



Direct Evidence for Organic Cargoes in the Late Bronze Age

Cheryl Haldane

World Archaeology, Vol. 24, No. 3, Ancient Trade: New Perspectives. (Feb., 1993), pp. 348-360.

Stable URL:

<http://links.jstor.org/sici?sici=0043-8243%28199302%2924%3A3%3C348%3ADEFOCI%3E2.0.CO%3B2-C>

World Archaeology is currently published by Taylor & Francis, Ltd..

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://www.jstor.org/about/terms.html>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://www.jstor.org/journals/taylorfrancis.html>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is an independent not-for-profit organization dedicated to creating and preserving a digital archive of scholarly journals. For more information regarding JSTOR, please contact support@jstor.org.

Direct evidence for organic cargoes in the Late Bronze Age

Cheryl Haldane

Since the first dive on the Late Bronze Age shipwreck at Ulu Burun, Turkey, Institute of Nautical Archaeology (INA) excavators have taken more than 1,000 archaeobotanical samples from ceramic containers, from below and between metal ingots and from every corner of the site. This collection of plant remains provides a unique opportunity to learn more about the well-documented eastern Mediterranean trade in organic materials.

The Ulu Burun ship sank in the late fourteenth century BC, during Egypt's Eighteenth Dynasty and the LH IIIB period in Greece (Bass 1986; Pulak 1988a; Bass et al. 1989). The sunken ship carried the finest luxury goods of the Late Bronze Age – a time of intensive trade and travel in the eastern Mediterranean. Unlike most finds from land sites, the Ulu Burun ship yielded primarily raw materials used in workshops throughout the Aegean, Egypt and the eastern Mediterranean world: ingots of copper, tin, silver and cobalt-blue glass; unworked hippopotamus and elephant ivory; tortoise shell; logs of Egyptian ebony (*Dalbergia melanoxylon*); scrap gold and silver jewelry from Egypt and the Levant; about a ton of aromatic resin probably destined for perfume factories; bronze tools and weapons for trade and defense; and an extensive collection of balance pan weights to facilitate exchange. The ship also carried oils, fruits, nuts, spices and other plants for trade and shipboard use.

The Ulu Burun vessel and the late thirteenth-century BC Cape Gelidonya ship, excavated in 1960 by George Bass, INA's archaeological director, operated at opposite ends of the Late Bronze Age trade economy. Bass has suggested that the Cape Gelidonya ship belonged to an itinerant Syro-Palestinian merchant and tinker (1967: 163–7), but the cargo of the Ulu Burun ship is described almost verbatim in several of the 'royal exchange' letters from el Amarna (Bass 1987a; 1987b). As he points out (1987b: 2), the Ulu Burun ship provides 'tangible evidence of ships and shipments known otherwise only from contemporary paintings, written documents, and the circumstantial evidence of artifact distribution patterns on land'.

B. Knapp's recent discussion of eastern Mediterranean Bronze Age trade also explores the relationship between direct and indirect evidence of trade in organic goods. He focuses on organic residues analysis and the much larger body of archaeological and textual sources (1991). Knapp agrees with Bass in concluding that 'international contacts and

episodes sketched in this study reveal a complex, multi-directional trade in which royal merchants and independent entrepreneurs operated, and in which “tramping” and collective ventures took place’ (1991: 52).

The plant products once carried by the Ulu Burun ship offer another perspective on Late Bronze Age trade in organic goods in the eastern Mediterranean and supplement the studies of Bass, Knapp and others.

Methodology

Archaeobotanists working on land sites in the Near East often deal with large quantities of charred grains, pulses and weed seeds, while fruits and spices are rare. Almost the opposite is true on shipwreck sites. The economics of shipping promoted transport of diversified, valuable cargoes, often transported in closed containers. Archaeologists rarely recover stoppered jars from underwater sites, and, as on land, sample context and integrity are vital concerns.

A. J. Parker’s discussion of stratification and contamination of ancient Mediterranean shipwrecks points out that shipwrecks are not sealed deposits and that many wrecks include artifacts of later date than the shipwreck (1981). Excavators retrieved a Roman amphora and an iron Byzantine anchor from the Ulu Burun wreck site, but all the artifacts found in archaeobotanical samples are contemporary with the shipwreck. In my opinion, almost all the archaeobotanical remains on the shipwreck date to the time of its sinking, although substantial mixing occurred within the hull.

Plants may occur on shipwrecks as dunnage (padding for the hull), protective matting, or as part of the working gear of the ship: wads of vegetation or dried figs used as container stoppers; seeds and leaves of plants near the wreck site; and food debris tossed overboard by sea travellers. Attempts to identify seeds that reached a wreck in a random way are likely to fail, so we tried to see how local flora and plant remains carried by the sea might affect contamination. In 1984, a wide-mouthed jar with nearly 500 olive stones, placed upslope of the wreck for 90 days, accumulated only a few cubic milliliters of sand and broken shell despite airlifting and intense activity on the site. By the end of the excavation season, three olive stones had disappeared. This short-term experiment suggests that seaborne contamination is probably not a primary factor in the composition of archaeobotanical samples on shipwrecks.

