Plant Use at Grapčeva Cave and in the Eastern Adriatic Neolithic

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Plant macroremains were recovered during the renewed excavation at Grapčeva Špilja, a cave on the island of Hvar in Croatia. This is the first archaeoboatnical investigation on an eastern Adriatic island to use flotation samples. Samples were taken from layers dating from the Early Neolithic to the Middle Bronze Age (ca. 6000–1500 B.C.*). Sixteen radiocarbon dates obtained from wood charcoal date the samples precisely. Detailed archaeobotanical analyses of plant macroremains reveal plant use during the occupation of the cave, with the highest density of plant remains in the Neolithic. Oak acorns were the most abundant plant remains. Finds of two types of juniper berry cones, various parts of gymnosperm cones, and cypress seeds and leaves indicate that the Mediterranean evergreen woodland was exploited. Remains of cultivated plants are rare. A small number of cereal grains, including emmer, einkorn, and possibly bread wheat were recovered from the Neolithic layers, as well as a few wheat grains from later horizons. Remains of typical wild Mediterranean fruits included almond nutshell fragments, a grape pip, and a fig seed. These finds indicate that the occupants of Grapčeva utilized processed crops but also gathered plants from the wild for food, fuel, and perhaps ritual. Fourier Transform Infrared Spectroscopy (FTIR) analysis was performed in order to assess charred versus mineralized preservation. Macroplant remains from Grapčeva were compared to the few available plant analyses from the eastern Adriatic. This comparison provides evidence that caves had different functions both from each other and from open-air sites. The plant remains are discussed in the context of the spread of farming on both sides of the Adriatic.*

Introduction

Renewed excavations using modern techniques and recovery methods were carried out at Grapčeva Špilja by the members of the Adriatic Islands Project in 1996 (Forenbaher and Kaiser 2000, 2008; Gaffney et al. 1997). Grapčeva is a cave located on Hvar, one of the largest islands in the Adriatic Sea (FIG. 1). The cave has a sequence of layers dating from the Early Neolithic to the Late Bronze Age (6000–1500 CAL B.C.), but is best known for its Late Neolithic finds.

The cave has attracted the attention of archaeologists for many years. Archaeologist Grga Novak carried out extensive excavations covering about one third of the cave's surface area (ca. 100 sq m) between 1947 and 1950 (Novak 1955). The distinctive Late Neolithic pottery Novak discovered at the cave inspired him to name the assemblage the "Hvar Culture," a designation that was subsequently

Figure 1. Map of the Adriatic showing the location of Grapčeva Cave and other sites mentioned in the text. Inset shows Grapčeva Cave on the island of Hvar and other central Dalmatian islands in the Eastern Adriatic.

applied to similar Late Neolithic assemblages throughout the eastern Adriatic region. Novak was impressed by the richness of the pottery finds and by the presence of human bones. He thought that Grapčeva served as a cult site where gods or ancestors were worshipped rather than as a place of habitation (Novak 1955). Grapčeva became regarded as a key site in Adriatic, and indeed Mediterranean, prehistory (see Trump 1980: 133; Wilkes 1992: 34).

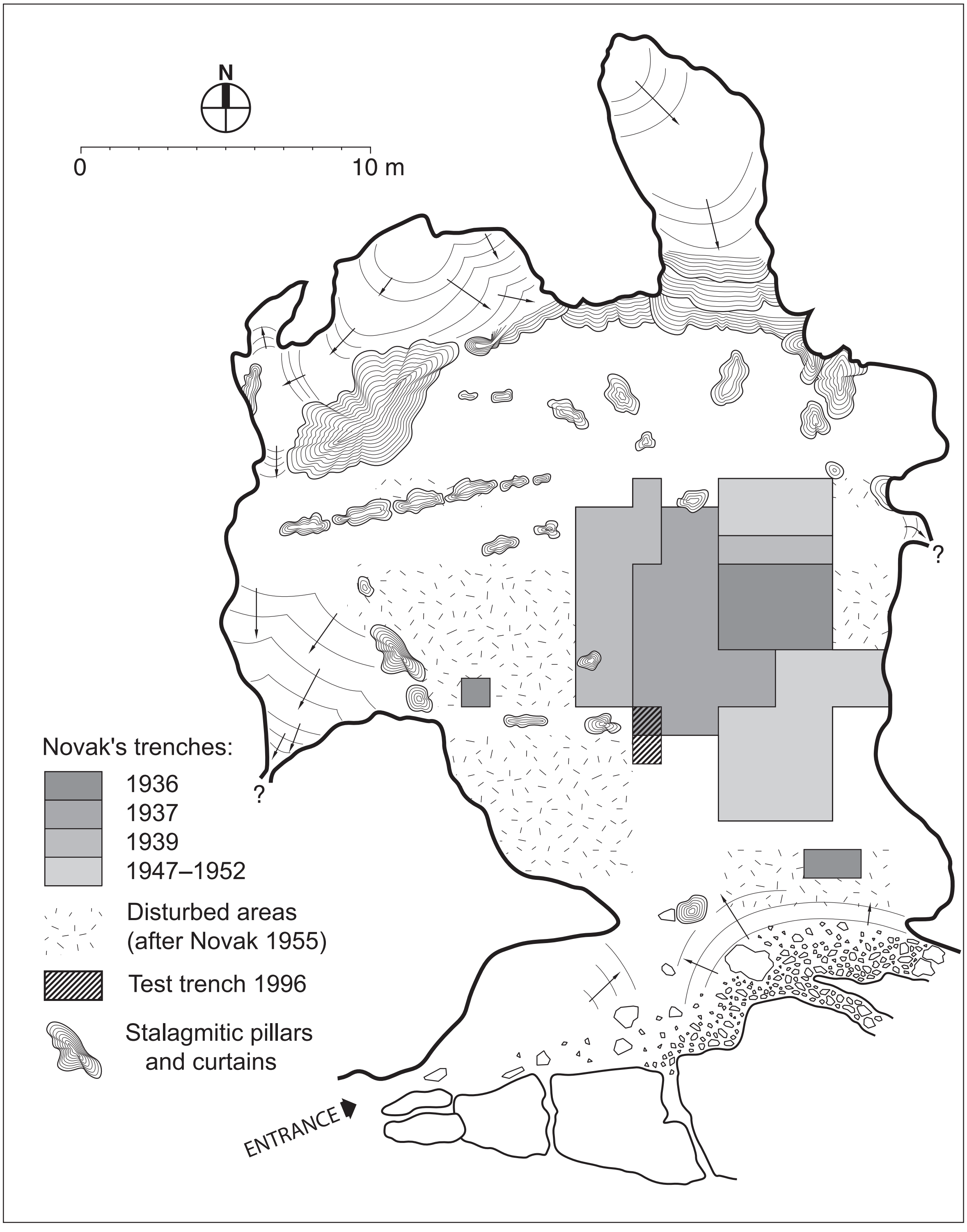

Figure 2. Plan of Grapčeva Cave showing the areas excavated previously by Grga Novak, as well as the control trench excavated in 1996 from which flotation samples were collected.

In 1996, a 1 × 2 m control trench (FIG. 2) was opened on the edge of the (backfilled) previous excavation and extended into an unexcavated area (Forenbaher and Kaiser 2000, 2008). During the excavation, soil samples were col-

Figure 3. View of the interior of Grapčeva Cave with stalagmites typical of the karstic environment.

lected for flotation (Darmanin, Kaiser, and Kirigin 1997). Sixteen radiocarbon dates were obtained from wood charcoal from the same stratigraphic units (SU) as the flotation samples, providing precise dating of the samples. In 2001, Timothy Kaiser, one of the project's excavators, submitted already floated and coarsely sorted samples to one of us (K. B.) for archaeobotanical examination. A preliminary report from the recent excavations was published by Forenbaher and Kaiser (2000) and a monograph detailing excavations, dating, and other archaeological analyses is forthcoming (Forenbaher and Kaiser 2008).

Until this study, no archaeobotanical investigation had been undertaken from a cave on an island in the eastern Adriatic Sea. The main aims of this analysis were to identify plant remains in Grapčeva Cave, to investigate taphonomic processes that led to different preservation of the plant remains (namely, charred versus mineralized preservation), and to reconstruct possible change in plant use through time. This study of plant macroremains yielded significant information about past human use of Grapčeva as well as its surrounding environment, a site already regarded as important to our understanding of Adriatic archaeology, and the Hvar culture in particular. Although first identified on Hvar, the characteristic pottery of this late Neolithic culture has since been found along Dalmatia and inland beyond the eastern Adriatic (Batović 1979).

The study of plant remains from a well-dated stratigraphic sequence at Grapčeva provides new information on plant exploitation which is important for understanding the spread of farming in the eastern Adriatic. It also offers an independent line of evidence for determining change in cave use from the 6th to the 2nd millennium B.C.

The Site and Environment

Grapčeva consists of a single large hall some 25 m across, divided by stalagmitic pillars and curtains into a number of unequally sized spaces (FIGS. 2, 3). It is situated at 239 masl on Hvar's south central coast in a karstic environment typical of the Dalmatian islands. The entrance to the cave faces south to the Adriatic Sea and the small island of Šćedro (FIG. 4).

Hvar is a long, narrow island dominated by a mountainous rocky spine that runs the length of the island and a large, low plain in the north central section (FIG. 1). The southern coast is steep, in places sheer cliff, while the northern shore is indented by numerous short valleys that terminate as coves and bays. Currently, there are no rivers on the island, but there are several small fresh water springs, the largest one being near Jelsa. Marshes that were close to the coast near Jelsa dried out in the middle of the 19th century. Nearer to Grapčeva there is a small spring at Virak cove located just beneath the site (Forenbaher and Kaiser 2000; Novak 1955).

