

Metode

Tanki uzorci tri različita usmjerenja (poprečni, uzdužni i radijalni) (Sl. III.4) izrezani su ručno, žiletom, i to svaki uzorak pojedinačno, te su montirani na stakalce. Za identifikaciju uzoraka korišten je mikroskop i anatomski atlas drva (Sl. III.5)[1] (Jacquiot 1955; Jacquiot *et al.* 1973; Schweingruber 1978, 1990.).

Methods

Thin sections in three planes (transverse, tangential, and radial) (Fig. III.4) were cut by hand with a razor blade for each of the samples and then mounted on slides. A microscope and an atlas of wood anatomy were used for their identifications (Fig. III.5)[1] (Jacquiot 1955; Jacquiot *et al.* 1973; Schweingruber 1978, 1990).



1. Godovi / Rings
2. Kora / Bark
3. Kambij / Cambium
4. Meko drvo / Sapwood
5. Tvrdo drvo / Earthwood
6. Srčika / Pith
7. Sržne trake / Rays

III.4
Referentni smjerovi i presjeci drva: poprečni presjeci (TR), radijalni presjeci (RA) i uzdužni presjeci (TA)
Wood grain direction and reference planes: transversal (TR), radial (RA), and tangential (TA)
(izradio / made by: P. Poveda after Kaennel, Schweingruber 1995, 463)

1 Pri radu su korišteni optički mikroskopi Olympus BH-2 (40x i 1000x) i Olympus CX41 (40x i 1000x), zajedno s digitalnim fotoaparatom Olympus PEN Lite E-PL3.

1 Optical microscopes Olympus BH-2 (40x and 1000x) and Olympus CX41 (40x and 1000x) were used, coupled with an Olympus PEN Lite E-PL3 digital camera.



III.5
Anatomska identifikacija drva mikroskopskim ispitivanjem
Microscopic examination of wood samples for anatomical identification

Rezultati

Analiza uzoraka drva otkrila je uporabu pet taksonomskih vrsta (Sl. III.6): brijest (*Ulmus* sp.) (Sl. III.7), joha (*Alnus* sp.) (Sl. III.8), divlja kruška (*Pyrus communis* L.) (Sl. III.9), topola (*Populus* sp.) (Sl. III.10) i jela (*Abies alba*) (Sl. III.11).

Sve platice (osam vojeva) izrađene su od brijesta. Brijest je također identificiran kod dva odvojena ulomka platica (PRL11 i PRL19) koji su pronađeni izvan brodske cjeline. Od tri sačuvane rebrenice, dvije (R1 i R3) su napravljene od johe, a jedna (R2) od drva divlje kruške. Osam analiziranih malih drvenih čavala koji su zaptivali rupe za šavove izrađeno je od dvije vrste drva: topole i johe. Šest analiziranih letvica položenih preko sljubnica platica izrađeno je od drva jele (Sl. III.12).

Rasprava

Upotreba drva za izradu brodske konstrukcije ukazuje na homogenost pri odabiru vrste za oplatu, dok odabir drva za rebra pokazuje određenu heterogenost (Sl. III.12, III.13). Homogenost ukazuje na važnost oplate pri izgradnji broda napravljenog po principu «prvo ljuska» (Pomey, Rieth 2005, 30-31).

Među upotrijebljenim vrstama nalaze se vrste drva

Results

The wood analysis revealed the use of five taxa (Fig. III.6): elm (*Ulmus* sp.) (Fig. III.7), alder (*Alnus* sp.) (Fig. III.8), wild pear (*Pyrus communis* L.) (Fig. III.9), poplar (*Populus* sp.) (Fig. III.10) and fir (*Abies alba*) (Fig. III.11).

All of the planks (eight strakes) were made of elm. Elm was also identified for the two disarticulated plank fragments (PRL11 and PRL19) found beside the wreck. Of the three preserved floor-timbers, two (R1 and R3) were made of alder and one (R2) of wild pear wood. The eight pegs used to lock the stitches in place that were analysed were cut from two wood species: poplar and alder. Fir was identified for the six lath samples placed over the plank seams and held in place by the sewing (Fig. III.12).

