A Quantitative Anatomical Study of Basket Fragments from Lovelock Cave

DEBBIE MAYNARD and **THOMAS L. ROST**,
Dept. of Botany, Univ. of California, Davis, CA 95616.

A small collection of basket fragments was donated to the authors by the Lowie Museum of Anthropology, Berkeley, California. The two baskets from which the fragments were removed had been collected from Lovelock Cave (latitude 39°57'42" N., longitude 118°33'25" W.), an archaeological site at an elevation of 4,240 ft. in the Humboldt Range of Nevada, two miles east of the bed of Humboldt Lake. This cave was the first major Great Basin archaeological site to be excavated (starting in 1912), and investigations have continued throughout the century. The site shows evidence of discontinuous occupation from ca. 2500 B.C. to ca. A.D. 1835 (Heizer and Napton 1970).

The fragments come from two coiled baskets constructed on a three-rod foundation with mixed split and interlocking stitches. Stitching material is very finely split shoots. The designs are laid out in horizontal bands; the decorative element is black-dyed bulrush root. Fragment No. 1-20025 has an overstitched rim worked in a herringbone pattern, while fragment No. 1-20010A has diagonal overstitching. Both baskets are reconstructed as having been 8-9 inches in diameter. Neither bear any culinary wear marks. They are part of the Transitional and early Late Lovelock material (500 B.C. to A.D. 500). Their construction and design is reminiscent of, but not identical to, baskets of the Northern Sierra Miwok (Tuohy and Napton 1986; L. Dawson, personal communication 1988).

The identification of the constituent materials of a basket usually is made by the educated scrutiny of their surface characteristics. However, when these criteria yield results that are confusing or without precedent, other methods sometimes may be employed. It therefore was decided to macerate and section the fragments; identification would be attempted on the basis of a detailed analysis of the wood anatomy of the fragments. The anatomical characteristics recorded were then compared with published anatomical descriptions of possible plants as well as dried herbarium samples of known composition.

METHODS AND MATERIALS

Each numbered fragment used in this study measured approximately 1 x 7 mm. Some of the fragments were soaked in acetone for one hour, then directly embedded in Spurr resin (Spurr 1969). Other fragments were presoftened before embedding by the following method: 6 hours in 2 parts glacial acetic acid to 8 parts absolute ethanol; followed by 15 min. in 3.5 parts absolute ethanol to 3.5 parts acetone to 3 parts distilled water; with a final passage through 15 min. changes of 70%, 80%, 95%, and 100% acetone (Gifford 1950). Two-micron sections of the embedded fragments were made on a Sorvall JB-4 microtome using glass knives. Sections were composed of incomplete portions of the first year's growth ring. Finally, hand sections were made of 1-year-old stems of *Salix lasiandra*, *S. lasiolepis*, and *S. geyeriana*, willow species native to California and Nevada (Tidestrom 1925; Munz and Keck 1968).

The rest of the fragments were macerated by treatment for 3 days with 1 part superoxal to 4 parts distilled water to 5 parts glacial acetic acid at 56°C. This was followed by 3 changes of distilled water over a period of 24 hours. The macerate was subsequently stained and stored in 1% Safranin O in 50% ethanol (Franklin 1951). For microscopic viewing, tiny pieces of fragment were teased out onto glass slides with metal probes, moistened with alcohol, and permanently affixed under a coverslip using Euparal synthetic resin.

Macerated cells were measured, with an ocular micrometer scale, for vessel member length, vessel member diameter, and fiber length. Vessel member diameters were obtained by measuring the width of solitary vessel members across their midregions.

Macerations also were made of parts of herbarium samples of *Salix lasiandra*, *S. lasiolepis*, and *S. geyeriana*.

STATISTICS

There are certain characteristics of a wood that are either present or absent. For instance, a wood may be ring porous or diffuse porous; its parenchyma cells may be located close to the vessel members or far from them, etc. These characteristics may be found in different combinations in different genera; within a genus their occurrence is stable and consistent. For our analysis, we compared the characteristics of the Lovelock Cave fragments with those qualitative parameters of other plants that do not vary with age.

The three cellular measurements--vessel length, vessel diameter, and fiber length--were separately subjected to one-way analysis of variance.