As a shipwreck disintegrates, residues of spilled cargoes, both organic and inorganic, get into shipping jars. Samples from such jars and other contexts on shipwrecks may contain waterlogged, mineralized and charred plant seeds, twigs, bark, leaves, flowers, fruits, resin, pitch, wood and other plant tissues, as well as artifacts, dyed animal hairs, textile fragments, insects, animal and fish bones, and even animal dung. Ulu Burun shipwreck samples for archaeobotanical materials have included all of the above, as well as bronze balance pan weights; silver and tin ingot fragments; glass, stone and faience beads; bits of ivory and pot sherds. At the time of sinking other containers held fishing net weights, glass beads, orpiment, stacked Cypriot and Syro-Palestinian pottery, and one of the most incredible finds on the Ulu Burun shipwreck, a wooden diptych.

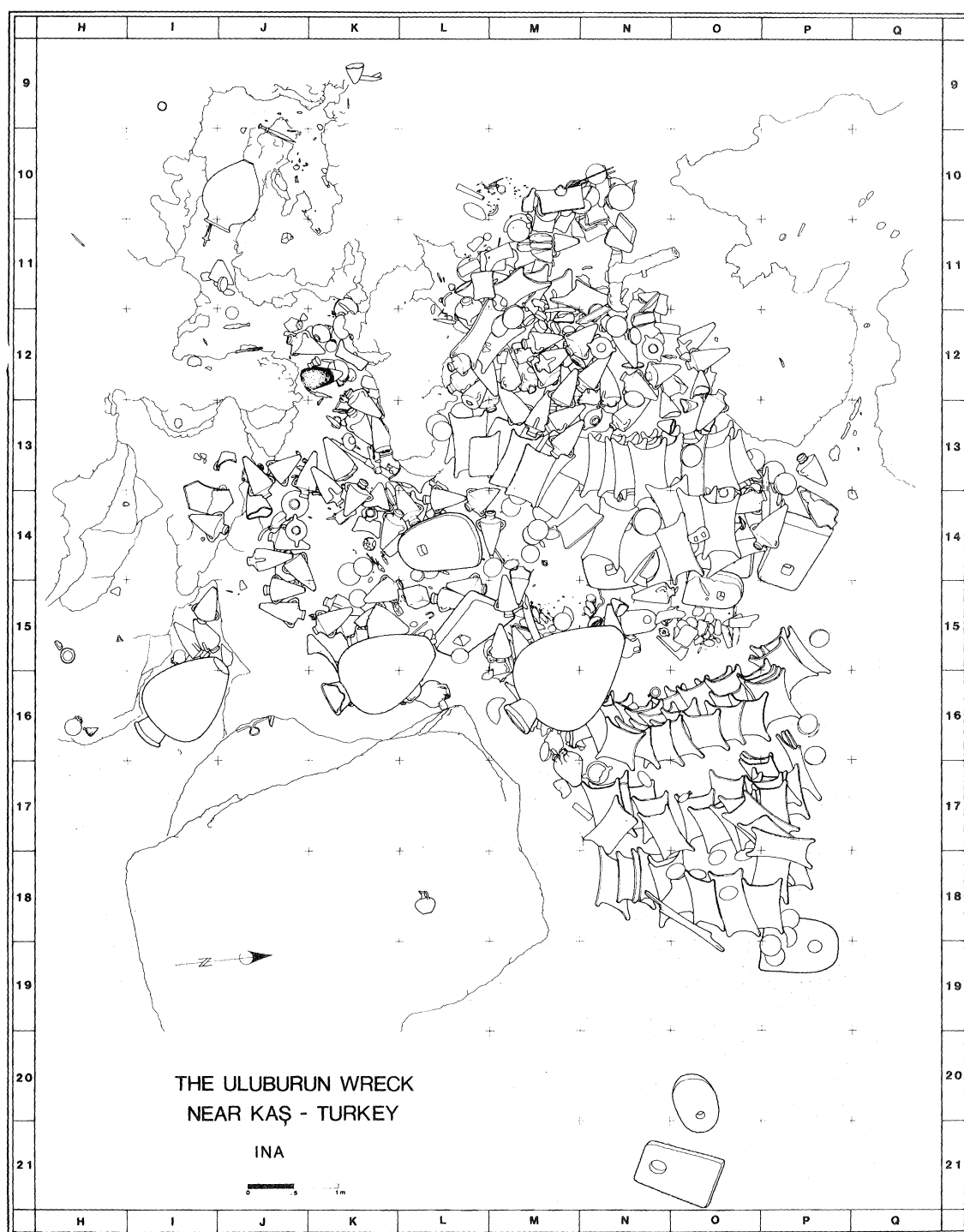


Figure 1 Plan of the Late Bronze Age Ulu Burun shipwreck. (Courtesy Institute of Nautical Archaeology)

The Ulu Burun ship sank less than 100 meters from a rocky point and settled on the steep seabed with its stern towards the cliff (Fig. 1). Like other ancient ships it may have been only partially decked, with plank walkways across the main cargo hold. Four-handled copper ingots lined the hull, and more than twenty stone anchors were stacked in the center of the ship. Amphoras were stored above the ingots; smaller ceramic closed containers such as stirrup jars and Syrian lentoid flasks tend to be found in the after portion of the ship. More than half a dozen large pithoi carried Cypriot and Syrian pottery, pomegranates and a liquid substance that created a huge dark stain in sand on the wreck, stored fish nets and perhaps held drinking water.