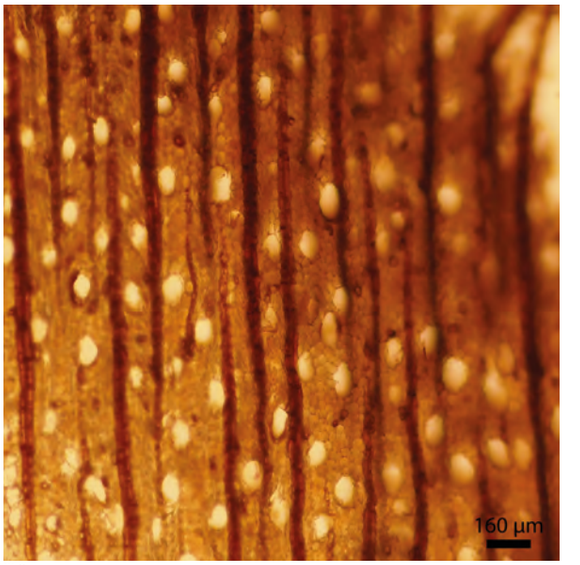
Discussion

The planking of the Zambratija boat was very homogenous while the framing is more varied (Figs III.12, III.13). This homogeneity illustrates the importance of the planking in 'shell-first' ship construction (Pomey, Rieth 2005, 30-31).

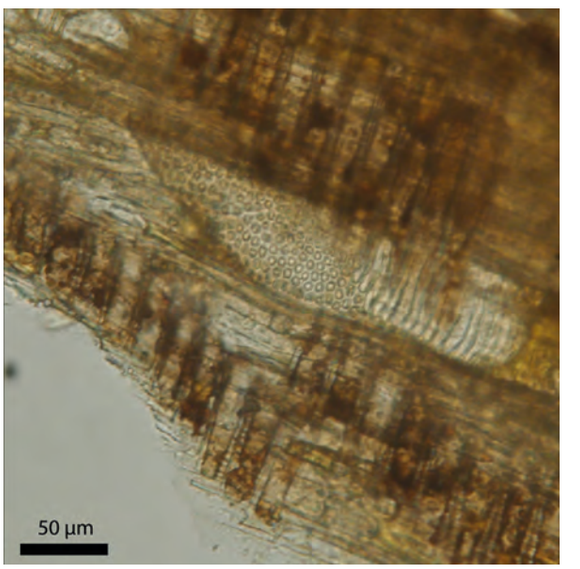
The wood used includes high-quality species such as elm (Giordano 1980, 184; Venet, Keller 1986, 141;

crnogorično drvo resinous tree	bjelogorično drvo deciduous tree
Abies sp.	*Ulmus* sp.
	Alnus sp.
	Pyrus communis L.
	Populus L.

III.6
Vrste drva identificirane na olupini Zambratija
Wood species identified on the Zambratija wreck



III.9



III.10

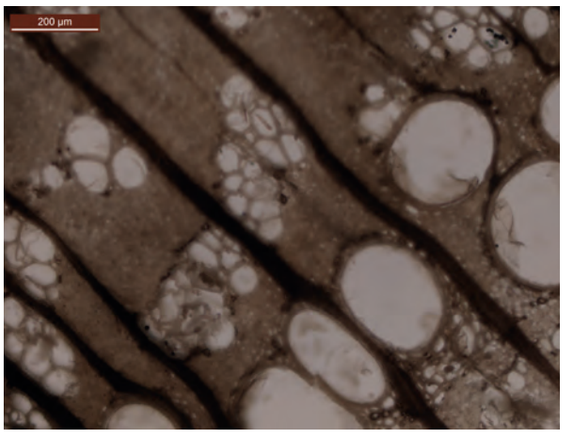
III.7
Poprečni presjek brijesta (*Ulmus* sp.) uzorka P3
Transverse section of elm (*Ulmus* sp.) from sample P3
(fotografija / photo by: C. Cenzon-Salvayre)

III.8
Poprečni presjek johe (*Alnus* sp.) uzorka R1-PRL16
Transverse section of alder (*Alnus* sp.) from sample R1-PRL16
(fotografija / photo by: A. Ferreira Dominguez)