RESULTS

Qualitative Comparisons

Tables 1 and 2 list plants that can be dispensed with reasonably as candidates for the fragment material. Plants in Table 1 are known to have been used in basketry by California Indians (Merrill 1923), but qualitative anatomical differences eliminated these plants from any consideration as possible sources of the fragment material. Plants in Table 2 would not have contributed stem parts to the baskets, so they were eliminated as well.

Careful observation of the sections suggested the Salicaceae (Willow Family) as a reasonable choice for the source of the fragment material. (Due to its restricted use in basketry, as well as the presence of anatomical differences such as spiral thickening in its vessel members, *Populus* sp., or cottonwood, was eliminated as a possible fragment source.) Not only is *Salix* sp. anatomically similar to the Lovelock Cave fragments, it was a material widely used in the Great Basin and the Humboldt Valley (Loud and Harrington 1929; Stewart 1941; Heizer and Kreiger 1956). The fragments were compared with *Salix* spp. anatomically; the results appear in Table 3. There are many similarities, although the match is not perfect. The sections also confirmed that the warp and the weft of the basket were made from the same wood.

The anatomy of the Lovelock Cave material is as follows:

In some of the sections the pith was slightly star-shaped; in others, a star-like shape was not conspicuous.

The sections showed diffuse-porous wood. Most of the vessel members were solitary, although multiples, especially radial multiples, were present. The frequency of radial multiples was 5 to 8 per section (average 6.5) with 2 to 5 cells per multiple (average 2.6). Two oblique multiples, each composed of two cells, were found.

There were clusters of vessel members at various points at the beginning of secondary growth. These clusters resembled adjacent, long chains of radial multiples. There were 3 to 5 clusters per section (average 3.6) with 6 to 27 cells per cluster (average 16).

The vessel members all had simple perforation plates and lacked spiral thickening on their sidewalls. Vessel members ranged from those totally without pits to those with moderate vessel-vessel and vessel-parenchyma pitting, as well as those that were

Table 1
GENERA WITH QUALITATIVE ANATOMICAL DIFFERENCES FROM THE LOVELOCK CAVE FRAGMENTS[a]

I. No wood present

A. Monocotyledonous Flowering Plants
- *Cinna* sp.
- *Epicampes (Muhlenbergia)*[b] sp.
- *Phragmites* sp.
- *Sporobolus* sp.
- *Iris* sp.
- *Agave* spp.
- *Juncus* spp.
- *Xerophyllum* sp.
- *Carex* spp.
- *Scirpus* spp.
- *Yucca* spp.
- *Typha* sp.
- *Smilax* sp.

B. Ferns
- *Adiantum* sp.
- *Ceropteris (Pityrogramma)* sp.
- *Pteris (Pellaea)* sp.
- *Pteridium* sp.
- *Woodwardia* sp.

II. Wood Present

A. Coniferous gymnosperms (no vessels present in wood)
- *Juniperus* sp.
- *Picea* sp.
- *Pinus* spp.
- *Pseudotsuga* sp.
- *Sequoia* sp.

B. Dicotyledonous Flowering Plants

Alnus spp. -	scalariform perforation plates; oblique vessel multiples most common.
Corylus sp. -	scalariform perforation plates.
Calycanthus sp. -	ring/semi-ring porous wood; biseriate rays; vessel members with spiral thickenings.
Cercis sp. -	paratracheal parenchyma abundant.
Ceanothus spp. -	ring/semi-ring porous; vessels in "flame-like" pattern; vessel members have spiral thickenings; rays 2-5 cells wide.
Acer sp. -	rays 5-7 cells wide; vessel members have spiral thickenings.

[a] Listed by Merrill (1923) as basketry plants.
[b] Names in parentheses indicate current synonomy (Munz and Keck 1968).

heavily armored with pits all around. It is the opinion of the authors that the heavily armored vessel members represent parts of multiples; when these parts are separated, the numerous connections between the vessel members of the multiple become visible. Vessel member pits are alternate in arrangement and of variable size. The placement of vessel-vessel pits correspond to the area of contact between adjacent or linearly connected vessel members; that is, on either side of the perforation plate or along an entire side. In both the Lovelock Cave fragments, and in material taken from *Salix* spp., the vessel-vessel pits are often smaller than the vessel-parenchyma pits.

