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Dendrology and dendrochronology of ancient shipwrecks from Caska (island of Pag, Croatia): New data for the definition of Adriatic shipbuilding traditions

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The island of Pag is one of the five largest Croatian islands, located in the region of Northern Dalmatia. Caska is a small bay at the north-eastern end of the Gulf of Pag, with traces of Roman presence both on the coast and in the shallow water of the bay. An overview of the site, the history of the research, and the principal archaeological evidence discovered to date was recently published in the proceedings of the fourteenth ISBSA conference held in Gdansk, so we will not address that issue.

Systematic underwater research began at Caska in 2005. In 2009 the excavation evolved into an international interdisciplinary project, called *Cissa Antiqua*, which focused on the systematic study of the ancient coastal cultural and natural landscape. This project is under the direction of Irena Radić Rossi of the University of Zadar, in collaboration with Giulia Boetto of the Aix Marseille University and the Centre Camille Jullian.

The research in the bay of Caska provided evidence of intense building activities which occurred during the first centuries AD. Remarkable is the reuse of old ships in the form of caissons, filled with rocks, and deliberately sunk in order to reinforce the coastal structures. The remains of three sewn boats (*Caska 1, 3 and 4*) and one mortise and tenon constructed ship (*Caska 2*) were excavated and studied between 2009 and 2017. Actually, wood analyses are still in progress. The ship structures were systematically sampled and analysed to identify the wood species and to determine the trunk size of the tree sources. As no ceramics were found in association with the

remains, dendrochronological dating and AMS mass spectrometry were carried out to attempt to date the ship construction.

Caska 1 is a coastal craft of about 10 m, probably propelled by oar and sail. Sewing was used only for the planking seams, while the frames were treenailed to the planking. The bases of the frames were crenelated to avoid damage to the sewn-plank seams.

Caska 2 is a sailing ship characterized by a tenon-and-mortise assembly technique for planking. The frames are treenailed to the planks.

Caska 3 is part of a large number of wooden planks and other elements of ships found inside the shipwreck *Caska 2*. The sewing is similar to that of *Caska 1* and, although the frames were not preserved, treenails were used to attach the frames to the planking.

Lastly, *Caska 4* is another similar coastal craft. Sewing was used for the planking seams, while these frames were lashed to the planking. As in *Caska 1*, the bases of the frames were crenelated to avoid damage to the sewn-plank seams.

Wood analyses show that the construction of the three sewn boats is particularly homogeneous. Planking is made of beech and two species of oaks were chosen for the keel and frame. The assemblages are made of between two and five different tree species.

The keels were made from trunks hewn in cross cut. Regarding the planking, radial splitting is systematically attested, and this same characteristic was also observed in one of the sewn boats discovered in Pula. When cut, the beech trunks were up to 169 years old and had a diameter of around 50 cm. In *Caska 4*, young oak branches or coppice were used for the frames.

The planking of *Caska 2* was built using four different pine species. Oaks and pines were chosen for the keel, the frame and the keelson. Two other hardwood species (holm oak and ash) were also employed in the assemblages. Several softwood and hardwood species were identified in the large number of discarded pieces found inside *Caska 2*. However, 137 planks, characterised by similar dimensions and the absence of assemblages, were made exclusively of fir.

A total of 18 species have been identified: 11 hardwood species and seven conifer species. All of them are commonly attested in other Mediterranean ancient ships. However, the sewn boats of *Caska* and the one discovered in Pula show the particularity of an outer shell entirely built with beech wood, despite its bad resistance to humid conditions. It is probable that other arguments rather than wood quality played a role in the selection of this wood. One hypothesis is that, in Antiquity in northern Dalmatia, beech forests were larger than today, and located closer to the coast, facilitating the supply of the shipyards. Beech is also a species particularly convenient for splitting and perhaps obtaining planks with mechanically adapted properties.

Considering the results of our analyses, all the wood species identified in the sailing ship *Caska 2* are common in the northern Mediterranean basin. The architectural characteristics of this ship are common to other 'mortise and tenon' sailing vessels of the same period. And, finally, its geographical sailing zone also seems very large. Given this, the identification of the origin and place of construction of *Caska 2* is difficult.

In contrast, the small sewn boats were used locally for a regional transport of goods and people. These sewn boats are also connected to a strong local shipbuilding tradition as attested by the Roman literary sources and the archaeological record. Thus, the existence of local shipyards building sewn boats in Dalmatia is certain.

Thanks to our study it is possible to advance the hypothesis that these local shipyards imported some wooden species from mountainous areas located near the Dalmatian coast, such as the Velebit, Ucka or Čičarija mountains.

The dendrochronological analyses allowed us to build up mean chronologies 200-years long for beech and fir which are probably local. Till now, only a series of AMS C14 analyses calibrated by wiggle matching technique date the construction of *Caska 1* between 42 and 107 AD. The other dendrochronological data are still not precisely dated because we did not find reliable correlations with other dated chronologies. In the future, we hope to date these curves by combining AMS C14 dates with the wiggle matching method.

Given the absence of a Croatian dendrochronological database for Antiquity, we will also try to crosscorrelate our curves with the datasets created by our Italian or Slovenian colleagues.

In conclusion, we hope that through our study it will be possible to better understand the development of the sewn boat tradition in the northeastern Adriatic and, perhaps, its relationships with other different shipbuilding traditions such as the one attested by the *Caska 2* shipwreck.

Our research also underlines the necessity to enlarge the dendrochronological database in Croatia. This country, with its exceptional richness of well-preserved ancient shipwrecks and other wooden structures, will certainly supply new data though the systematic combination of underwater research, nautical and maritime studies with dendrological analyses.