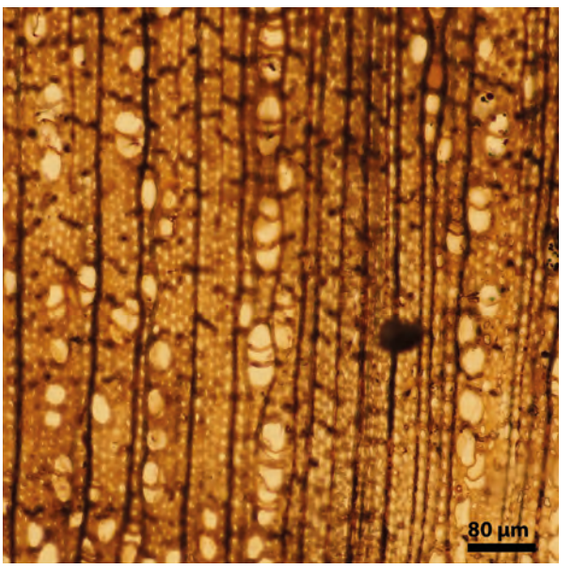
III.9
Poprečni presjek divlje kruške (*Pyrus communis* L.) uzorka R2-PRL17
Transverse section of wild pear (*Pyrus communis* L.) from sample R2-PRL17
(fotografija / photo by: A. Ferreira Dominguez)

III.10
Radijalni presjek topole (*Populus* sp.) uzorka PRL14
Radial section of poplar (*Populus* sp.) from sample PRL14
(fotografija / photo by: A. Ferreira Dominguez)

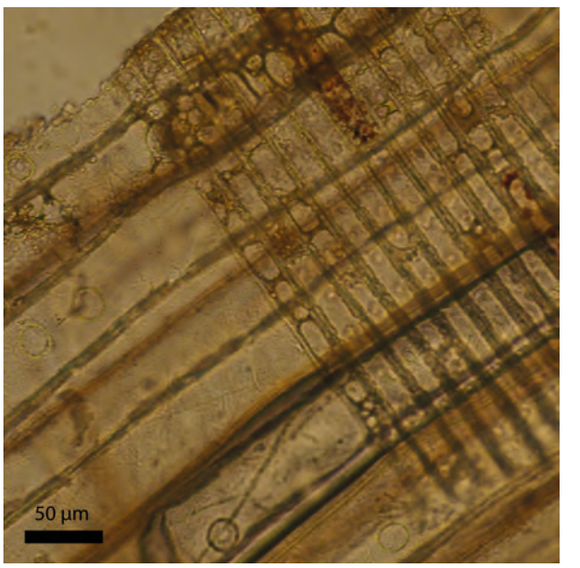
III.11
Radijalni presjek jele (*Abies* sp.) uzorka PRL9
Radial section of fir (*Abies* sp.) from sample PRL9
(fotografija / photo by: A. Ferreira Dominguez



III.7



III.8



III.11

visoke kvalitete, poput brijesta (Giordano 1980, 184; Venet, Keller 1986, 141; Rival 1991, 62), te vrste koje su poznate po dobroj izdržljivosti u vlažnoj sredini, kao što je joha (Giordano 1980, 184-185; Venet, Keller 1986, 127; Rival 1991, 70-71). Obično se za izgradnju oplate upotrebljavaju crnogorične vrste koje zbog svoje elastičnosti omogućavaju savitljivost potrebnu prilikom oblikovanja u skladu s postupcima gradnje «prvo ljuska».

Izgleda da je izbor brijesta možda, pored lokalne dostupnosti, povezan i s potrebom za deblima velikog promjera, osobito za izradu kobiličnog elementa.

Upotreba brijesta (koji ima izrazito gusta, debela i međusobno isprepletena vlakna) za izgradnju oplate plovila, nije bila česta na zapadnom Mediteranu[2]. Međutim, na Jadranu se brijest gotovo sustavno upotrebljavao za izgradnju šivanih brodova. Ostaci broda Pula 1, pronađeni u antičkoj luci Pule i datirani u vrijeme 2. - 3. stoljeća, jasan su primjer navedenoga (Boetto *et al.* 2014; 2017)[3].