Pits between vessel members and parenchyma cells also are alternate. The pits are crowded, and there often is what appears as a coalescence between the pits in one row or adjacent rows, resulting in an amorphous appearance. At times the angles of the pit

Table 2
DICOTYLEDONOUS FLOWERING PLANTS WHOSE STEM PARTS ARE NOT DIRECTLY USED IN BASKETRY[a]

I. **Used in dye**
- *Berberis* sp.
- *Sambucus* sp.
- *Dendia* sp.
- *Suaeda* sp.
- *Arctostaphylos* sp.
- *Quercus* sp.
- *Dalea* sp.
- *Parosela (Dalea)*[b] sp.
- *Nymphea (Nuphor)* sp.
- *Evernia* sp.
- *Rubus* sp.

II. **Used in other ways**
- *Martynia (Proboscidea)* spp. (seed pods used)
- *Prosopis* sp. (used for rope)

[a] Merrill (1923).
[b] Names in parentheses indicate current synonymy (Munz and Keck 1968).

rows did not vary much from the horizontal. Adjacent rows of parenchyma cells, connected to the same vessel member, might have their pit rows running in the same or opposite direction. Pit shape varied from squarish to roundish to ovoid.

The rays are heterocellular; the pits are in the upright cells only. The number of pit rows per cell varies from 4 to 6. This same figure was obtained by counting obvious pit groups on vessel member side walls. The number of vessel-parenchyma pits per row varied from 1 to 3.

Quantitative Comparisons

The analysis of variance is summarized in Table 4; calculated F-values are presented in Table 5 (Steel and Torrie 1980).

The comparison of the cell lengths and diameters yielded the following results:

For both vessel member length and fiber length, the obtained F-value was much smaller than the critical tabular F-values of 2.93 (0.5 level) or even 2.29 (0.10 level), allowing acceptance of the hypothesis that the fragments and the herbarium material belong to populations with a common mean, and strengthening the hypothesis that they are derived from the same general population; i.e., the genus *Salix*.

In the case of the vessel member diameter, variation was extensive enough to exceed the critical F-value. In order to ascertain exactly which of the samples had the deviant mean or means, pairwise comparisons were carried out using Fischer's Protected Least Significant Difference Test (Steel and Torrie 1980). The results were as follows:

Sample	Mean	Group
S. lasiolepis	27.88	a
1-20025	31.94	a
S. geyeriana	32.46	a
1-20010A	37.10	b

As can be seen from the groups, the mean of fragment 1-20010A is significantly different from the others. Among all the other means, the differences that separate them are not that significant.

DISCUSSION

Although the limited quantity and physical condition of the fragment material prevented the collection of the total range of information possible, those qualitative characteristics that could be observed showed good resemblance between the fragments and *Salix* spp. In those cases where the fragment anatomy deviated from the published *Salix* spp. literature, e.g. vessel-vessel pit size, similar deviation occurred in the herbarium material as well.

Among the quantitative data, the F-values for both vessel length and fiber length were well within the critical value. Vessel diameter, however, greatly exceeded the critical F-value. The increased vessel width of fragment 1-20010A was probably due to a more abundant water supply and very vigor-

Table 3
QUALITATIVE COMPARISONS

Characteristic	***Salix* spp.**	**Lowie Museum Fragments**
Stratification of wood	Non-storied	Perhaps non-storied (incomplete data)
Pith	Star-shaped, w/5 points;[a] more or less star-shaped (herbarium material)	Perhaps star-shaped (incomplete data)
Xylem fibers	Fibers make up the bulk of the axial, wood tissue	Fibers make up the bulk of the axial wood tissue.
Vessel members: Distribution	Diffuse-porous; vessels mostly solitary	Diffuse-porous; vessels mostly solitary
Vessel members/mm (1st year's wood)	*S. lasiolepis* - 39 *S. lasiandra* - 37 *S. geyeriana* - 57	40
Vessel multiples	Present; 2-5 cells long; usually radial in orientation, occasionally oblique or tangential occasionally oblique or tangential.	Radial multiples - 5-8/section (average = 6.5) 2-5 cells/multiple (average 2.6) Tangential multiples - none found; Oblique multiples - only 2 found; 2 cells/multiple
Perforation plate type	Simple	Simple
Vessel-vessel pitting pattern	Alternate; pits are large.[a] Alternate; pits are small (herbarium material).	Alternate; pits are small.
Vessel - ray parenchyma pitting pattern	Alternate; pits are large.	Alternate; pits are large.
Axial parenchyma distribution	Terminal (produced around outer perimeter of growth ring)	Insufficient data
Rays:		
Width	Uniseriate	Uniseriate
Composition	Heterocellular; 1-3 rows of squarish upright cells[a]	Heterocellular; partial macerates of rays reveal 1 row of upright cells.
Pitting pattern	Pits in upright cells only 3-5, sometimes 6 rows of pits per cell; *S. geyeriana* - 3-6 rows/cell, 1-3 pits/row	Pits in upright cells only 4-5, sometimes 6 rows of pits per cell; 1-3 pits/row