As containers spilled or broke, their contents added to a layer of organic matter in the hull, reflected in the increasing variety and number of plant remains recovered by archaeologists near the hull. The ubiquity of fig seeds in almost all contexts on the shipwreck, and coriander in many others, suggests the containers, perhaps boxes or bags, holding these products gradually broke up allowing their contents to drift into protected areas of the wreck, including small- and large-mouthed jars. On the Ulu Burun shipwreck archaeologists recover plant remains from sediment surrounding artifacts or overlying the hull, metal ingot surfaces, stains on the seabed, and all containers. Excavators also recover sediment samples from containers and other contexts for chemical and palynological analysis.

Finds of large nuts and fruit stones, honey, resin and pitch had helped to define cargoes since the beginning of underwater archaeology, but little systematic retrieval occurred until the 1970s. INA archaeologists have experimented with recovery techniques for plant remains on shipwreck excavations in Turkish waters since 1974 (Frey et al. 1978: 229; Bryant and Murry 1982). At first, archaeologists investigated jar contents by emptying them onto a screen, washing away the matrix and collecting recognizable plant remains. Plant remains were also recovered from concretion matrix in large lumps of artifacts. As a consequence, only large seeds, nut fragments and fruit stones were retrieved during the eleventh-century AD Serçe Limani shipwreck excavation in 1978–9 (Haldane 1991: 216).

In contrast, 3ml of plant material removed during later conservation of a glass vase from the same wreck included five previously unrepresented taxa as well as rope, insect fragments and black, beige and red hairs or fibers. The contents of a Serçe Limani amphora, sealed with pitch and therefore slowly dried, reflect a similar diversity with the addition of grape skins and more than a hundred grape seeds, pedicels and tendril fragments; insects; a large pulse and land snails.

By 1980 recovery of plant remains by suspension-flotation was standard on INA shipwreck excavations and surveys. On land sites flotation relies on the buoyancy of charred or dry plant remains, but plant remains from shipwrecks are waterlogged and rarely float. To compensate for this difference, we add about 0.5 liter of the sample to a 15 liter bucket of seawater and create a vortex that briefly suspends most plant remains. (The water used for suspension is changed frequently.) The suspended contents are quickly poured through a set of nested sieves (0.2–4mm). Large shells, bones, bits of concretion and artifacts such as glass or stone beads, small weights and potsherds are removed by hand. Everything left on the screens is placed in a storage basin. After the entire sample has been floated, the contents of the storage basin are floated separately to remove as

many shell and crustacean fragments as possible. The residue is stored in water, then sorted under 10–50× magnification.

Results

So far, Ulu Burun samples have produced almonds, acorns, pine nuts, pine cone fragments, wild pistachio nutlets, olives and olive stones, pomegranate and fig seeds and fruit fragments, and grape seeds of two types (Fig. 2). Also recorded are coriander, nigella (black cumin) and sumac seeds, charred barley in the husk and charred wheat, rachis and chaff fragments from barley and other grasses, several kinds of small grass seeds, at least three types of pulses and seeds from more than forty different weeds and other plants. This section provides information about some of the more important traded organic cargoes on the Ulu Burun shipwreck.

About 120 Canaanite jars carried terebinth resin, chemically identified by J. Mills and R. White (1989) and H. H. and E. M. Hairfield (1990). Resin coated the interior or filled