According to Novak, the island was heavily forested in the beginning of the 20th century, which suggests that it was similarly forested in the past. Novak mentions that there was a vineyard in front of the cave and that almonds, fig trees, and Dalmatian chrysanthemum were planted above it. Using the local vernacular, Novak (1955: 19) identifies types of plants growing around the cave as Dal-

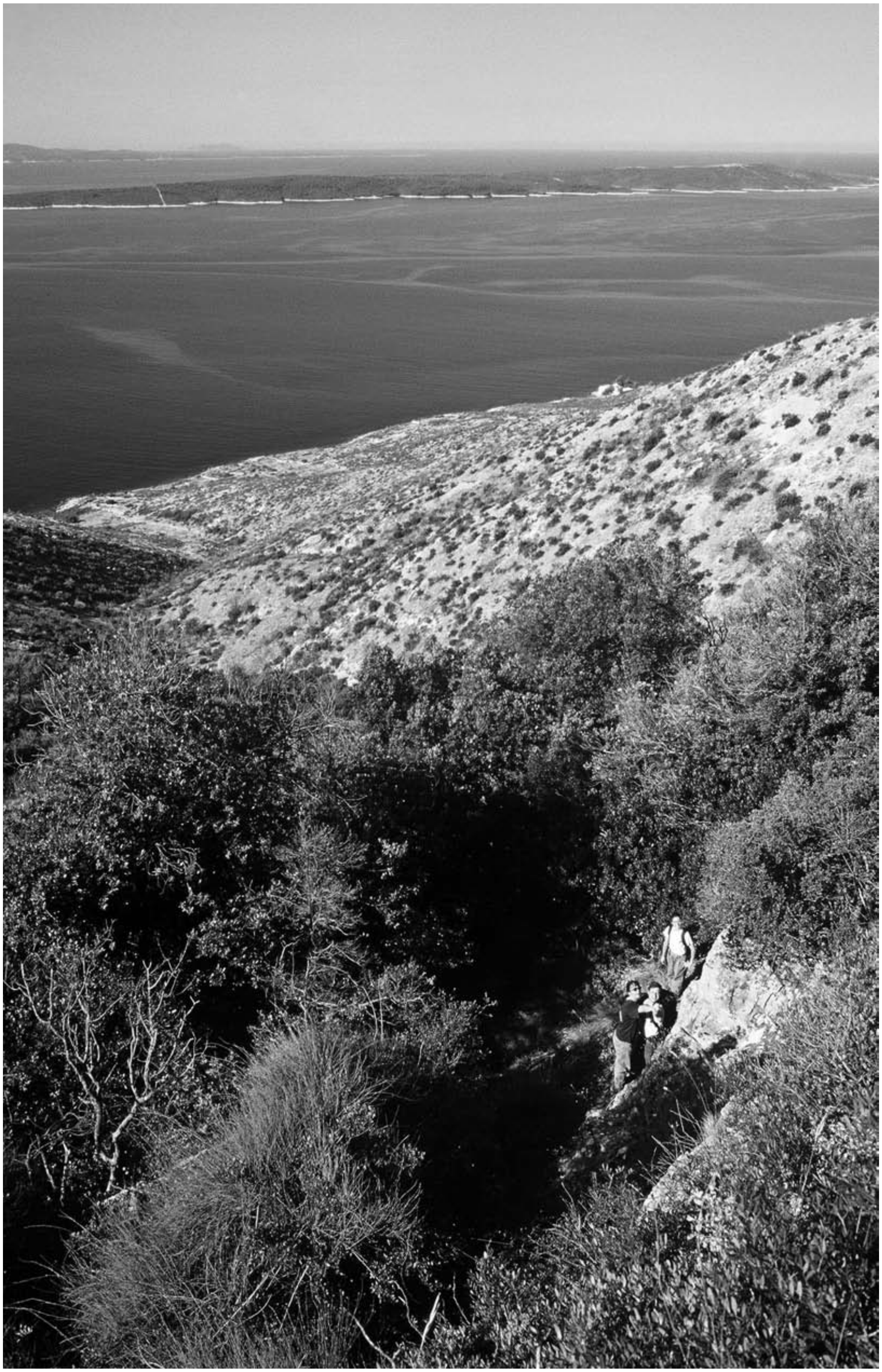

Figure 4. View of the entrance of Grapčeva Cave with the present-day vegetation. The entrance of the cave faces south. In the back is the island of Šćedro.

Table 1. Periods and horizons, depths, dating, number of analyzed flotation samples per period, and stratigraphic units of analyzed samples.

Period/horizon/phase	*Depth of horizons (m)*	*Date (millennium B.C.)*	*Samples per horizon*	*Stratigraphic units of samples*
Early and Middle Neolithic—Phase 0	2.5	6th	3	1400, 1410, 1420
Late Neolithic (Classic Hvar)—Phase 1	2.5–1.5	Early–middle 5th	11	1310, 1311, 1312, 1320, 1330, 1340, 1350, 1360, 1370, 1380, 1390
Late Neolithic (Late Hvar)—Phase 2	1.5–1.4	Last quarter 5th	3	1280, 1290, 1300
Early Copper Age (Nakovana)—Phase 3	1.4–1.1	Middle–late 4th	6	1230, 1240, 1250, 1260, 1262, 1270
Late Copper Age (Early Cetina)—Phase 4	1.1–0.9	3rd	3	1200, 1210, 1220
Early Bronze Age—Phase 5.1	0.9–0.6	Late 3rd	11	1090, 1100, 1110, 1120, 1130, 1140, 1150, 1160, 1170, 1180, 1190
Middle Bronze Age—Phase 5.2	0.6–0.2	First half 2nd	4	1040, 1060, 1070, 1080

matian black pine, Mediterranean cypress, strawberry tree, Holm oak, spruce, scotch heather, juniper, sage, and rosemary, among others (FIG. 4).

Present-day Hvar has a typical Mediterranean climate with an annual mean temperature of 16.5 degrees C and an average rainfall of 701 mm per year. The largest part of the forest in the littoral belt consists of Aleppo pine (*Pinus halapensis*) and Holm oak (*Quercus ilex*) forests, while in the montane belt there are Dalmatian pine forests (*Pinus nigra* subsp. *dalmatica*; Trinajstić 1985, 1993). There are no pollen analyses from Hvar that would provide direct information about the changing vegetation of the island during the Neolithic period or after. Recent palynological investigations of deposits from Malo Jezero (Jahns and Bogaard 1998; Jahns 2002), a lake on the island of Mljet south of Hvar (FIG. 1), along with a recent synthesis of the development of postglacial vegetation in coastal Croatia from the Boreal Period (Šoštarić 2005), provide some insights into the reconstruction of potential vegetation on Hvar and in Dalmatia generally.

Archaeological Context

During excavation of the control trench in 1996, the excavators uncovered a sequence of undisturbed layers about 2.5 m thick overlying a massive stalagmite crust (FIG. 5). The upper layers, down to 1.5 m, consist of numerous compact, thin lenses of humus, ash, and charcoal. In the upper layers, the accumulation rate was slower than in the lower layers, approximately 50 cm per 1000 years. Obvious changes in the stratigraphy occur around 1.5 m below the surface. The lower layers, from 1.5–2.5 m, consist of relatively homogeneous and loose, thick, dark humic layers with high percentages of small angular rock and quantities of charcoal. The excavators identified five hearths made of thin layers of compacted clay which were split into six superimposed segments. Below these layers were compact calcareous silt layers without archaeological remains. Forenbaher and Kaiser (2000, 2008) divided the stratigraphic sequence into seven main phases and several subphases. From bottom to top, these are as follows: Early and Middle Neolithic (0); Late Neolithic, Classic Hvar (1.1, 1.2, and 1.3); Late Neolithic, Late Hvar (2); Early Copper Age, Nakovana (3.1 and 3.2); Late Copper Age, Early Cetina (4); Early and Middle Bronze Age (5.1 and 5.2); Recent (6). The 16 radiocarbon dates are illustrated in Figure 5 (Forenbaher and Kaiser 2000).

One of the tasks of the recent excavations at Grapčeva was to implement careful and systematic recovery of plant remains. From the control trench, three-liter soil samples were collected for flotation from each context deemed at the time of excavation to be relatively undisturbed. Table 1 shows the location of stratigraphic units from which samples were taken, their cultural attribution and dating. The flotation samples were recovered from distinctive but similar contexts: hearths and humus and ash above the hearths. Thus the contexts are comparable. It was not possible to establish the spatial distribution of the plant remains within the cave because the samples came from a small trench (1 × 2 m). Post-depositional preservation processes were investigated using Fourier Transform Infrared Spectroscopy (FTIR) analysis (FIG. 6).

Flotation and Analysis

A flotation machine was specially constructed from a metal barrel for this project. In total, 41 soil samples were floated. All samples were 3 liters in volume. The barrel had a constant supply of water and the samples were manually agitated. Two screens, sizes 1.0 mm and 0.425 mm, were used to collect the light fraction. The flot samples (light fraction) were air-dried and later packed in gauze pouches (Darmanin, Kaiser, and Kirigin 1997). Heavy fraction remains larger than 1 mm were air-dried and sorted into different botanical categories, e.g., seeds larger and smaller than 4 mm, and wood charcoal larger and smaller than 4 mm.

The plant samples were stored until 2001 when 203 bags of light and heavy fraction flotation and hand collected samples were analyzed at the Paleoethnobotany Labo-

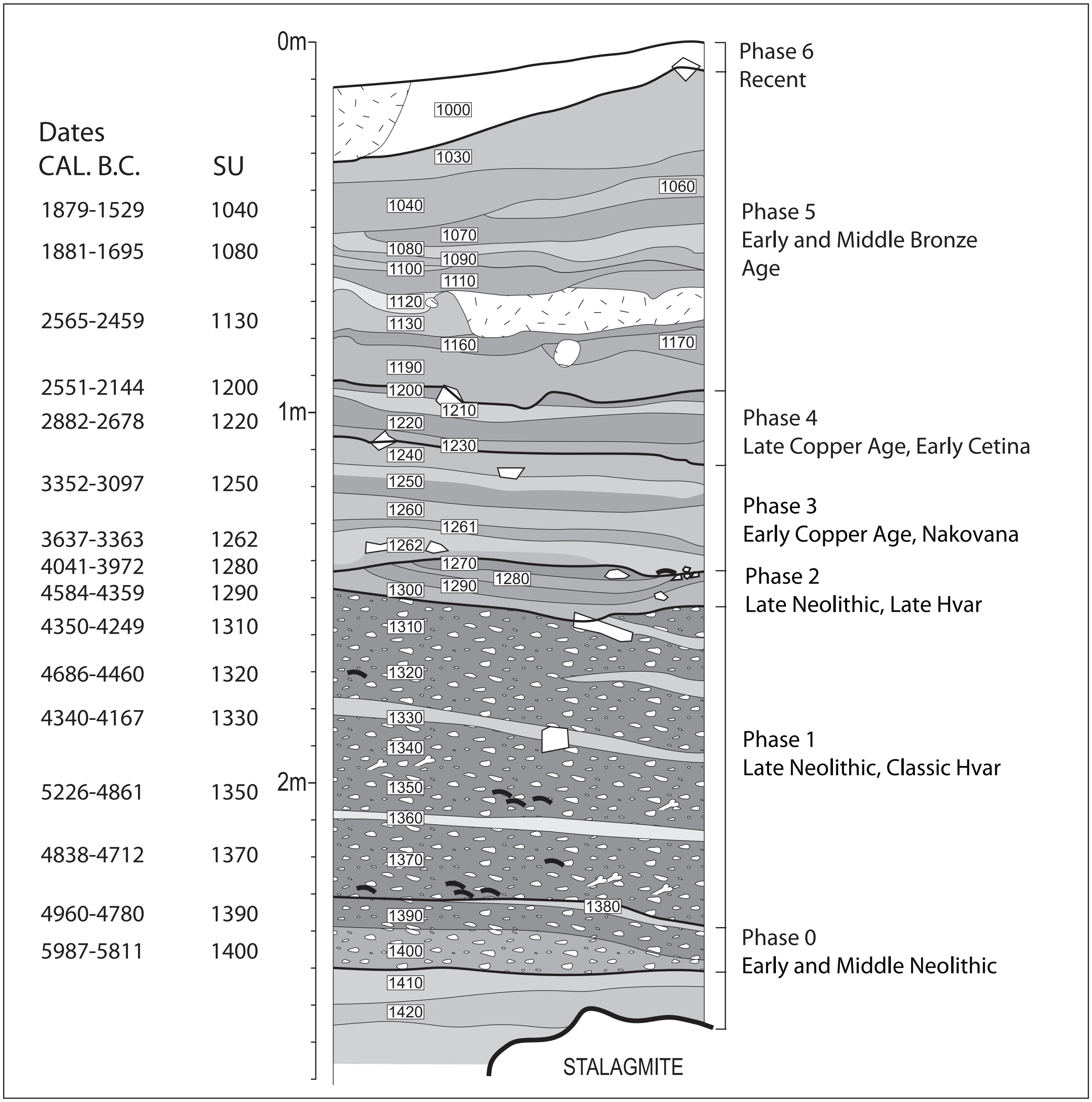

Figure 5. The stratigraphy of Grapčeva Cave (South Profile), cultural phases, and horizons of the control trench excavated in 1996 linked with calibrated radiocarbon dates (1 SD range). The numbers of stratigraphic units (SU) are shown on the section. Relative depth (m) of the excavation trench is indicated on the left. Details on calibrated radiocarbon dates from Grapčeva Cave appear in Forenbaher and Kaiser (2000).

ratories of the University of Alabama at Birmingham and Boston University from 2001 to 2006. In total, flotation samples from 41 stratigraphic units (contexts), including hand-collected samples were analyzed (TABLE 1). Initially, light and heavy fraction bags were analyzed separately and tabulated for each stratigraphic unit. The total numbers of specimens include counts of material from both light and heavy fraction for each stratigraphic unit plus the hand-picked plant material, mostly acorn cotyledons, indicated in parenthesis. The number of acorns, considering two

Table 2. Counts and weights of identified plant remains from Grapčeva flotation samples grouped by period. Numbers in parentheses indicate plant specimens recovered by hand from a screening sieve. Weight is rounded to the nearest hundredth of a decimal point. Asterisks indicate mineralized plant remains, all others were charred.