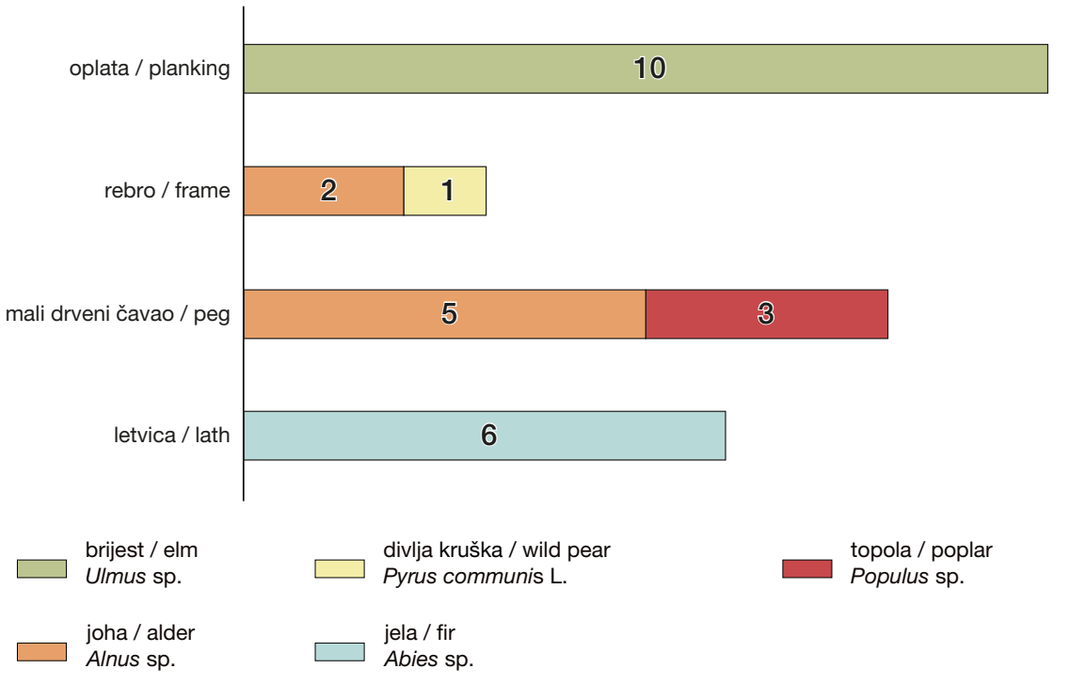
Nasuprot tomu, upotreba kruške, tvrdog drva vrlo uskih godova, koje je osobito traženo u stolarstvu (Rameau *et al.* 1989, 553), mnogo je rjeđa u brodogradnji.

Rival 1991, 62), and those reputed for their resistance in wet conditions such as alder (Giordano 1980, 184-185; Venet, Keller 1986, 127; Rival 1991, 70-71). Commonly the resinous species are more often used for boat planking, because their elasticity provides the flexibility necessary to shape the planks in the 'shell-first' construction process.

It is likely that the choice of a deciduous species is based not only on local availability, but also the need for trunks with a relatively wide diameter, particularly for the sculpted keel-like timber used for this vessel.

The use of elm, which has extremely dense, thick and interwoven fibres, is not very widely used for planking of vessels in the Western Mediterranean[2]. In the Adriatic, however, this species was used almost systematically for the construction of sewn-plank boats. The Pula 1 wreck, found in the ancient port of Pula and dated to the 2nd-3rd century, is another fine example (Boetto *et al.* 2014, 2017)[3].

Pear, a hard wood with a very fine grain that is highly prized for cabinet making (Rameau *et al.,* 1989, 553), is much more rarely seen in boat construction.