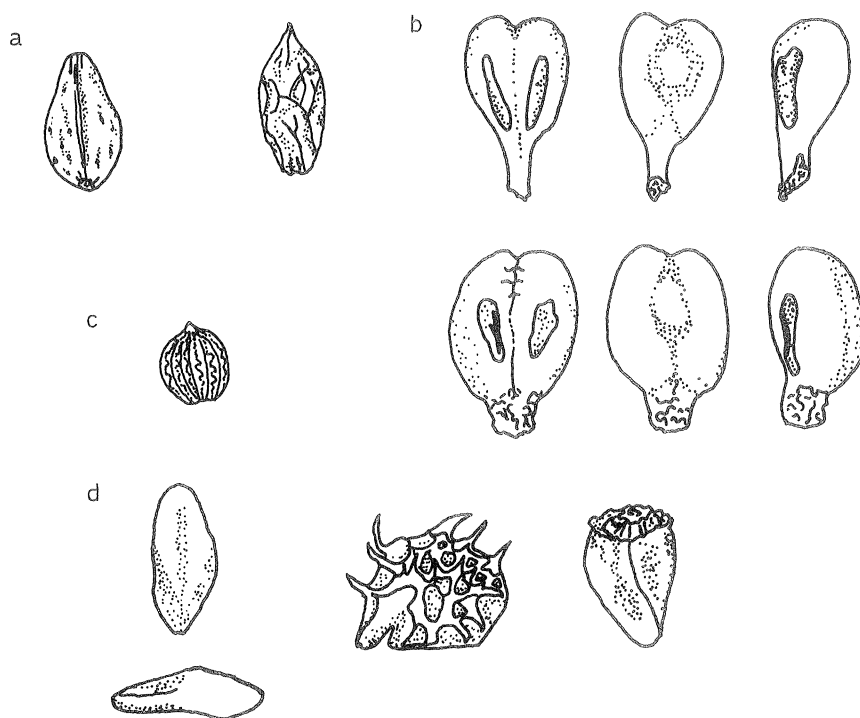


Figure 2 Plant remains on the Ulu Burun Shipwreck include (a) almonds, olive stones, (b) two varieties of grape seeds, (c) coriander seeds, (d) pomegranate seeds, and many other species such as sainfoin and safflower. Thin, heart-shaped grape seeds are found loose on the wreck and in small flasks; thick puffy seeds with short beaks are restricted to those containers with toe conglomerates. [a] *Amygdalus communis* and *Olea europaea* 16mm long; b) *Vitis vinifera* 3.7mm long; c) *Coriandrum sativum* 4.2mm long; d) *Punica granatum*, *Onobrychis* sp., *Carthamus lanatus* (safflower), c. 5.5mm long.]

jar shoulders and toes at the time of excavation, and hundreds of resin globules have been collected across the site. Each amphora could have carried about 9 kilos of resin, bringing the total weight of resin to about a metric ton. The smell and taste of the pure resin are distinctive, and its color ranges from bluish-white to dark golden brown. Up to a kilo of resin has been found in a single amphora, but most contain less than 100gm. Some resin samples collected loose on the wreck incorporate sand and bits of shell, suggesting that the resin was still fluid when it spilled.

A conglomerate of impure resin chips that typically includes charcoal, thick, round grape seeds with ruggulated beaks, weed seeds, sumac fruits, many insects and grayish sediment sometimes fills the toes and lowest c. 5cm of amphoras. C. Pulak has suggested that this conglomerate, sometimes found with a potsherd above it, is the remains of imploded stoppers (1988a: 11). In my opinion it is more likely to be accumulated small debris from previous cargoes incompletely emptied from the amphora and impregnated by the new resin, or a by-product of resin processing used to plug the small, inaccessible toe cavities of the jars.

Ten centuries after the Ulu Burun ship sank, Theophrastus described great mountains of terebinth trees in Syria (9.2.2). At that time, the resin was recovered by slashing the bark or by burning the tree, a process that could contribute to the presence of charred seeds and wood in toe conglomerates. The further processing of fluid resin was described by Dioscorides (I.71.5–6). One part resin and two parts rainwater were boiled in a bronze vessel over coals until many of the volatile oils had dispersed. After straining to separate the ‘dirty part’, resin poured off into a ceramic vessel that had not been smeared with pitch would become white, a desired indication of quality. Resins treated this way were particularly useful as astringents for making aromatic emollients and for coloring perfumed oils.

Whitehouse (1957: 319) described a similar process in modern Syria:

In Syria, large quantities of [terebinth] resin are collected in skins or clay vessels, allowed to harden, and transported to villages. Later, the resin is heated to the point where it liquifies, then it is cooled to make a whitish product. It is displayed in this form for sale in bazaars and perfumers’ shops in Iran, Turkey and Arabia. It is also used medicinally to relieve catarrhal troubles by stimulating the flow of body liquids.

Even in 1988, terebinth resin and nutlets for sale in markets in Turkey, Syria, Jordan and Egypt were valued for the same qualities catalogued by Classical writers.

M. Serpico reports that R. White’s analysis of resin from the Eighteenth Dynasty site of Tell el Amarna shows that it is virtually identical to terebinth resin from the Ulu Burun shipwreck (pers. comm.). The presence of terebinth resin at Amarna and on the Ulu Burun shipwreck may support V. Loret’s identification of the Egyptian *sntr*, a treasured gum-resin obtained in great quantities from Syria in the Eighteenth Dynasty, as terebinth (1949).

A Canaanite jar containing more than 2,500 olive stones is the largest single deposit of olive stones from the Late Bronze Age Mediterranean. Although these olives may have been part of the ship’s stores, their size and presence in large numbers may indicate yet another luxury product transported by the Ulu Burun ship. Ulu Burun olive stones, with a mean size of 15.3×8 mm, are larger than most other Late Bronze Age remains (Table 1).

Table 1 Measurements of Late Bronze Age olive stones. (*Sources:* Lachish, Apliki, Nimrud from Helbaek 1962: 182–3; Hala Sultan Tekke from Hjelmqvist 1979: 111; Tiryns from Kroll 1984: 216; Timna from Kislev 1988: 239.)

