'Atiqot 50, 2005

Identification of the Wood in the Ancient Boat from the Sea of Galilee

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Introduction

The ancient boat of Galilee is built of wooden parts serving different roles in its construction: strakes, frames, keel, tenons and pegs. A report on the botanical identification of 41 wooden parts of the boat has already been published (Werker 1990). The rest of the boat's timbers, including 95 strakes, 43 frames and the central part of the keel, were subsequently examined and identified. The conclusions reached in the first report were rechecked and compared with those attained after examination of the entire boat.

Materials and Methods

Small blocks from each of the wooden parts of the boat were removed for preparation of anatomical sections for plant identification. The total number of the examined parts, including those of the previous report, was 180. The first 41 samples were waterlogged, whereas the 139 parts studied later were embedded in polyethylene glycol from the conservation of the boat (see Cohen, this volume). Cross sections, and tangential and radial longitudinal sections were made by hand with a razor blade or with a sliding microtome. They were mounted in an aqueous solution of glycerol. Where the embedding material obscured the plant tissue it was first dissolved in water. The sections were examined under the light microscope.

Results

Identification of all the wooden parts of the boat, including those previously published, is presented in Table 1.

The boat is built of twelve plant genera (see Plan 2 in rear pocket). The wood anatomy (based mainly on Fahn, Werker and Baas 1986) of seven of the identified genera—*Cedrus, Cercis, Crataegus*, *Pinus, Quercus*, *Salix* and *Ziziphus*—was described and discussed in the first report (Werker 1990). Regarding the identification of

Table 1. Botanical Identification of the Boat's Wooden Parts

Boat Part	Plant
Keel	
Fore part	*Cedrus* (Cedar)
Aft part	*Ziziphus spina-christi* (Sidder/Christ-thorn)
Central part	*Ceratonia siliqua* (Carob)
Strakes	
1–10, 20–27, 31, 32, 34a	*Cedrus* (Cedar)
34b	*Platanus* (Plane)
35, 36, 40, 46, 47, 52, 54, 54.1, 55, 60	*Cedrus* (Cedar)
61	*Ficus sycomorus* (Sycamore)
62, 64, 68	*Cedrus* (Cedar)
68.1	*Ficus sycomorus* (Sycamore)
69	*Cedrus* (Cedar)
69.1	*Ficus sycomorus* (Sycamore)
70–72, 72.1, 73, 74, 77, 83	*Cedrus* (Cedar)
97	*Pinus halepensis* (Aleppo pine)
98, 99, 99 repair, 101	*Cedar* (Cedar)
102	*Ficus sycomorus* (Sycamore)

Table 1. Botanical Identification of the Boat's Wooden Parts (cont.)

Boat Part	Plant
160–175, 201–203, 205, 301–315	*Cedrus* (Cedar)
316	*Ficus sycomorus* (Sycamore)
317–331, 333	*Cedrus* (Cedar)
350, 350 repair	*Ficus sycomorus* (Sycamore)
400, 521, XX	*Cedrus* (Cedar)
Frames	
13	*Quercus* (Oak)
14	*Laurus* (Laurel)
15	*Crataegus* (Hawthorn)
16–18	*Quercus* (Oak)
19	*Salix* (Willow)
29, 30	*Quercus* (Oak)
33	*Cercis siliquastrum* (Redbud)
37, 38, 41	*Quercus* (Oak)
42, 42A	*Ficus sycomorus* (Sycamore)
43, 44	*Quercus* (Oak)
44A	*Ficus sycomorus* (Sycamore)
45, 48 with bark, 49–51, 56–59, 65, 66, 76, 78–81, 84, 86–88	*Quercus* (Oak)
88A, 89	*Ficus sycomorus* (Sycamore)
90	*Quercus* (Oak)
91	*Pistacia atlantica* (Atlantic Terebinth)
92, 92A, 93, 94	*Quercus* (Oak)
100 with bark	*Crataegus* (Hawthorn)
103–105, 152, 153	*Quercus* (Oak)
154	*Ficus sycomorus* (Sycamore)
155	*Quercus* (Oak)
156	*Laurus* (Laurel)
157, 158, 176	*Quercus* (Oak)
177	*Pistacia atlantica* (Atlantic Terebinth)
316	*Ficus sycomorus* (Sycamore)
Tenons	
(a) Strake A521/3 (stem part); (b) Strake A10/11; (c) Strake A82	*Quercus* (Oak)
Peg	
Strake A521/3	*Quercus* (Oak)

the species of *Quercus*, it has been observed that most of the anatomical sections of wood belonging to this genus included the border between two growth rings, and the ring-porosity of the wood could be discerned. It was accordingly defined as Q. *ithaburensis*. A few of the segments were so deteriorated that the anatomical sections prepared from them were very fragmentary and no conclusion regarding the species could be reached.

The anatomical features, on which plant identification of the five additional genera identified here was based, are described below. In general, only the habitats closest to the site of the boat are indicated.

Ceratonia siliqua.— Vessels diffuse, solitary and in radial multiples of usually 2–4.[1] Rounded in cross section, some with gummy contents. Parenchyma mainly vasicentric to aliform; part of the cells chambered, crystalliferous. Rays 1–4-seriate, up to 25 cells high, heterocellular.

Carob trees grow on the eastern slopes of the Galilee.

Ficus sycomorus.— Growth rings absent. Parenchyma in wide (6–20-seriate) tangential bands alternating with fiber bands. Vessels diffuse, in radial multiples of 2–3(6), sometimes in clusters, rarely solitary, rounded in cross section. Rays of two sizes: 1–4-seriate up to 14 cells high, and 5–14-seriate up to 1.4 mm high; heterocellular.

In the past the sycamore was one of the most extensively grown trees in the coastal plain and Jordan Valley.