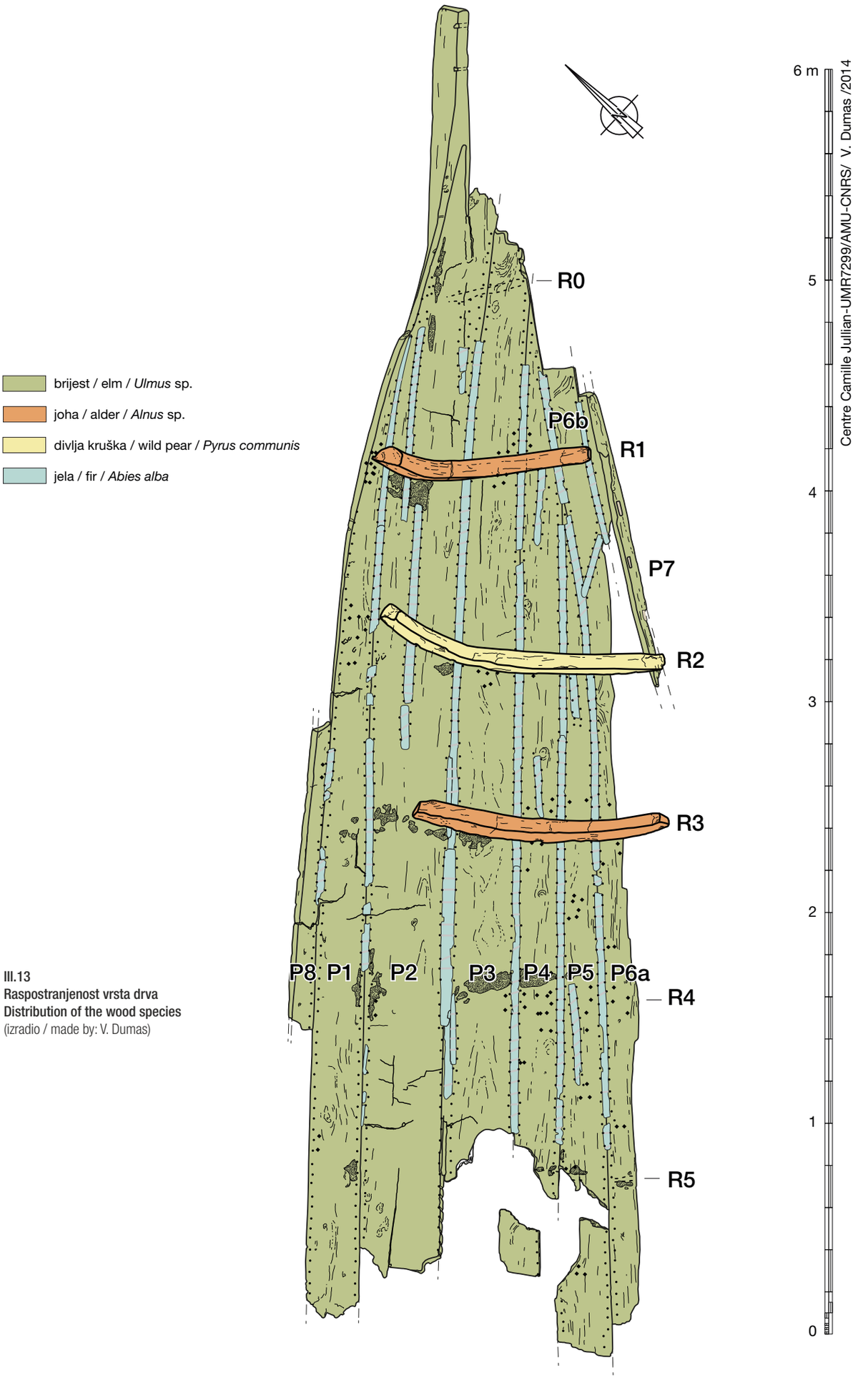
III.12
Dijagram koji pokazuje relativnu prisutnost vrsta drva identificiranih na ostacima olupine Zambratija s obzirom na različite brodograđevne dijelove
Diagram showing the relative frequency of the wood species identified in the Zambratija wreck remains by structural element