<i>Site</i>	<i>Length</i>	<i>Breadth</i>	<i>Comments</i>
Lachish, Palestine	13.2mm	6.4mm	largest stone
Apliki, Cyprus	13.3mm	8.0mm	1 stone
Late Assyrian Nimrud	10.7–12.5mm	5.7–7.5mm	3 stones
Hala Sultan Tekke	12.2mm	6.2mm	avg. of 8 stones
LH III Tiryns	12.7mm	6.7mm	avg. of 41 stones
Timna	16.3mm	7.4mm	avg. of 5 stones
Ulu Burun Shipwreck	15.3mm	8.0mm	mean of 100 stones

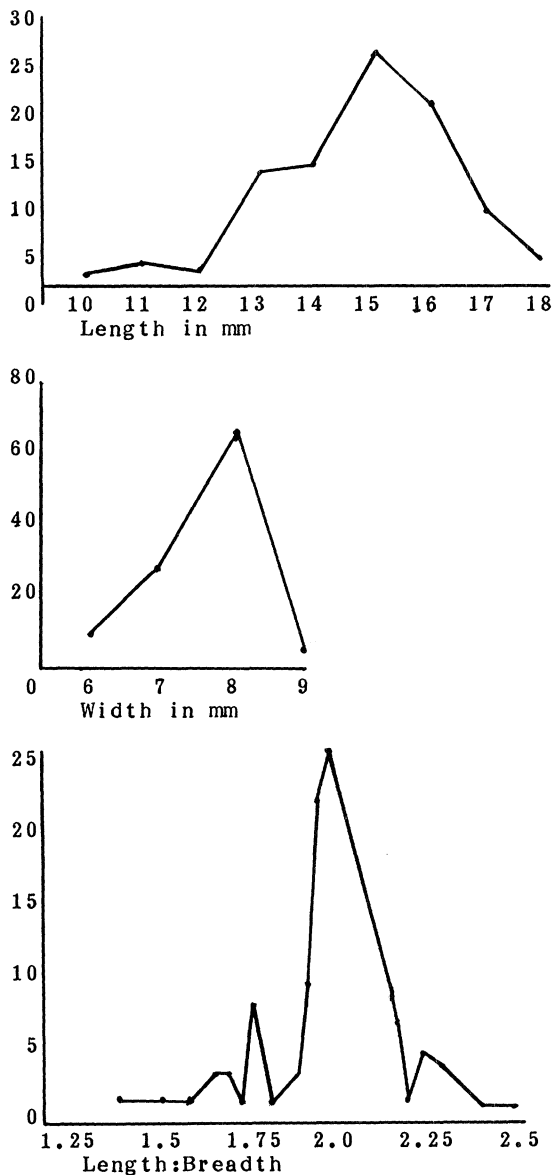
One hundred randomly selected stones from the Ulu Burun deposit measure 10–18mm long and 6–9mm wide. Figure 3 shows mean size distribution and length: breadth indices. The closest parallels for olive stones on the Ulu Burun shipwreck come from the New Kingdom Egyptian mining temple at Timna, at the head of the Gulf of Aqaba. Five desiccated stones there averaged 16.3mm long and 7.4mm wide (Kislev 1988: 239).

Runnels and Hansen review evidence for the domestication of the olive, and point out that few olive remains are recorded from Late Helladic (mainland Greece) or Cretan Late Bronze Age sites with the exception of Tiryns (1986: 301; Hansen 1988: 44–7; Kroll 1984: 212). The general scarcity of olive stones may suggest that most people did not eat olives regularly. Even in the medieval period, legal and economic records show that shipboard diet and the diet of lower classes typically consisted of fish or meat, oil, inexpensive dried fruit, bread and cheese (e.g. Jados 1975: 79; Bell 1926; Ashtor 1970: 10–14). It is also possible that the increasing excavation of domestic architecture will provide a broader representation of Late Bronze Age diet.

Melena has argued that Mycenaean Greek Linear B tablets refer more often to wild than cultivated olives, and that their oil was preferred for perfume manufacturing (1983). In the Late Bronze Age, olive oil was primarily an industrial raw material used in manufacturing textiles, soap, and perfumes and unguents. Linear B tablets record the production of perfumed oils, scented with sage, rose or nut grass (*Cyperus rotundus*) and sometimes colored red (Shelmerdine 1984 and 1985). These products were traded in both large and small stirrup jars (Shelmerdine 1984 and 1985; Leonard 1981: 91–4), a number of which have been discovered on the Ulu Burun shipwreck.

For the most part, archaeobotanical remains from these jars include only a few fig seeds in each jar, and chemical and palynological analysis of contents will add more to our knowledge of transported goods. Archaeobotanical recovery has, however, allowed unusual aspects of jar contents to be noted for further analysis. For example, some small stirrup jars held a substance different in color, taste, smell and texture from terebinth resin carried in Canaanite amphoras. A lump of yellow resin from a large stirrup jar recently retrieved from the c. 1200 BC Cape Gelidonya shipwreck (Pulak 1988b: 13) shares physical properties with terebinth resin. The presence of resins in stirrup jars reinforces documentary evidence for perfume and unguent trade.