[a] Literature sources of *Salix* anatomy are Metcalfe and Chalk (1965:1315-1320) and Jane (1970).

Table 4
FRAGMENT CELL SIZES

Fragments	1	2	3	4	5	6	7	8	9	10	Yi.	$\bar{Y}$i.
Vessel diameter												
Species												
1-20025	30.82	34.44	29.29	34.22							127.77	31.94
1-20010A	34.70	36.59	32.93	36.74	39.53	38.38	38.58	41.65	34.10	37.78	370.98	37.10
Salix geyeriana	34.58	36.70	32.23	26.34							129.85	32.46
Salix lasiolepis	30.35	26.43	26.40	28.33							111.51	27.88
$\underline{Y}$.j.	130.45	133.16	120.85	126.23	39.53	38.38	38.58	41.65	34.10	37.78	$\underline{Y}$.. =	740.11
Y.j.	32.61	33.29	30.21	31.56	39.53	38.38	38.58	41.65	34.10	37.78	Y.. =	33.64
Vessel length												
Species												
1-20025	251.82	281.55	291.93	290.80							1,116.10	279.02
1-20010A	240.02	288.76	237.36	274.04	281.05	292.15	269.87	298.09	241.62	266.77	2,689.73	268.97
Salix geyeriana	266.42	289.73	273.61	273.60							1,103.36	275.81
Salix lasiolepis	288.19	273.58	271.96	257.00							1,090.73	272.68
$\underline{Y}$.j.	1,046.45	1,133.62	1,074.86	1,095.44	281.05	292.15	269.87	298.09	241.62	266.77	$\underline{Y}$.. =	5,999.92
Y.j.	261.61	283.41	268.72	273.86	281.05	292.15	269.87	298.09	241.62	266.77	Y.. =	272.72
Fiber length												
Species												
1-20025	420.61	285.43	392.64	380.96							1,579.64	394.91
1-20100A	381.82	376.73	357.93	380.04	392.64	378.56	378.56	411.36	391.84	332.29	3,781.77	378.17
Salix geyeriana	405.40	398.56	378.16	376.51							1,558.63	389.66
Salix lasiolepis	373.53	356.32	380.81	361.76							1,472.42	368.10
$\underline{Y}$.j.	1,581.36	1,517.04	1,509.54	1,499.27	392.64	378.56	378.56	411.36	391.84	332.29	$\underline{Y}$.. =	8,392.46
Y.j.	395.34	379.26	377.38	374.82	392.64	378.56	378.56	411.36	391.84	332.29	Y.. =	391.47

Table 5
STATISTICAL ANALYSIS

Source	Dif.	SS	MS	F-value
Vessel length				
Total	22	6,708.96		
Between Species/Fragments	4	338.35	84.59	
Within Species/Fragments	18	6,370.61	353.89	0.24
Vessel diameter				
Total	22	419.14		
Between Species/Fragments	4	269.48	67.37	8.3[a]
Within Species/Fragments	18	149.66	8.31	
Fiber length				
Total	22	7,797.45	453.4	
Between Species/Fragments	4	1,813.6	890.15	1.36
Within Species/Fragments	18	5,983.85	332.44	

a The F-value for this test is significant.

ous shoot growth of the plant from which it was removed. Vessel member diameter is affected by hormonal stimulation originating in the actively growing shoot apices (Digby and Wareing 1966). A surfeit of growth would promote the formation of very wide vessel members.

The finding of this study, that the baskets probably were constructed from juvenile *Salix* sp. stems, is an unsurprising conclusion from an anthropological point of view. Nevertheless, the techniques and anatomical knowledge that were used to deduce the probable identity of the fragments could provide future workers with the tools necessary to solve identification problems of greater complexity or obscurity.

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