Period/horizon	*Early and Middle Neolithic*		*Late Neolithic (Classic Hvar)*		*Late Neolithic (Late Hvar)*		*Early Copper Age (Nakovana)*	
Phase	0		1		2		3	
Dates (millennium B.C.)	6th		Early and middle 5th		Last quarter 5th		Middle and late 4th	
Count and weight (g)	Ct.	Wt.	Ct.	Wt .	Ct.	Wt .	Ct.	Wt .
Number of samples analyzed per period(3 liters of soil each)	3	–	11	–	3	–	6	–
Weight (g) of the samples	–	9.83	–	240.82	–	11.77	–	18.38
Wood charcoal weight (g)	–	4.55†	–	213.57	–	8.26	–	8.74
Taxa (common names)								
Cereals (grains)								
Triticum dicoccum (emmer)	–	–	3	0.04	–	–	–	–
Triticum monococcum (einkorn)	–	–	1	0.01	–	–	–	–
Triticum cf. *aestivum* (bread wheat)	–	–	2	0.02	–	–	–	–
Triticum sp. (wheat)	–	–	14	0.07	–	–	1	0.01
cf. *Hordeum* sp. (barley?)	–	–	2	0.02	–	–	–	–
Cerealia fragments (cereals)	–	–	14	0.05	–	–	–	–
Legumes								
Lens culinaris (lentil)	–	–	1	0.01	–	–	–	–
Fabaceae (legume)	–	–	1	–	–	–	–	–
Weeds and ruderals								
Asteraceae (daisy)	–	–	–	–	–	–	–	–
Caryophyllaceae (pink)	–	–	1	0.01	–	–	–	–
Convolvulaceae (morning-glory)	–	–	–	–	–	–	–	–
Poaceae (grass)	–	–	1	0.01	–	–	1	0.01
Small legume seeds	–	–	–	–	–	–	–	–
Fruits, nuts, cones								
Amygdalus communis nutshell (almond)	–	–	17	0.17	–	–	–	–
cf. *Ficus carica* nutlet (fig?)	–	–	–	–	–	–	–	–
Vitis vinifera subsp. *sylvestris* pips* (grape)	–	–	–	–	–	–	–	–
Quercus sp. nutshell (acorn cupule)	–	–	–	–	1	0.01	–	–
Quercus sp. cotyledon fragments	–	–	20	0.82	9	0.09	22	0.11
Quercus sp. cotyledons (acorn meat)	–	–	(3)	(0.73)	–	–	(16)	(5.78)
Juniperus phoenicea berry cone (juniper)	–	–	6	0.28	–	–	–	–
Juniperus sp. berry cone fragment (juniper)	–	–	3	0.02	1	0.01	–	–
Juniperus sp. berry cone* (juniper)	–	–	10	0.09	–	–	–	–
Pinus sp. cone (pine)	–	–	1	0.01	–	–	–	–
cf. Gymnosperm cone fragments (evergreen cone)	–	–	9	0.03	4	0.02	5	0.02
cf. *Cupressus* sp. seeds (cypress)	–	–	16	0.28	2	0.01	2	0.01
Cupressus/Juniperus leaf (cypress/juniper)	–	–	–	–	–	–	–	–
Thick nut fragment	–	–	–	–	–	–	(2)	(0.59)
Small rounded reticulate seeds*	–	–	–	–	–	–	–	–
Plant material unidentified	–	–	30	0.11	3	0.11	6	0.12
Unknown seed	–	–	4	0.04	2	0.02	2	0.03
Unknown seed fragment	–	–	4	0.04	2	0.02	1	0.01
Undetermined	–	–	3	0.03	2	0.03	3	0.62

*These plant remains were mineralized. All others were charred.
† Only wood charcoal was recovered from this horizon.

cotyledons per acorn, was calculated when the number of whole acorns (from SU 1262) was divided by their weight, averaging 0.56 g per acorn. The counts and weights of identified plant specimens from each stratigraphic unit were added and grouped according to period and cultural attribution, for example, Late Neolithic–Classic Hvar Horizon, etc. (TABLE 2). In order to standardize counts, density (average abundance) of counts and weights was computed for each period; that is, total count and weight of specimens per period was divided by the volume (liters) of floated samples from the layers attributed to that period (FIGS. 7, 8). Seven large wood charcoal pieces from four stratigraphic units were examined in detail and some identified to the genus level (TABLE 3).

Late Copper Age (Early Cetina)		*Early Bronze Age*		*Middle Bronze Age*			
4		5.1		5.2			
3rd		Late 3rd		First half 2nd			
Ct.	Wt.	Ct.	Wt.	Ct.	Wt.	Total Ct.	Total Wt.
3	–	11	–	4	–	41	–
–	6.68	–	27.06	–	16.53	–	331.07
–	2.41	–	7.81	–	10.35	–	255.69
–	–	–	–	–	–	3	0.04
–	–	–	–	–	–	1	0.01
–	–	–	–	–	–	2	0.02
	–	3	0.02	1	0.01	19	0.12
–	–	–	–	–	–	2	0.02
–	–	–	–	–	–	14	0.05
–	–	–	–	–	–	1	0.01
–	–	–	–	–	–	1	–
–	–	1	0.01	–	–	1	0.01
–	–	3	0.02	–	–	4	0.03
–	–	1	0.01	–	–	1	0.01
–	–	3	0.01	–	–	5	0.03
–	–	–	–	2	0.01	2	0.01
–	–	–	–	–	–	17	0.17
–	–	1	0.01	–	–	1	0.01
–	–	1	0.01	–	–	1	0.01
1	0.01	40	0.04	–	–	42	0.06
–	–	1	0.19	–	–	52	1.21
–	–	(3)	(0.66)	–	–	(22)	(7.17)
–	–	–	–	–	–	6	0.28
–	–	–	–	–	–	4	0.03
6	0.02	1	0.03	2	0.15	19	0.29
–	–	–	–	–	–	1	0.01
–	–	–	–	–	–	18	0.07
–	–	1	0.01	–	–	21	0.31
3	0.01	–	–	–	–	3	0.01
–	–	–	–	–	–	(2)	(0.59)
5	0.03	–	–	–	–	5	0.03
10	0.07	29	0.43	4	0.06	82	0.9
–	–	11	0.05	1	0.01	20	0.15
1	0.01	12	0.06	2	0.015	22	0.155
–	–	–	–	1	0.06	9	0.74

Identification of plant macroremains was done with the aid of low-power (6.3–63 ×) microscopes and micro-photographs. The identification of the plant macroremains was based on the morphological characteristics of plant material, using reference collections of the Palaeoethnobotany Laboratory at Boston University and the Asa Grey Herbarium, Harvard University.

Preservation and Fourier Transform Infrared Spectroscopy (FTIR)

Plant macroremains in caves can be deposited either fresh or charred, and later preserved as desiccated, mineralized, or charred (carbonized). They are often subject to various kinds of alterations making it difficult to distinguish

Table 3. Identified wood charcoal from flotation samples from the stratigraphic units (SU).

SU	*Type of wood*
1350	Ring porous cf. *Quercus* sp.
1350	Soft without resin cf. *Juniperus* sp.
1311	Soft without resin canals cf. *Juniperus* sp.
1310	Ring porous cf. *Quercus* sp.
1310	Soft with resin canals
1260	Soft with resin canals
1260	Soft without resin canals cf. *Juniperus* sp.

different modes of arrival and post-depositional process (Hansen 2001). While most of the plant remains from Grapčeva were charred, some were preserved through a process of mineralization. We decided to conduct FTIR analysis in order to assess different preservation types (mineralized vs. charred) and to further investigate taphonomic processes that have led to different preservation of plant remains. Another objective was to exclude the possibility of intrusion of modern plants into the cave deposits and hence in the flotation samples.

FTIR is a powerful tool for identifying the organic and mineralogical components of materials of archaeological specimens. Only a small amount of material is needed for the analysis (a few micrograms are sufficient), allowing high-resolution investigations with minimal damage to the specimens.

Five of the seven analyzed specimens were taken from among the Grapčeva flotation samples; these specimens included both plant and what turned out to be non-plant material. Two other specimens subjected to FTIR were reference plant specimens: juniper berry cones of *Juniperus phoenicea* and *Juniperus excelsa* from the Harvard Herbarium (TABLE 4). We decided to focus on juniper cone berries (FIGS. 9) because they were found charred and/or uncharred from all the horizons in the cave and because we wanted to determine whether the specimens were actually mineralized plant cone berries or perhaps modern intrusions.

The analysis of seven different specimens was made using a Nicolet Nexus 470 spectrometer at the Department of Archaeology, Boston University. Representative FTIR spectra were obtained by grinding a few tens of micrograms of sample using an agate mortar and pestle. About 0.1 mg or less of the sample was mixed with about 50 mg of KBr (IR-grade). A 7 mm pellet was made using a hand press (Qwik Handi-Press, Spectra-Tech Industries Corporation) without evacuation. The spectra were collected between 4000 and 400 wavenumbers expressed in reverse cm (cm^{-1}) at 4 cm^{-1} resolution.

Results of the FTIR analysis are presented in Table 4 and in Figure 6. The IR spectra of the reference berry cones of *Juniperus phoenicea* and *Juniperus excelsa* from the Harvard Herbarium were both characterized by numerous absorptions of the resinous material contained in the two fruits (FIG. 6A, B). The two berry cones of different species show identical IR patterns suggesting that the use of this technique is not helpful for differentiation of the two species with the same genus. The analysis has demonstrated that the two cones were preserved in an identical manner regardless of their different age; the specimen of *Juniperus phoenicea* was collected 28 years ago and that of *Juniperus excelsa* 79 years ago.

The IR pattern of a particle of charred *Juniperus phoenicea* berry cone from the late Neolithic horizon (FIG. 6C) was characterized by the absorptions of well preserved charred material with graphite-like structure (Ch) as described by Cohen-Ofri et al. (2006). None of the resinous material present in the modern juniper berries survived the carbonization process of the juniper berries from the past.