2 Primjer je brod Madrague de Giens (Hyères, Francuska, 70-65 god. pr. Kr., Guibal, Pomey 1998, 433).

3 Brijest je upotrijebljen za izradu oplate 11 brodova na sjevernom Jadranu: Cavanella d'Adige (Motta di Cavanella d'Adige, Rovigo, 2.-1. st. pr. Kr., Tiboni, 2009, 2017), Comacchio (Ferrara, 1. st. pr. Kr., Castelletti et al. 1990, 150); Stella 1 (1. st., Palazzolo dello Stella, Udine, Castro, Capulli, 2016, 32); Aquileia 1 i 2 (uglavnom 1. st. i 2. - 3. st, Canale Anfora, Akvileja, Beltrame, Gaddi 2013, 298 i 301); Lido di Venezia 1 i 2 (1. - 2. st., Venice Lido, Beltrame 2002a, 356 i 368); Padova (2. st., Padua, Beltrame 2002a, 366); San Francesco del Deserto (rimski, Venecijanski zaljev, Capulli, Pellegrini 2010, 265); Santa Maria in Padovetere (Comacchio, Ferrara, 5. st., Beltrame, Costa 2016) i Cervia (7. st., Ravenna, Beltrame 2002a, 359).

2 For example the Madrague de Giens wreck (Hyères, France, 70-65 BCE, Guibal, Pomey 1998, 433).

3 Elm is also used for the planking of 11 other North Adriatic wrecks: Cavanella d'Adige (Motta di Cavanella d'Adige, Rovigo, 2nd-1st century BCE, Tiboni 2009, 2017), Comacchio (Ferrara, 1st century BCE, Castelletti *et al.* 1990, 150), Stella 1 (1st century CE, Palazzolo dello Stella, Udine, Castro, Capulli 2016, 32), Aquileia 1 and 2 (respectively 1st and 2nd-3rd century CE, Canale Anfora, Aquileia, Beltrame, Gaddi 2013, 298 and 301), Lido di Venezia 1 and 2 (1st-2nd century CE, Venice Lido, Beltrame 2002a, 356 and 368), Padova (2nd century CE, Padua, Beltrame 2002a, 366), San Francesco del Deserto (Roman, Venice lagoon, Capulli, Pellegrini 2010, 265), Santa Maria in Padovetere (Comacchio, Ferrara, 5th century CE, Beltrame, Costa 2016), and Cervia (7th century CE, Ravenna, Beltrame 2002a, 359).



III.13
Raspostranjenost vrsta drva
Distribution of the wood species
(izradio / made by: V. Dumas)

Trenutno je kruška identificirana jedino na rebru brodske konstrukcije Baie de l'Amitié (Francuska, druga polovina 1. st., Wicha 2002; Wicha *et al.* 2003, 235; Wicha, Girard 2006, 114).

Naposljetku, drvo johe i topole je zbog svoje elastičnosti odabrano za izradu malih drvenih čavala kojima su zaptivane rupe za šavove (Rameau *et al.* 1989, 441 i 807). Jela je, pak, sigurno odabrana zbog mogućnosti rasijecanja pri izradi tankih letvica (Rival 1991, 40-41).

Da zaključimo, dobiveni rezultati ukazuju na uporabu vrsta dostupnih u blizini obale, u okolišu bogatom vodom, koji karakteriziraju močvare i obalne lagune. Samo je jelu, planinsku vrstu, trebalo tražiti u šumama udaljenijim od obale. Još i danas, sve vrste drva potvrđene na brodu Zambratija rastu u obalnom dijelu Istre, osim jele koja je prisutna na manje od 60 km od obale (Baćić 2005).

At present is has been identified only as a frame in the Baie de l'Amitié wreck (France, second half of the 1st century CE, Wicha 2002; Wicha *et al.* 2003, 235; Wicha, Girard 2006, 114).

Finally, alder and poplar may have been chosen for the pegs used to lock the stitches in place for their flexibility (Rameau *et al.*, 1989, 441 and 807), while fir could have been selected because it is easily split into thin laths (Rival 1991, 40-41).

In conclusion, the results of this analysis reflect the use of wood that was locally available near to the coast, in a rich freshwater environment characterized by marsh and coastal lagoons. Only fir, a mountain species, would have grown in forests at higher altitudes at some distance from the coast. Today, all the species used for the Zambratija boat can be found along the Istrian coast, except fir which can be found less than 60 km inland (Baćić 2005).