Figure 3 Dimensions of 100 olive stones from the Ulu Burun shipwreck.



More than a thousand pomegranate seeds and fragments of fruit skin in the sediment filling a large storage jar or pithos, and hundreds of pomegranate seeds in samples across the wreck site point to another plant cargo. Pomegranate rind occurs in a Classical list of perfume ingredients (Pliny, *Natural History* 13.8) and pomegranate juice can act as an astringent to prepare oil to receive a scent. Pomegranate fruits were highly valued in the Late Bronze Age and appear as symbols of fertility and rebirth in religious iconography. The pomegranate grew throughout the Levant and appeared in Egypt during the Middle Kingdom (Baum 1988: 151). It was well established by the Late Bronze Age and is

featured in a number of Eighteenth Dynasty tomb paintings and funerary garlands (e.g. Davies 1936: pls 44 and 52).

Coriander fruits also served as both perfume astringents and ritual offerings in the Late Bronze Age (Haldane 1990: 57). About 100 fruits are represented in samples from the Ulu Burun shipwreck, and they are generally well preserved. Coriander is seldom reported from Late Bronze Age sites, but Helbaek noted one fruit from Apliki. He suggested that since its high oil content promotes combustion rather than charring, coriander is seldom reported from land sites (1962: 183).

Archaeobotanical samples from the wreck include many fragments of charcoal, much of it identifiable, from at least twelve different trees and shrubs common to the eastern Mediterranean shoreline; wood fragments of at least seven species; fragments of rope, basketry and matting; well preserved leaves from several kinds of oaks, pistachio, and conifers; and thousands of fragments of thorny burnet (*Sarcopoterium spinosum*) used as dunnage in the bottom of the hull. Charred capsules and twigs of thorny burnet may point to its use as fuel on a shipboard hearth.

Many of the weed species probably arrived on the ship in dunnage and other packing materials and were protected by their position low in the hull. Whole specimens of thorny burnet from roots to leaves have been found compressed between copper ingots (Plate 1). The spiny branches of thorny burnet protect other species from grazing animals, and it is not uncommon to see as many as ten different plants growing within its branches (Plate 2).

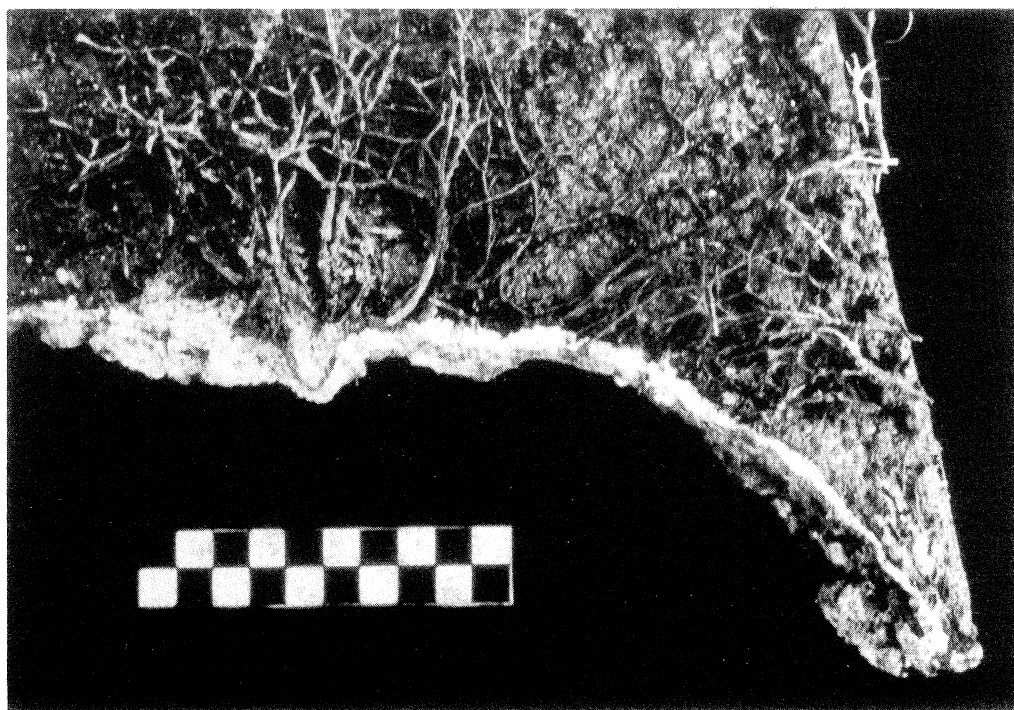


Plate 1 An example of thorny burnet (*Sarcopoterium spinosum*) preserved on the underside of a four-handled copper ingot. (Courtesy Institute of Nautical Archaeology)



Plate 2 In the coastal regions of Turkey today, thorny burnet (*Sarcopoterium spinosum*) grows on field margins, low hills and cleared land. More than 15 different species of weeds and trees contributed to the plant assemblage pictured here, suggesting one way the variety of plants from dunnage samples may have originated.