The mineralized *Juniper* sp. berry cone particle (SU 1340) showed IR absorptions (see Ch in FIG. 6D) typical of the mineral carbonated hydroxyl apatite (Weiner, Goldberg, and Bar-Yosef 1993). This kind of apatite forms commonly in the sediments of cave environments and/or anthropogenic contexts due to the decomposition of large quantities of organic matter such as bat and bird guano or herbivorous dung (Shahack-Gross et al. 2004). The organic material from the cell walls of the juniper berry was replaced by the large quantity of phosphate present in the soil solution indicating that a similar phosphatization process could have taken place at Grapčeva. A small, mineralized, rounded, unidentified reticulate seed (one of five from the heavy fraction from SU 1220) is also composed of carbonated hydroxyl apatite as shown by its IR pattern (FIG. 6E).

The FTIR analysis demonstrates that similar taphonomic processes led to the mineralization of juniper berry cones from the Late Neolithic horizon and the small, rounded, unidentified reticulate seeds from the Later Copper Age horizon, separated by ca. 1 m of interlaying deposits (FIG. 4). Furthermore, we confirmed that the light-colored botanical specimens are mineralized and are not modern inclusions.

A "pea-like" small, light, rounded particle from the same stratigraphic unit as the small, rounded, unidentified reticulate seeds (FIG. 6F) shows absorptions characteristic of the mineralogical components of soil forming in karstic environments; these are clay minerals (Cl) such as illite-smectite (I-S) and kaolinite (K), quartz (Q) sand and silt, and calcite (C) (Van der Marel and Beutelspacher 1976). Similarly, the absorption spectra of dark, rounded particles which were found in the same context as mineralized ju-

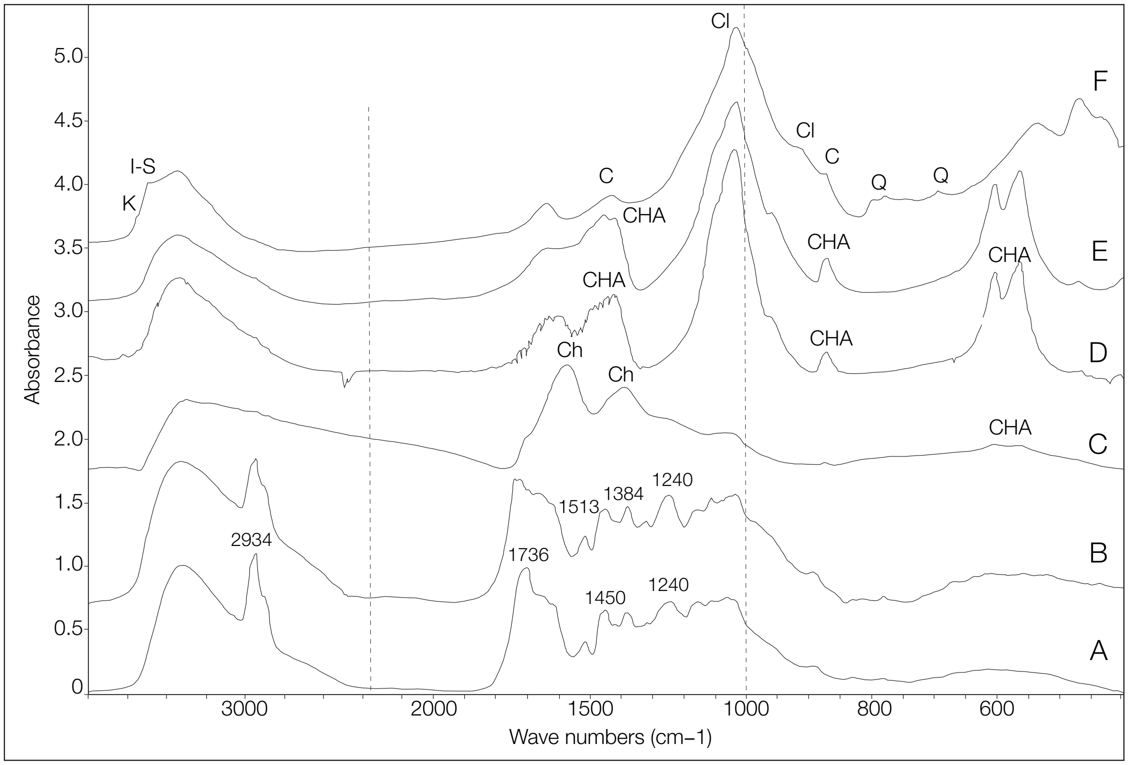

Figure 6. FTIR spectra of specimens from Grapčeva Cave and modern plant specimens. A) Fresh berry of *Juniperus phoenicea* collected in 1980 (Harvard Herbarium). The IR spectrum is characterized by numerous absorptions of resinous material composing the specimen; B) Berry of *Juniperus excelsa* collected in 1929 (Harvard Herbarium). The IR pattern is similar to specimen A (*Juniperus phoenicea*); C) Charred *Juniperus phoenicea* seed from SU 1312: Note the IR absorptions at ca. 1377 and 1570 cm^{-1} (Ch) characteristic of well preserved charred material with graphite-like structure (Cohen-Ofri et al. 2006); D) Mineralized *Juniperus* cf. *excelsa* berry from SU 1340. Note the characteristics IR absorptions of calcium phosphate carbonated hydroxyl apatite (CHA) at 567, 603, 875, 1035, 1420, and 1450 cm^{-1} (Weiner, Goldberg, and Bar-Yosef 1993); E) Unidentifiable mineralized reticulate seed from SU 1220. The IR pattern is highly comparable to specimen D; F) Rounded dark brown particle of dubious botanical origin from SU 1340. Note the characteristic absorption of the mineralogical components of soil forming in karstic environment: Clay minerals (Cl) at ca. 915 and 1030 cm^{-1} such as illite-smectite (I-S) at ca. 3615 cm^{-1} and kaolinite (K) at ca. 3700 cm^{-1}, quartz (Q) sand and silt at ca. 695, 778, and 795 cm^{-1} and calcite (C) at ca. 712, 875, and 1430 cm^{-1} (Van der Marel and Beutelspacher 1976).

Table 4. The results of the FTIR analysis: specimens analyzed, provenience, and their composition.

Sample description	*Provenience*	*Composition*
Mineralized unknown reticulate seed	Grapčeva SU 1220	Carbonated hydroxyl apatite
Mineralized *Juniperus* cf. *excelsa* berry	GrapčevaSU 1340	Carbonated hydroxyl apatite
Charred *Juniperus phoenicea* berry	Grapčeva SU 1312	Charcoal
Modern *Juniperus excelsa* berry	Harvard Herbarium collected in 1929	Resinous material
Modern *Juniperus phoenicea*	Harvard Herbarium collected in 1980	Resinous material
Rounded dark brown particle	Grapčeva SU 1340	Soil
Rounded "pea-like" particle	Grapčeva SU 1200	Clay

niper berries (SU 1340) were determined to be made of soil (not shown here). It is therefore certain that these small, rounded, "pea-like" particles and the dark ones are not of botanical origin. These findings are in agreement with previous microscopic observations.

Temporal Distribution of Plant Macroremains

Flotation samples were taken at Grapčeva from what were thought at the time of excavation to be undisturbed contexts (Forenbaher and Kaiser 2000), and it was possible to establish the temporal distribution of plant macroremains and to assess change through time in this part of the cave. The results obtained by the analysis of plant macroremains from 41 stratigraphic units at Grapčeva Cave are grouped below according to seven archaeological horizons within Phases 0–5 (TABLES 1–4; FIGS. 5, 7, 8). The radiocarbon dates were initially published in Forenbaher and Kaiser (2000).

Phase 0: Early and Middle Neolithic Horizon (6th Millennium B.C.)

Only a small quantity of wood charcoal was recovered from the three samples from this horizon and there were no non-wood remains. The paucity of plant remains is not surprising since the horizon was only 15 cm thick and was directly over the stalagmite crust (TABLE 1, FIG. 5). The excavators (Forenbaher and Kaiser 2008) interpreted the evidence to indicate rare and ephemeral visits to the cave during the Early and Middle Neolithic stretching over a period of about a thousand years.

Phase 1: Late Neolithic (Classic Hvar) Horizon (Early and Middle 5th Millennium B.C.)

The largest quantity of plant remains from both light and heavy fractions was recovered from this horizon. These remains were also the most diverse (TABLES 1, 2), which was expected because the layer was ca. 1 m thick and 11 flotation samples were collected from it. The samples were from a context associated with hearths, that is, from superimposed humic layers. The highest density of wood charcoal and plant macroremains is from this horizon (FIGS. 7, 8). It also yielded the highest density of potsherds, animal bones, and a few human bones, possibly from two individuals. Phase 1 may have lasted ca. 500 years (FIG. 5) (Forenbaher and Kaiser 2000).

The most abundant plant macroremains were acorn meat fragments (23 cotyledon fragments of *Quercus* sp. fruit including three whole, hand collected cotyledons). Parts of the fruits of other trees were also recovered from this horizon. Sixteen charred cypress (*Cupressus* sp.) (FIG. 9.1) seeds and cone fragments most probably belong to *Cupressus sempervirens*, also called Mediterranean cypress, which is common in this region. Additionally, there were other gymnosperm cone fragments which could not be more precisely identified, except for a fragment of a rather large gymnosperm cone.

Surprisingly, 17 charred fragments of the nutshell (endocarps) of almond fruits (*Amygdalus communis* subsp. *spontanea*) were identified from the heavy fractions alone, although they could have come from just one or two almonds (FIG. 9.2). Almond remains were only recovered from this horizon. The majority of the shell fragments (14) were found in adjacent contexts (SU 1312 and 1320). Unit 1320 was dated to 4686–4460 CAL B.C., but this date is considered too early (Forenbaher and Kaiser 2000, 2008). The radiocarbon date from the unit above (SU 1310) is 4350–4249 CAL B.C. (FIG. 5).

Exceptional finds include identified juniper berry cones from several stratigraphic units (four from SU 1320). Six charred berry cones were positively identified as *Juniperus phoenicea* (FIG. 9.3), along with three additional fragments of *Juniperus* sp., which probably belong to the same *J. phoenicea* species. Ten mineralized berry cone fragments of another juniper species were identified from the heavy fraction of SU 1340. The cone berries were a light cream color and rather deformed (FIG. 9.4). They resemble *Juniperus* berry cones and were sampled for FTIR analysis (above). There are no radiocarbon dates from these stratigraphic units, but the closest acceptable date is 4340–4167 CAL B.C. from the unit above (SU 1330). For identification purposes, archaeological juniper berries were compared with the modern juniper berries from the Harvard Herbarium that were also sampled for FTIR analysis. One charred cypress (*Cupressus* sp.) seed fragment from a cone was recovered from the heavy fraction. Only wood charcoal was recovered from the light fraction of the same sample (SU 1340), however. This stratigraphic unit was composed of very loose humus with large angular rocks next to a hearth. Human bones were recovered along with numerous pottery fragments, as well as animal bone, wood charcoal, and ash.

Several larger fragments of wood charcoal from the flotation samples from this horizon were examined in more detail (TABLE 3). Two specimens exhibit morphological features of soft wood without resin canals, characteristic of *Juniperus* sp. wood. One piece is ring porous wood, possibly of evergreen *Quercus* sp.