Laurus nobilis.— Growth rings distinct. Vessels diffuse, solitary, in radial multiples of 2–6(11), occasionally in small clusters. Rays (1)2–3-seriates up to 6 cells high, multiseriates up to 30 or more cells high, mostly heterocellular with one row of square to upright marginal cells; many cells crystalliferous.

Laurel trees grow in Upper and Lower Galilee and in the Dan Valley.

Pistacia atlantica.— Growth rings distinct. Wood ring- to semi-ring-porous. Vessels solitary especially at the beginning of growth ring, mainly in radial multiples of 2–10(13) or in clusters including vascular tracheids in the rest of growth ring; rounded in cross section. Tyloses, containing crystals, very common. Rays 1–5(6)-seriate, uniseriates 1–9 cells high, multiseriates 3–33; heterocellular, with square, upright or weakly procumbent, mostly crystalliferous marginal cells and strongly procumbent central cells.

In the sections spiral thickenings, which are usually prominent, were hardly distinguishable, presumably due to the conditions to which the wood of the boat had been subjected.

The trees of *Pistacia atlantica* are large; they grow in the Upper Jordan Valley, Upper and Lower Galilee, Dan Valley and Ḥula Plain.

Platanus orientalis.— Growth rings distinct. Vessels diffuse, solitary or in tangential to radial multiples or clusters of 2–4(6), angular in cross section. Rays mostly multiseriate up to 14 cells wide and 3 mm high; homocellular composed mostly of procumbent cells, sometimes with one marginal row of square cells. Apotracheal parenchyma diffuse-in-aggregates and in short uniseriate tangential bands.

Plane trees grow on riverbanks, in the Upper Galilee, Dan Valley, Ḥula Plain and Upper Jordan Valley.

DISCUSSION

The boat's hull was constructed of wood belonging to twelve different plant genera (see Plan 2 in rear pocket), five more than reported previously (Werker 1990). As a result the boat has been defined as a "boat of many woods". This title however, is somewhat misleading, since a clear pattern of the hull can be discerned, showing it to consist of two main wood genera: cedar and oak.

Of the 113 strakes of the boat, 105 (92%) were made of cedar and one strake was made of pine; both of these are conifers. Of the 60 frames, 45 (75%) were made of unworked branches of oak. This pattern of using coniferous wood for strakes, and wood of broad-leaved trees, usually oak, for frames, was a common practice in the past and is also followed today in the construction of boats. Long straight beams can be obtained from *Cedrus* trees. The wood is homogeneous in cell type and the cell lumina are narrow. In addition, as mentioned by Bärner (1962) for *Cedrus atlantica*, the wood of which is indistinguishable from that of *C. libani*, the wood becomes harder and more durable under water. Oak wood is very hard and heavy due mainly to the low density of its vessels and its thick-walled fibers. Thus, the choice of wood from these two groups of plants is based on both their morphological and anatomical qualities: the size and shape of the tree branches and the hardness and durability of their wood.

The remaining wood species are restricted to one or a few boat parts, except for sycamore from which 7 frames and 4 strakes were made. It is difficult to decide, based on anatomical structure, which of the timbers differing from the main scheme of conifer/oak wood was originally used as an integral part of the boat and which was added later as a replacement for damaged parts. The quality of wood can give only a very partial answer to this question.

The wood of willow (one specimen) is soft due to the large number and diffuse arrangement of its thin-walled vessels and the thin- to medium-thick walls of the fibers. *Platanus orientalis* (one strake) has quite hard, medium heavy wood but it has short durability, apparently due to the large number of vessels and very wide and high rays. An expert boat carpenter would

probably not use these types of wood for the primary building of a boat.

Bärner (1962) described *Ficus sycomorus* (13 specimens) wood as hard, dense, strong and durable—suitable for building and furniture, while Zohary (1982) considered it to be light and porous. The anatomy of this wood, which contains wide tangential thin-walled parenchyma bands and wide and high rays, does render it light and porous. Its specific weight is 0.4 (Fahn 1990), which is within the range of 0.35–0.65, and it is usually used for timber (Eames and McDaniels 1947). This is the only wood of a broad-leaved tree from which strakes were made. Sycamore wood was used in the construction of an ancient well on the Mediterranean coast and was also found in archaeological excavations around the Dead Sea and in ancient Egypt (Carmi et al. 1994 and literature cited therein). According to the above it is difficult to decide whether the sycamore beams were inserted as repairs or existed in the original boat.

On the other hand, the long keel is constructed of three parts, each of a different plant genus, all having hard wood: *Cedrus, Ziziphus spina-christi* and *Ceratonia siliqua.* The qualities of *Cedrus* have been mentioned above. *Ziziphus spina-christi* has very hard wood due to its thick-walled fibers, the low density and small diameter of vessels and uniseriate rays. *Ceratonia siliqua* has hard wood due to medium thick- to thick-walled fibers, small pore diameter and scarcity of parenchyma, although its branches have many knots.

Laurus nobilis and *Pistacia atlantica* have hard and durable wood, and are used for building. Nevertheless, only two frames were made of each. The same also applies to *Cercis siliquastrum* (one frame) which has dense, hard and heavy wood, but is not usually used for timber.

All the identified tree species grow in the region, at various distances from the Sea of Galilee, except for *Cedrus*, which had to be brought from further north. The choice of timber replacement might have been due not only to the hardness and durability of wood but to other factors, such as the species' proximity to the lake shore, the abundance of its trees, the shape and length of branches, or other wood qualities not mentioned here. In addition, there may well have been reuse of timber parts from other old boats.

NOTE

[1] These are number of cells. When followed by a number in parentheses it means: 'rarely up to', e.g., 2–6(11); when preceded by a number in parentheses it indicates 'rarely from' e.g., (1)2–3.

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