The fig, a Late Bronze Age dietary staple, is represented by tens of thousands of seeds, but only a few individuals of other important plant foods have been recovered. Charred cereal grains and pulses probably reflect shipboard diet. Nuts and condiments may have been cargo, part of ship's stores or accidental inclusions in dunnage or organic goods.

Fewer than a dozen almond stones and fragments have been recovered from the shipwreck. Some are long, thick and distinctly keeled with thick walls (e.g. $28 \times 11 \times 18\text{mm}$), but most are small, shallowly pitted and have an indistinct keel and thin walls (e.g. $20 \times 9 \times 10\text{mm}$). The two types may represent the range of a single type or separate varieties. The small number of nuts on the wreck today may reflect either their attractiveness as food to marine creatures or their insignificance on the ship's last voyage. People have collected and eaten almonds since at least the Palaeolithic period in Greece and the Levant (c. 10,000 BP), and their shells are present at sites in Anatolia and the eastern Mediterranean (Zohary and Hopf 1988: 162). Little comparable Late Bronze Age material has been published, but at Apliki on Cyprus (c. 1250 BC), the only almond shell measured 16.8mm long and 10mm wide. Its shell was smooth but deeply pitted (Helbaek 1962: 179–80).

Conclusions

Container analysis and the chemical identification of organic residues have scarcely begun on the Ulu Burun shipwreck, but the potential for direct knowledge of traded goods is

enormous. Preliminary archaeobotanical studies have documented differences in container contents, identified residues for further analysis, defined several organic cargoes, suggested original quantities for others and recorded Late Bronze Age plants used as dunnage. Further work on identification of weed species, analysis and co-ordination with the extremely detailed proveniences of samples throughout the site will aid the reconstruction of the ship's final voyage and may document shipwreck formation processes.

The collection of plant remains adds depth to both shipwreck archaeology and studies of trade in organic goods. Seafaring in the ancient Mediterranean began more than 10,000 years ago, and dependence on ships to transport merchandise is reflected in texts dating from the end of the fourth millennium BC. Archaeological evidence for trade and commerce is abundant in the eastern Mediterranean, as many authors have noted. The archaeology of ships, harbors and warehouses can be integrated with archaeobotanical studies of plant remains to help explain the processes that brought a particular item to a particular place.

Shipwrecks are rare and valuable archaeological sites that represent discrete events in time. It is relatively simple and inexpensive to recover archaeobotanical remains from shipwreck sites, and the utility of archaeobotanical analysis is clear. Plant remains on shipwrecks, currently an underexploited source of information about shipping and trade, offer scholars direct evidence of ancient seafaring and commerce.

Acknowledgements

This research has been supported in part by the Institute of Nautical Archaeology, the Harriet W. Pomerance Fellowship in Aegean Bronze Age Archaeology, and Elise Haldane and Texas A & M University. Many patient archaeologists and volunteers have helped recover organic remains from the Ulu Burun and other shipwrecks; their contributions and the support of G. F. Bass have made this study possible. I am also grateful to Cynthia W. Shelmerdine of the Department of Classics at the University of Texas at Austin for her translation of the Classical passages used in this paper.

7.vii.92

*Institute of Nautical Archaeology
Texas A&M University
College Station, Texas*

References

- Ashtor, E. 1970. The diet of salaried classes in the Medieval Near East. *Journal of Asian History*, 4: 1–24.
- Bass, G. F. 1967. *Cape Gelidonya: A Bronze Age Shipwreck*. Transactions of the American Philosophical Society NS 57.8. Philadelphia: American Philosophical Society.
- Bass, G. F. 1986. A Bronze Age shipwreck at Ulu Burun (Kas,): 1984 Campaign. *American Journal of Archaeology*, 90: 269–96.