Crop remains are rare and the highest number was recovered from this horizon (TABLE 2). The majority of cereal grains were charred, poorly preserved, rather deformed and fragmented, and lacked distinctive species characteristics (FIG. 9.5–9.7). Moreover, no chaff remains were recovered, making the precise identification of grains ambiguous. The total number of cereal grains and fragments is 34, including three identifiable emmer grains (*Triticum dicoccum*) (FIG. 9.5), one grain of einkorn (*Triticum monococcum*) (FIG. 9.6), two grains that are likely bread wheat (*Triticum* cf. *aestivum*) (FIG. 9.7), and two grain fragments resembling barley (cf. *Hordeum* sp.). One lentil seed (*Lens culinaris*) was recovered from this horizon. The possible bread wheat grains are small, rounded, and rather flat and were classified as *Triticum* cf. *aestivum,* although without glumes

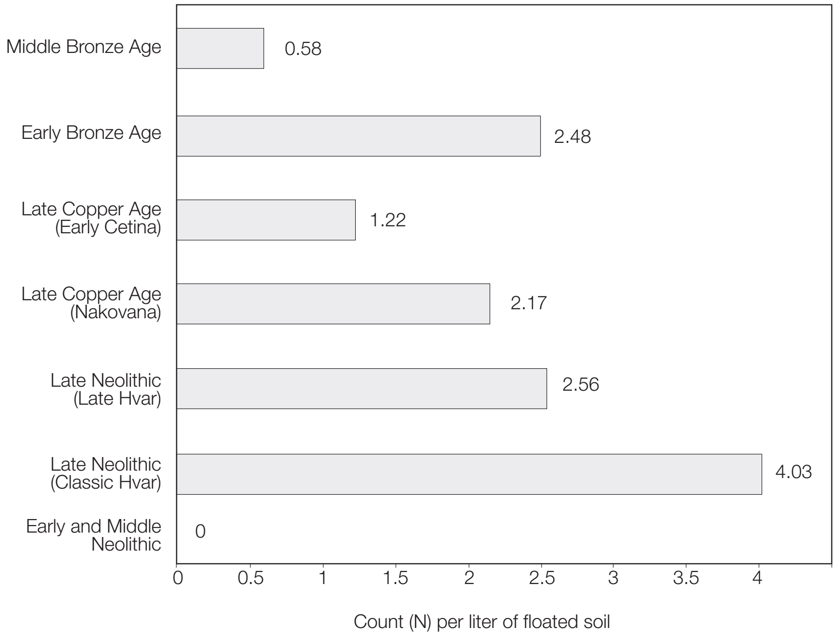

Figure 7. Density of plant specimens by count through periods. In the Early and Middle Neolithic periods only wood charcoal was recovered and weighed (see Figure 8).

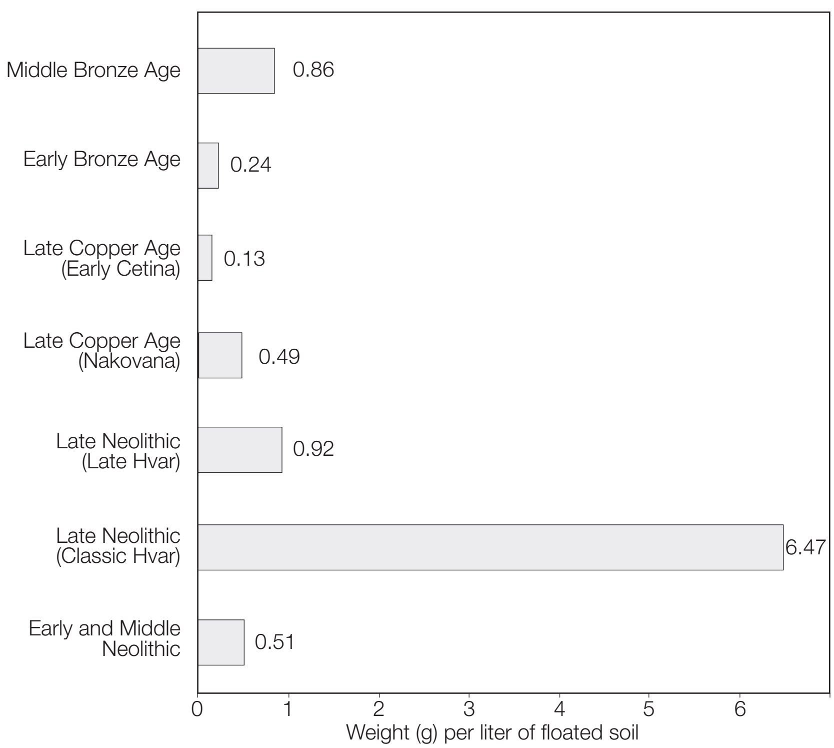

Figure 8. Density of wood charcoal by weight (g) through periods.

or rachis fragments such a distinction among free-threshing wheats cannot be ascertained (*Triticum aestivum/durum/turgidum*). The earliest appearance of *Triticum* sp. fragments is from SU 1390, radiocarbon dated to

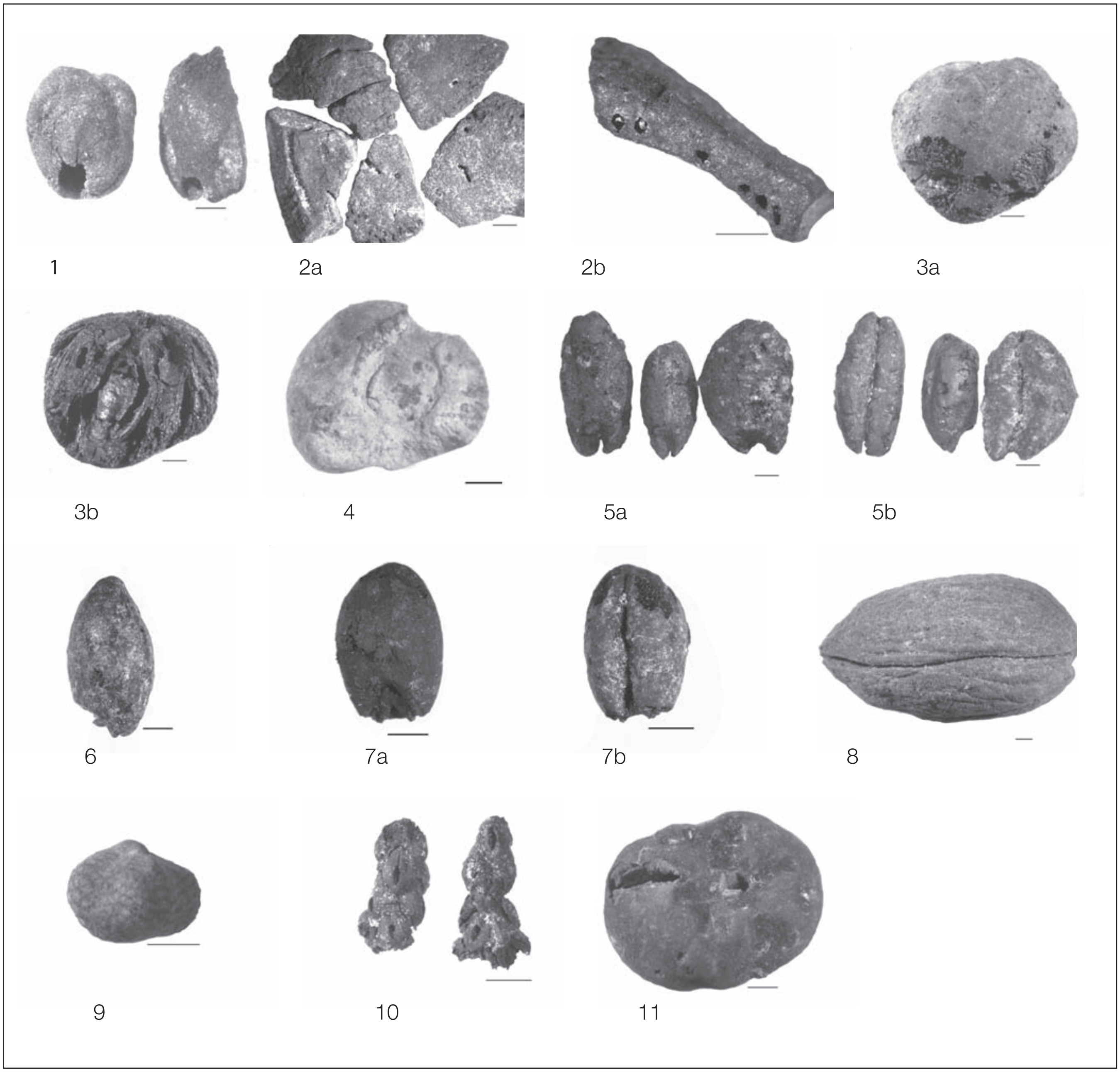

Figure 9. Selected plant macroremains from Grapčeva Cave. 1) Cypress seeds (*Cupressus* cf. *sempervirens*), SU 1370; 2) Nutshell (endocarps) of almond fruits (*Amygdalus communis* subsp. *spontanea*), SU 1320: a) fragments; b) cross section; 3) Juniper berry cones (*Juniperus phoenicea*), SU 1312: a) whole berry; b) cross section; 4) Mineralized juniper berry cones (*Juniperus* cf. *excelsa*), cross section of a berry, SU 1340; 5) Emmer grains (*Triticum dicoccum*—emmer and *Triticum* sp.), SU 1311: a) dorsal side; b) ventral side; 6) Einkorn grain (*T. monococcum*) lateral side, SU 1350; 7) Bread wheat grain (*T.* cf. *aestivum*), SU 1370: a) dorsal side; b) ventral side; 8) Acorn meat (cotyledon of *Quercus* cf. *ilex*), SU 1262; 9) Mineralized small unidentified seed with rounded reticulation, SU 1220; 10) Scaly leaves of *Juniperus* or *Cupressus* sp., SU 1220; 11) Mineralized juniper berry cone (*Juniperus* sp.), whole, SU 1040. All specimens charred unless indicated as mineralized. Scale = 1 mm.

4960–4780 cal b.c. The possible free threshing wheat *Triticum* cf. *aestivum* grain is from SU 1370, radiocarbon dated to 4838–4712 cal b.c. The most diverse sample possibly includes all three types of wheat mentioned above, a lentil seed, a gymnosperm cone, and acorn fragments is from SU 1350, dated to 5226–4861 CAL B.C. The date is considered too early by the excavators due to the "old wood effect" (Forenbaher and Kaiser 2000, 2008).

Phase 2: Late Neolithic (Late Hvar) Horizon (Last Quarter of the 5th Millennium B.C.)

This horizon is very thin and the samples come from three stratigraphic units. An obvious change in the stratigraphy begins in this horizon; it consists of a sequence of more compact, thin layers with a low accumulation rate. There is a low frequency of archaeological material and plant macroremains. The rather high density of plant macroremains (FIG. 7) is due to acorn fragments—cotyledons of *Quercus* sp. (9) and an acorn nutshell fragment (1), followed by gymnosperm cone fragments (4), *Cupressus* seeds (2), and a *Juniperus* cf. *phoenicea* cone berry fragment (1). No cereal grains were recovered from this horizon (TABLE 2). The accepted radiocarbon date 4041–3971 CAL B.C. is from SU 1280 (FIG. 5) from which eight acorn cotyledons and both cypress seeds were recovered.

Phase 3: Early Copper Age (Nakovana) Horizon (Middle and Late 4th Millennium B.C.)

Flotation samples were taken from 6 stratigraphic units. The majority of plant remains consist of acorn (FIG. 9.8), with 38 cotyledon fragments, including 16 hand-collected cotyledons. The remaining 22 acorn fragments from flotation contribute to the highest density of plant remains from this horizon (FIG. 7). Ten well preserved acorn cotyledons were measured for length and width and seem to be characteristic of the elongated *Quercus ilex* acorns (length: mean = 15.33 cm; min = 10.3 cm; max = 18.7 cm). Two fragments of a thick nutshell were also hand-collected, but could not be more precisely identified. Gymnosperm cone fragments (5) and *Cupressus* seed fragments (2) were recovered from the flotation samples. Only one *Triticum* sp. grain fragment was identified from SU 1250 (3352–3097 CAL B.C.) One half of a seed resembled *Bromus* sp. in cross-section but it lacked the surface reticulation typical of *Bromus* sp. seeds and thus was classified among Poaceae seeds.

Phase 4: Late Copper Age (Early Cetina) Horizon (3rd Millennium B.C.)

The most abundant plant remains from this horizon, from which only three samples were collected, were mineralized plant remains from heavy fractions. They include six fragments of mineralized *Juniper* sp. berry cones from SU 1210 similar to the ones recovered from SU 1340 (FIG. 9.4) and five unidentified small, rounded seeds from SU 1220 (2882–2678 CAL B.C.). The unidentified mineralized seeds are oval in shape (ca. 2.5 × 1.8 mm) and have small, rounded reticulations on their surfaces (FIG. 9.9). One of the small, rounded, unidentified seeds was subjected to FTIR analysis (FIG. 6E).

Preserved portions of charred gymnosperm leaves found in the light fraction were of particular interest. Scaly leaves have a vertical gland opening with three leaves per row (FIG. 9.10) and were classified in a *Cupressus/Juniperus* category. One acorn shell fragment (pericarp) was also recovered from the light fraction. No cereal remains were found from this horizon either.

Phase 5.1: Early Bronze Age Horizon (Late 3rd Millennium B.C.)

Only the Late Neolithic Classic Hvar Horizon had a more diverse range of plant remains than Phase 5.1. (TABLES 1, 2). One mineralized grape pip from a depression filled with ash (SU 1180) was found. A sample from a hearth (SU 1100) yielded numerous small fragments, but the preservation was rather poor. Three *Triticum* sp. grain fragments were also recovered from this sample, their second occurrence since the Late Neolithic Classic Hvar Horizon, but there is no radiocarbon date available from this unit. Although 39 acorn nutshell fragments were identified, the fragments could have been part of the pericarp of only one or two acorn nuts. A small oval seed, ca. 1 mm long, was identified as a possible fig seed (cf. *Ficus carica* nutlet). In addition, seeds of Asteraceae (1), *Chenopodium* sp. (2) and Convovulaceae (1) were identified from the same sample. All the seeds were poorly preserved; thus, a more precise identification was impossible. Remains from the other samples from this horizon included one acorn cotyledon recovered from the flotation and three that were hand-picked. One *Cupressus* sp. seed was also identified.

Phase 5.2: Middle Bronze Age Horizon (First Half of the 2nd Millennium B.C.)

Very few plant remains were recovered from this horizon (TABLES 1, 2). Only one *Triticum* sp. grain fragment and one mineralized *Juniperus* sp. cone berry were identified in this horizon; the mineralized *Juniperus* berry from SU 1040 (1879–1529 CAL B.C.) was especially well preserved and similar to the mineralized juniper berry cones from SU 1340 (FIG. 9.11). Additional interesting and peculiar finds are "endocasts," from SU 1060, representing a type of carbonate filling of unidentified seeds, ca. 7 mm long and 6 mm wide. Two small legume seeds were also recovered from this horizon.

Plant Utilization

Although what we know about the use of plants at

Grapčeva Cave is based on the analysis of plant samples from the 1 × 2 m trench alone, some patterns are evident. Analysis of plant material recovered by flotation corroborates the pattern observed during the renewed excavation: several series of fires were built in Grapčeva in different periods. The samples that contained the largest number of plant remains come from contexts described as various types of humus between the hearths (FIGS. 7, 8). The observed temporal change in plant species composition and the difference in quantity of plant remains from various horizons provide an independent line of evidence for change in cave use over time (TABLE 2; FIGS. 7–9).

Trees and Shrubs

The occupants of Grapčeva used wood from evergreen Mediterranean vegetation as a fuel as indicated by the large quantity of small fragments of wood charcoal, the most abundant category by weight of plant material in all horizons (TABLE 2; FIG. 8). The highest density of wood charcoal (6.47 g) is from the Late Neolithic (Classic Hvar), which contained samples from four hearths and the layers in between (FIG. 5). Hearths, however, can yield high concentrations of wood charcoal and can obscure frequency shifts of other plants.

At Grapčeva, the exploitation of evergreen Mediterranean vegetation is indicated by the ubiquitous presence of elongated acorn kernels from the Late Neolithic Classic Hvar Horizon to the Middle Bronze Age Horizon. The identified charcoal specimens of soft wood (especially those without resin canals) and the ring porous wood from the Late Neolithic (Classic Hvar) and Early Copper Age (Nakovana) Horizons are further evidence for the use of juniper, pine, and oak as fuel (TABLE 3). It is possible that branches of gymnosperm and oak trees were coppiced for firewood. Juniper berries and cypress cones could have been attached to the branches when they were burnt and must have produced a scent from their resins.

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It is interesting that charred juniper berry cones (*Juniperus phoenicea*) were found only in the Late Neolithic (Classic Hvar) Horizon but, with the exception of one fragment from the Early Copper Age (Nakovana), these do not appear in later horizons (TABLES 1, 2; FIG. 9.3–9.4, 10–11). On the other hand, mineralized berry cones different from *Juniperus phoenicea* berry cones and possibly from another *Juniper* species occur in the Late Neolithic (Classic Hvar) Horizon and in the later horizons (but not in the Early Copper Age [Nakovana] Horizon).

Juniperus phoenicea is listed as common in the present-day vegetation of Hvar (Trinajstić 1993). It is unlikely that *Juniperus phoenicea* were completely wiped out by the Late Neolithic period on Hvar. Instead, the decrease in charred *Juniperus phoenicea* berry cones at Grapčeva Cave may reflect the general decrease of *Juniperus* species indicated in the pollen diagram from the island of Mljet (some 40 km south of Hvar) (FIG. 1) and dated to ca. 3100–1300 B.C. (Jahns and Bogaard 1998; Šoštarić 2005).

The mineralized berry cones from Grapčeva most closely resemble *Juniperus excelsa* berry cones (FIG. 9), but *Juniperus excelsa* does not occur in the present-day vegetation of the Adriatic, including Hvar (Trinajstić 1993). It is instead typically found in the eastern Mediterranean (Vidaković 1991). The other possible explanation of the mineralized juniper berry cones is that they belong to *Juniperus oxycedrus*.

The fact that a number of juniper berry cones were preserved in a mineralized form and recovered from the Late Neolithic, Late Copper Age, and Middle Bronze Horizons poses the intriguing question of what led to their mineralization and to the mineralization of five unidentified, small rounded seeds with reticulation from the Late Copper Age Horizon. FTIR analysis has shown that organic matter in both juniper berry cones and the small, rounded seeds was replaced by carbonated hydroxyl apatite. Whether these mineralized berries and seeds were ingested by animals and preserved in their feces or whether they were initially brought in by humans remains unresolved.

Many peoples have used the aromatic foliage and resins of juniper plants (*Juniperus communis* and *J. oxycedrus*) for medicinal or spiritual purposes. Wood and foliage are often burned for incense in temples (Dallimore, Jackson, and Harrison 1967). Oil from the leaves and shoots of junipers is also used in traditional medicine, being an antiseptic, diuretic, stimulant, and laxative. In ancient Egypt, juniper berries were mixed with salt and used in mummification processes among early Christians (Manniche 1989). Whether *Juniperus phoenicea* berry cones were exposed to fire while still being attached to branches used for firewood or whether they were used for some other purpose has not been determined.

OAKS

The abundance of charred acorn kernels (*Quercus* sp. cotyledons) and the dozens of acorn nutshell fragments indicate that these fruits were collected from oak trees and brought to Grapčeva during different periods. The largest number of acorn cotyledons came from two hearths—one from the Classic Hvar Horizon (SU 1310) and the other from the Nakovana Horizon (SU 1262). Most of the better preserved acorn cotyledons are elongated and resemble evergreen Holm oak acorns (*Quercus* cf. *ilex*) (FIG. 9.8). It is possible that the smaller acorns from the Neolithic horizons are from another *Quercus* species, cf. *Q. pubescens.* Against this possibility we note that in the Dalmatian islands vegetation dominated by deciduous *Quercus pubescens* had already been replaced by evergreen vegetation of *Phillyrea, Juniperus,* and *Quercus ilex* by ca. 6000 B.C., according to Šoštarić (2005). The plant remains of juniper and cypress from Grapčeva provide additional evidence for the existence of evergreen Mediterranean forests.

The Holm oak *(Quercus ilex)* acorns are most commonly reported to have been used as human food (for archaeological reviews of acorn finds in Europe see Karg and Haas 1996; Mason 1995; Vencl 1996). Acorns of Holm oak have a sweet/bitter taste and are palatable even raw; the least bitter (sweetest) can be eaten after boiling or roasting like chestnuts (Mason 1995). It is likely that the recovered acorns from Grapčeva represent over-roasted, burnt acorns.

Acorns are rich in carbohydrates and are often regarded as buffer food, to be consumed in lean years when crop yields are low. Acorn remains identified from different periods in the cave point to continuity in the exploitation of this resource over millennia. Acorns were found in samples together with wheat grains, indicating that wheat was available, at least in small quantities, and that the acorns were intended for human consumption. It is less likely that the recovered charred acorns were brought to the cave to feed animals, since roasting and shelling of acorns is not necessary for feeding animals. In addition to numerous cotyledons, remains of acorn nutshells were identified. It is also unlikely that acorns were brought to the cave while still on branches because no remains of acorn cupules were found and because acorns easily fall out of cupules soon after ripening. Acorns could have also been used medicinally or in rituals—since classical antiquity they have been known to have healing properties (cf. Vencl 1996). The reoccurrence of acorns at Grapčeva Cave through various occupation horizons points to the importance of this resource. This is a trend already observed elsewhere in southeastern Europe, where acorns occur in 20% of sites with archaeobotanical finds (cf. Kroll 1991; Vencl 1996). In the absence of non-woody plant macroremains at Pupićina cave in Istria, charred acorn cotyledons (*Quercus* sp.) and stones of Cornelian cherry (*Cornus mas*) dating to the Middle Bronze Age were interpreted as fodder or bedding when fresh branches were brought to the cave (Fletcher and Madella 2006).