- Bass, G. F. 1987a. Oldest known shipwreck reveals splendors of the Bronze Age. *National Geographic*, 172: 693–734.
- Bass, G. F. 1987b. The Tell el Amarna tablets and the shipwreck at Ulu Burun. Presented at the 100th Anniversary Conference celebrating the discovery of the Tell el Amarna tablets held at the Oriental Institute, University of Chicago. To be published in forthcoming proceedings (ed. Gordon Young).
- Bass, G. F., Pulak, C., Collon, D. and Weinstein, J. 1989. The Bronze Age Shipwreck at Ulu Burun: 1986 Campaign. *American Journal of Archaeology*, 93: 1–29.
- Baum, N. 1988. *Arbres et Arbustes de L'Égypte Ancienne*. Leuven: Orientalia Lovaniensia Analecta, 31.
- Bell, H. I. 1926. Two official letters of the Arab Period. *Journal of Egyptian Archaeology*, 12: 275–9.
- Bryant, V. M. Jr and Murry, R. 1982. Preliminary analysis of amphora contents (Appendix E). In *Yassi Ada I: A seventh-century Byzantine shipwreck* (eds. G. F. Bass and F. H. van Doorninck, Jr). College Station, TX: Texas A&M University Press, pp. 327–31.
- Davies, N. de G. 1936. *Ancient Egyptian Paintings*, vol. I. Chicago: University of Chicago Press.
- Dioscorides. *De materia medica*.
- Frey, D., Keith, D. and Hentschel, F. 1978. Deepwater archaeology. The Capistello wreck excavation, Lipari, Aeolian Islands. *International Journal of Nautical Archaeology*, 7(4): 279–300.
- Hairfield, H. H., Jr and Hairfield, E. M. 1990. Identification of a Late Bronze Age resin. *Analytical Chemistry*, 62(1): 41a–45.
- Haldane, C. W. 1990. Shipwrecked plant remains. *Biblical Archaeologist*, 53: 55–60.
- Haldane, C. W. 1991. Recovery and analysis of plant remains from some Mediterranean shipwreck sites. In *New Light on Ancient Farming* (ed. J. Renfrew). Edinburgh: Edinburgh University Press, pp. 213–23.
- Hansen, J. M. 1988. Agriculture in the prehistoric Aegean: data vs. speculation. *American Journal of Archaeology*, 92: 39–52.
- Helbaek, H. 1962. Late Cypriote vegetable diet at Apliki. *Opuscula Atheniensia*, 4: 171–86.
- Hjelmqvist, H. 1979. Some economic plants and weeds from the Bronze Age of Cyprus, *Studies in Mediterranean Archaeology*, 45(5): 110–33.
- Jados, S. S. 1975. *Consulate of the Sea and Related Documents*. Mobile: University of Alabama Press.
- Kislev, M. 1988. Fruit remains. In *The Egyptian Mining Temple at Timna* (ed. B. Rothenberg). London: Institute of Archaeology, pp. 236–41.
- Knapp, A. B. 1991. Spice, drugs, grain and grog: organic goods in Bronze Age East Mediterranean trade. In *Bronze Age Trade in the Mediterranean* (ed. N. H. Gale). Studies in Mediterranean Archaeology 90. Göteborg: Paul Åströms Förlag, pp. 19–66.
- Kroll, H. 1984. Zum ackerbau gegen end deer Mykenischen epoche in der Argolis. *Archäologische Anzeiger*, 5: 211–22.
- Leonard, A. 1981. Consideration of the morphological variation in the Mycenaean Pottery from the southeastern Mediterranean. Bulletin of the American Schools of Oriental Research, 241: 87–101.
- Loret, V. 1949. *La résin de térébinthe (sonter) chez les anciens Égyptiens*. L'Institute Française d'Archéologie Orientale, Recherches d'archéologie de philologie et d'histoire 19. Cairo.
- Melena, J. L. 1983. Olive oil and other sorts of oil in the Mycenaean tablets. *Minos*, 18: 89–123.
- Mills, J. and White, R. 1989. The identity of the resins from the Late Bronze Age shipwreck at Ulu Burun (Kas). *Archaeometry*, 31(1): 37–44.

- Parker, A. J. 1981. Stratification and contamination in ancient Mediterranean shipwrecks. *International Journal of Nautical Archaeology*, 10: 309–35.
- Pliny. *Natural History*.
- Pulak, C. 1988a. The Bronze Age shipwreck at Ulu Burun: 1985 Campaign. *American Journal of Archaeology*, 92: 1–37.
- Pulak, C. 1988b. Excavations in Turkey: 1988 Campaign. *INA Newsletter*, 15(4): 12–17.
- Runnels, C. N. and Hansen, J. M. 1986. The olive in the prehistoric Aegean. *Oxford Journal of Archaeology* 5: 299–308.
- Shelmerdine, C. W. 1984. The perfumed oil industry at Pylos. In *Pylos Comes Alive: Industry and Administration in a Mycenaean Palace* (eds T. G. Palaima and C. W. Shelmerdine). New York: Archaeological Institute of America, pp. 81–95.
- Shelmerdine, C. W. 1985. *The Perfume Industry at Pylos*. Studies in Mediterranean Archaeology, Pocketbook 34. Göteborg: P. Åström's Förlag.
- Theophrastus. *Enquiry into Plants*.
- Whitehouse, W. E. 1957. The pistachio nut. *Economic Botany*, 11: 281–321.
- Zohary, D. and Hopf, M. 1988. *Domestication of Plants in the Old World*. Oxford: Clarendon Press.

Abstract

Haldane, Cheryl

Direct evidence for organic cargoes in the Late Bronze Age

The excavation and recovery of plant remains from the Late Bronze Age shipwreck at Ulu Burun provides direct evidence of traded organic goods in the eastern Mediterranean. Archaeobotanical studies contribute to a better understanding of economic systems by identifying seaborne cargoes that leave few traces on land but are preserved on shipwreck sites.