Crops

The presence of domesticated crops such as emmer, einkorn, and bread wheat (*Triticum dicoccum, Triticum monococcum,* and *Triticum* cf. *aestivum)* (FIG. 9.5–9.7), grains and fragments of possibly barley (cf. *Hordeum* sp.), and a lentil seed (*Lens culinaris*) indicates that those crops were accessible to the occupants of Grapčeva. They were brought to the cave for food preparation or consumption from the time of the Late Neolithic (Classic Hvar) Horizon. No grinding stones or storage pits were found during Novak's excavations or during the recent excavations. Since no remains of chaff were recovered, the dehusking of the glumed cereals (*T. dicoccum* and *T. monococcum*) must have taken place elsewhere, outside the excavation trench, or probably outside the cave. In the later periods, a few fragments of wheat grains, which could not be more precisely identified than *Triticum* sp., occur sporadically. Based on the few remains of crops and the even fewer weed seeds, it is impossible to conclude whether the crops were grown locally or brought to the cave from some distance. It is possible that the cereals and legumes were grown in small fields below the cave and/or around the present-day settlement of Jelsa, which has a fresh water supply today. No domestic plants were found in the Early and Middle Neolithic Horizon at Grapčeva, but this is not surprising given the small sample size (as already noted, only a few specks of charcoal were recovered from that horizon) and ephemeral and short visits to the cave during this period.

Wild/Weed Seeds

The near absence of wild/weed seeds from the Neolithic horizons attests that already processed crops were brought to the cave. There were only four seeds (*Chenopodium* sp., Asteraceae, and Convolvulaceae) from the Early Bronze Age Horizon that could be identified as possible weeds accompanying crops. They could equally have been wild plants growing around the cave.

Wild Fruits

Remains of fruits found at Grapčeva include almond nutshell fragments, one possible fig pip, and one grape pip. All the fruits were identified as wild.

Charred almond nutshell fragments were recovered only from the Late Neolithic Classic Hvar Horizon (FIG. 9.2), which is dated to the first part of the 5th millennium B.C. The 17 almond shell fragments (0.17 g) could have been derived from one or two nuts and are identified as wild almond (*Amygdalus communis* subsp. *spontanea*). The nut fragments have sparsely pitted shells, characteristic of wild almonds of the *Communis* species group, within the section of the *Amygdalus* subgenus (for the recent revision of the *Amygdalus* genus, see Browicz and Zohary 1996). Unlike most other fruit trees, which reproduce from suckers of cuttings, almonds have the ability to reproduce from seeds.

Wild almond nuts differ from the cultivated forms in having harder shells, fewer pits, and intensely bitter seeds. The bitterness derives from the toxic glycoside amygdaline, which becomes transformed into deadly hydrogen cyanide after crushing or chewing of the almond seeds (Zohary and Hopf 2000). The use of wild almond seeds thus necessitated the removal of latent toxins, probably by leaching or by extraction and use of almond oil.

Archaeological evidence indicates that cultivated almonds appeared later, i.e., in the 3rd millennium B.C., and in the eastern part of the Mediterranean (Zohary and Hopf 2000). Trees of *Amygdalus communis* subsp. *spontanea* thrive in Mediterranean environments with 350–800 mm of annual rainfall, and the present day annual precipitation of ca. 700 mm is favorable for the cultivation of domesticated almonds in Hvar today; however, no wild species of almonds are listed in the modern vegetation of the island (Trinajstić 1993). Furthermore, none of the wild species of the almond *Communis* group, to which the nutshell from Grapčeva is attributed, are present in the region today. The closest region where wild almond trees (*Amygdalus webbii* Spach.) are recorded is southern Italy (Browicz and Zohary 1996). Almond nutshells were not identified from Neolithic sites in the northern Adriatic, despite careful retrieval and analyses of macroplant remains at Pupićina cave in Istria (Fletcher and Madella 2006) and several sites in northeastern Italy (Rottoli and Castiglioni 2008). There is a long tradition of gathering and processing wild almond nuts from the late Epipaleolithic and early Neolithic sites in Anatolia, the Levant, and Greece, however (Martinoli and Jacomet 2004).

It is possible that the vegetation change ca. 6000–4400 B.C. was caused by the onset of Mediterranean conditions (Šoštarić 2005) favoring the growth of almonds on Hvar in locales where there was more moisture. Almond nuts could have been collected around the island, perhaps not far from the cave. Most of the almond nutshell fragments from Grapčeva are several mm long and do not show evidence of fresh breakage, indicating that the nuts were cracked sometime in the past, probably to release the seeds. Since the occupants of Grapčeva had access to water to leach the bitter almond seeds and remove the toxic glycoside amygdaline, they could have roasted almonds or extracted oil which might then have been used medicinally or ritually. The nutshells were then tossed into the fires.

Similarly, bitter acorns also require leaching or roasting. If some of the oak acorns recovered from Grapčeva were bitter, it is likely that the tannins were removed by roasting them—we found charred acorns as well as charred almond nutshells. The recovered acorn cotyledons then represent over-roasted acorns intended for human consumption.

One charred possible fig nutlet (cf. *Ficus carica*) and one mineralized grape pip (*Vitis vinifera* subsp. *sylvestris*) were recovered from the Early Bronze Age Horizon, from different contexts, which probably explains the difference in preservation. The mineralized grape pip was recovered from a depression filled with ash, and the charred fig seed from a hearth together with other charred plant remains. Mineralization of grape pips seems to be a frequent means of preservation of these remains. Animals also readily eat grapes, and the mineralized pip raises the question of whether it was brought to the cave by humans or animals.

It is difficult to identify a single specimen of fig or grape pip as wild or cultivated, since there is great morphological variation within populations of wild or cultivated forms of grapes and particularly of figs. Thus, grape and fig remains from archaeological excavations can be interpreted as either wild or cultivated (Zohary and Hopf 2000), depending on the context. Both wild grape vines and wild/feral fig trees abound in the sclerophyllous vegetation of the Mediterranean, including the present-day Adriatic coast and islands. The occupants of Grapčeva could have collected the fruits from the wild and brought them to the cave to consume them.

All of the identified fruits at Grapčeva (almonds, grapes, and figs), as well as acorns and juniper berries, can be stored and used long after gathering, so we cannot determine the season or seasons when the cave was occupied. There was no concentration of plant remains that would be evidence of storing food in this part of the cave, perhaps indicating only short-term occupations or visits.

Remains of almonds, figs, and grapes have been recovered from a number of Mesolithic and Neolithic sites in southeast Europe (Kroll 1991). These fruits appear wild or feral in the vegetation of Hvar and are mentioned by Novak (1955) as growing around the cave, pointing to a long exploitation of the available wild resources before they became classic fruits in the eastern Mediterranean basin (Zohary and Hopf 2000).

Grapčeva Plant Remains and the Spread of Farming in the Adriatic

Plant remains, especially crops from early Neolithic sites, are often invoked as evidence for the spread and adoption of farming. Various interpretations of this process in the Adriatic have been proposed over the past two decades. Discussions have centered on which parts of the Adriatic experienced the initial spread of farming, which elements of a putative "Neolithic package" (i.e., pottery, domesticated plants and animals) were present, and whether the changes that took place were due to colonization or the adoption of new cultural traits by local populations (see Bass 1998; Budja 2001; Chapman and Müller 1990; Miracle and Forenbaher 2006; Mlekuž 2005; Müller 1994).

The beginning of the Neolithic along the eastern Adriatic is usually associated with the appearance of a characteristic pottery style known as Impressed Ware. In the absence of archaeobotanical data and with only scant faunal data, the spread of food production is traced by following the appearance of Impressed Ware pottery in well-dated sequences, starting from sites in the southern Adriatic that appear to be the oldest in the region. Forenbaher and Miracle (2006) propose a two-stage model for the dispersal of Impressed Ware in which seafaring was essential. During the first stage, the southern Adriatic coast was rapidly explored by pioneers carrying Impressed Ware pottery with them. They established contacts with local hunter-gatherer groups, made seasonal camps, and brought domestic animals. During the second stage, colonization was slower and farming was established by the Middle Neolithic, not reaching Istria in the northern Adriatic until ca. 5600 B.C.

The earliest appearance of Impressed Ware is at the open-air site of Sidari on the island of Corfu which dates to ca. 6200 B.C. (Perlès 2001). There are no published reports, however, of non-woody plant macroremains from any sites south of Grapčeva. Plant remains are mentioned from just two caves: Konispol in southwest Albania, and Drakaina on the island of Cephalonia in the Ionian Sea in Greece (FIG. 1). The analysis of wood charcoal from Konispol revealed that wild almond (*Prunus* cf. *dulcis*) dominates the plant assemblage from the Neolithic layers (Hansen 1999, 2001). At Konispol, cereal agriculture is evidenced by the presence of emmer (*T. turgidum dicoccum*) in the Neolithic levels dating to ca. 7000 B.P. (Hansen 2001: 428). At Drakaina cave, processed cereals, legumes, and almond fruits were recovered from the Late Neolithic (ca. 5600/5500–4800 CAL B.C.) and Final Neolithic (ca. 4800–3700 CAL B.C.) (Anaya Sarpaki, personal communication 2008; Stratouli 2005).

On the western side of the Adriatic, the earliest sites with Impressed Ware pottery are from the Tavoliere Plain in southern Italy and date to ca. 6000–5800 B.C. (Forenbaher and Miracle 2005; Pluciennik 1997). These dates are contemporaneous with the earliest date from Grapčeva (5987–5811 CAL B.C.), a very modestly represented horizon that contained no plant remains other than wood charcoal. From the southwestern Adriatic there are only a few plant reports, based on seed impressions and descriptive analyses of cereal grains from several Neolithic sites (see Hopf 1991; Rottoli and Castiglioni 2008; Rottoli and Pessina 2007; Malone 2003). It appears that the main cereals were barley, emmer, and einkorn, while free threshing wheats were present sporadically in small numbers. Legumes were rare and were represented by lentils, peas, vetches, and broad beans (Rottoli and Pessina 2007). During the later phases of the Neolithic free threshing wheats became more common in central and southern Italy (Constantini 2002), but the spectrum of legumes remained the same.

At Grapčeva, there were no crops dating to the Early and Middle Neolithic periods—layers from which only a single sherd of Impressed Ware and a few Middle Neolithic Danilo sherds were recovered (Forenbaher and Kaiser 2008). The most abundant and diverse plant remains, including grains of three species of wheat (*Triticum dicoccum, T. monococcum,* and *T.* cf. *aestivum*), possibly two barley fragments (cf. *Hordeum* sp.), and one lentil (*Lens culinaris*) seed were from the Late Neolithic Horizon (Classic Hvar) dated to ca. 4800–4500 CAL B.C. The earliest appearance of *Triticum* sp. from Grapčeva is from SU 1390, which was radiocarbon dated to 4960–4780 CAL B.C. None of the crops identified in the Late Neolithic Horizon are known to have been domesticated in the eastern Adriatic (Colledge 2007; Hopf 1991; Zohary and Hopf 2000) and were likely brought by humans to the region before the Late Neolithic.

Archaeobotanical data are available from only three Neolithic open-air sites on the central Dalmatian mainland (Tinj, Pokrovnik, and Danilo), as well as from the multilayer cave of Pupičina in Istria (FIG. 1). The repeated or long term occupation at the Early Neolithic site of Tinj (5815–5185 CAL B.C.) provides the earliest dates for the establishment of a mixed economy in the region (Chapman, Shiel, and Batović 1996; Chapman and Müller 1990). Flotation samples were taken primarily from pits that yielded datable wood charcoal. The samples were dominated by wheat chaff: *Triticum* glume bases, some of which were identified as bread wheat rachises (*T. aestivum*), and spelt wheat spikelet forks (*T. spelta*). These were taken as evidence that the crops were grown and processed in the area (Huntley 1996). At the Middle Neolithic site of Pokrovnik, a concentration of charred cereal grains and a few spikelet bases was found, providing the only direct radiocarbon date on cereal grains (5330–5220 CAL B.C.) (Karg and Müller 1990). The majority of identifiable grains at Pokrovnik were emmer (*T. diccocum*); the next most frequent grains were einkorn (*T. monococcum*) (Karg and Müller 1990). Excavations are still in progress at the Middle Neolithic site of Danilo (Moore 2007), but the flotation samples examined so far have yielded plant macroremains identified by Reed (2006). Among crops, grains of einkorn (*T. monococcum*), emmer (*T. dicoccum*), barley (*Hordeum vulgare*), and a few bread wheat grains (*T.*

aestivum) were found. Also, a few flax (*Linum* cf. *usitatissimum*), lentil (*Lens* sp.), and grass pea (cf. *Lathyrus sativus*) seeds were identified. Fruits include stone pits of Cornelian cherry and dogwood (*Cornus mas* and *C. sanguinea*), seeds of rose hips (*Rosa* cf. *canina*), blackberries (*Rubus* sp.), and pistachio fruits (*Pistacia* sp.). From Pupićina Cave in Istria, only wood charcoal remains were recovered from the Middle and Late Neolithic layers. Combined with the almost total absence of typical cereal phytoliths, this site provides no evidence for on-site processing or consumption of crops (Fletcher and Madella 2006).

The comparison of plant remains from Grapčeva and the three mainland open-air sites in central Dalmatia can be assessed only on the basis of presence or absence. Several wheat species were identified at Grapčeva and all three open-air sites but very few or no legume seeds were found. At all the sites, glumed wheats (*T. diccocum* and *T. monococcum)* dominate the crop assemblage and are found together with a few grains of free threshing wheat (*T. aestivum)* indicating that those crops were perhaps grown together in fields.

The same species of cereals are thus present on both sides of the Adriatic, but there appears to be an increase in free threshing wheat in southern and central Italy in the Late Neolithic, which is not apparent in the eastern Adriatic. The spectrum of legumes seems to be more diverse in Italy than in central Dalmatia, including pea (*Pisum sativum*) and broad bean (*Vicia faba*), none of which have been recovered so far in Dalmatia. These differences between Italy and Dalmatia may reflect the fact that sampling for flotation is still a rather novel procedure in Dalmatia. Broad bean is also absent from the Neolithic sites in northern Italy where flotation was employed (Rottoli and Pessina 2007), though it was identified further west at Early Neolithic sites in Spain, e.g., La Draga in Catalonia, dated to 5300–5150 cal b.c. (Buxó 2007).

Crops identified at Grapčeva are from the Late Neolithic while those from the open-air sites are Early and Middle Neolithic, indicating that these crops were already grown by the inhabitants of the central Dalmatia. Were the crops later brought to the island from the mainland? Hvar is a large island visible from both the mainland and the surrounding islands; the channels in between are normally easy to navigate and should not have posed any problem for the mariners of the Neolithic who were evidently quite experienced (Bass 1998; Kaiser and Kirigin 1994). It is likely, however, that seafaring early farmers would have reached the islands as early as, or even before, they reached the mainland. The Early Neolithic occupation of Hvar is well attested by abundant Impressed Ware finds at Markova Cave (Novak 1974), but sampling for macrobotanical remains was not carried out at that site. On the other hand, it is possible that the crops were initially brought from the mainland, but it is unlikely that cereals were brought to the island each time the cave was visited or occupied. The possibility that inhabitants of Hvar exchanged other goods or services for crops cannot be excluded.

Rich archaeological material from the Late Neolithic (Classic Hvar) Horizon yielded unusually large quantities of animal bones and potsherds and a number of human bones indicating intensive activities at the cave (Forenbaher and Kaiser 2008). The bone assemblage includes the domestic animals cattle, goat, and sheep, as well as the wild animals deer and hare, and has been interpreted as evidence of feasting (Forenbaher and Kaiser 2008). Similar to Grapčeva, perhaps, at Drakaina cave in Greece the plant assemblage is rather poor and includes processed wheat species and barley grains without chaff, in addition to legumes, and almond nutshell. Together with a large quantity of animal bones and sherds this plant assemblage is interpreted as evidence of feasting during rituals (Anaya Sarpaki, personal communication 2008; Stratouli 2005).

The comparison of plant remains distinguishes Grapčeva not only from the open-air sites, but also from Pupićina cave. The spectrum of identified plant species at Grapčeva is less diverse than at Tinj and Danilo, but acorns, almonds, and juniper berries are present only at Grapčeva. The more diverse spectrum from the open-air sites results from the wider area sampled, while the lesser diversity of species at Grapčeva probably reflects specific activities taking place in the cave. At Grapčeva, small quantities of cleaned cereal grains were brought from storage areas perhaps located elsewhere on the island, while acorns and almonds were probably gathered nearby and were prepared around the hearths to be consumed in the cave. At Pupićina cave, although flotation was employed, there is no evidence of such activities, indicating the different uses to which these caves were put. Evidence for a relatively intensive occupation of Pupićina during the Middle Neolithic was interpreted as habitation by shepherds and their flocks, while the Late Neolithic occupation was interpreted as the use of the cave primarily for penning flocks (Miracle and Forenbaher 2006).

Summary and Conclusions

The analysis of plant macroremains from Grapčeva is the first archaeobotanical investigation using flotation from a cave on an eastern Adriatic island and the first published report on plant macroremains from the southeastern Adriatic. In total, 41 samples were collected and analyzed from seven horizons from the Early and Middle Neolithic, Late Neolithic (Classic Hvar), Late Neolithic (Late Hvar), Early Copper Age (Nakovana), Late Copper Age (Early Cetina), Early Bronze Age (Early Cetina), and Middle Bronze Age, radiocarbon dated to ca. 6000–1500 B.C.

Plant remains are scarce, which is not surprising considering that the 41 samples, each only 3 liters in volume, were collected from a 1 × 2 m trench. Due to the flotation, however, even small particles such as acorn and almond nutshell fragments were retrieved and identified. FTIR analysis demonstrated that plant materials were mineralized and differentiated them from "seed-like" soil and clay particles and modern seed intrusions. The FTIR results also demonstrated that it is impossible to distinguish between modern berry cones of two different species of juniper (*Juniperus phoenicea* from *J. excelsa*). This confirms that FTIR is not a useful tool for discriminating fruits of different species within the same genus even using modern uncharred specimens. The presence of mineralized juniper berries points to a different mode of preservation and, together with other mineralized seeds, may indicate a different mode of arrival. For example, animals might have brought them to the cave.

Wood charcoal was ubiquitous in the samples and is the only plant material recovered from the Early and Middle Neolithic Horizon, indicating short visits to the cave and probably not much food consumption. Besides wood charcoal, abundant plant remains included acorns of evergreen oak (*Quercus* cf. *ilex*); most of these were collected by hand during the excavations, although some were recovered by flotation. Exceptional finds include whole berries of two types of junipers—charred berries of a Phoenician juniper (*Juniperus phoenicea*) and mineralized berries of another juniper (possibly *Juniperus excelsa*)—in addition to various parts of gymnosperm cones and cypress seeds and leaves (*Cupressus sempervirens*). In addition, a few remains of wild fruits such as nutshell fragments (*Amygdalus communis* subsp. *spontanea*) were recovered from the Late Neolithic Classic Hvar Horizon. Wild almonds are not recorded in the modern vegetation of Hvar. Almonds were not identified from any Neolithic northern Adriatic sites. They are present only at Grapčeva in the central Adriatic and in the southern caves of Konsipol and Drakaina. If the climate on the island of Hvar was not more conducive for natural distribution of these species during the Late Neolithic, their presence at Grapčeva indicates that they were probably brought by humans from the south at some time in the past. The finds of wild almonds (*Amygdalus communis* subsp. *spontanea*) together with juniper berries of possibly *Juniperus excelsa* (another plant that is absent from the present-day vegetation of Croatia but is typical of the eastern Mediterranean) provide new information about the westward expansion of these species. Wild fruits were also found, such as one mineralized grape seed (*Vitis vinifera* subsp. *sylvestris*) and one charred fig nutlet (cf. *Ficus carica*) from the Early Bronze Age Horizon.

These finds demonstrate that the occupants of Grapčeva exploited evergreen Mediterranean vegetation for fuel, food, and possibly for ritual or medicinal purposes. It is interesting to note that all the trees identified from the prehistoric layers were mentioned by Novak (1955: 19) as growing near the cave when he excavated there. This suggests that similar vegetation was thriving during the prehistory of the island, at least as long ago as the Late Neolithic period.

A few emmer, einkorn, and likely bread wheat grains (*Triticum dicoccum*, *T. monococcum* and *T.* cf. *aestivum*), as well as two possible barley fragments (cf. *Hordeum*), and a lentil seed (*Lens culinaris*) were identified from the Late Neolithic Classic Hvar Horizon. Few wheat grains (*Triticum* sp.) were identified from the later horizons. The presence of charred cereal grains indicates that cereals were available and were consumed by the occupants of the cave. Neither concentrations of crop grains or seeds nor grinding implements were discovered during any of the excavations at Grapčeva, however. This may indicate that plant food was brought for immediate consumption. The paucity of crop finds at Grapčeva might imply that whatever grain was brought there was all eaten or that the occupants relied more on wild resources, at least while they were in the cave. Hvar is one of the larger islands in the Adriatic and has valleys, some of which have fresh water sources, where crops could have been grown. While the crops could have been brought to the island from the mainland, the island itself could have supported a mixed economy that incorporated the cultivation of some crops, gathering from the wild, raising of domestic animals, and hunting during the Late Neolithic.

The richest plant assemblage was from the Late Neolithic, particularly from the Classic Hvar Horizons, followed by the Early Copper Age (Nakovana) Horizon. During the Late Neolithic the occupants brought to the cave some cereals and fruits gathered from the wild to the cave. Both cereals and acorns are rich in carbohydrates and are considered staples. Whether acorns were gathered more intensively in the years when there was insufficient cereal intake or whether they were considered a delicacy or were used for some ritual or medicinal purpose by the occupants remains unresolved.

Acorns continue to appear up to, but not during, the Middle Bronze Age Horizon, while emmer appears mostly during the Late Neolithic. Only a few wheat grain fragments were found in the later horizons, including the Middle Bronze Age. Charred *Juniperus phoenicea* berry cones are found only in the Late Neolithic Horizons and are absent in the later periods. Whether juniper berries were gathered for some kind of ritual or medical purposes or whether parts of the trees were coppiced for fuel remains unclear; however, the later occupants of the cave discontinued gathering of *Juniperus phoenicea,* perhaps as a consequence of the general decline in juniper trees, as indicated in the pollen diagram from the island of Mljet. On the other hand, some mineralized juniper berries (*Juniperus* cf. *excelsa*) continue to appear in the later horizons.

Finds of charred wild almond nutshells suggest that the fruits were brought by humans and intended for human consumption. Although the tannins from acorns can be removed without the use of water, leaching of glycoside amygdaline toxins from wild almonds usually necessitates water. The presence of fruits that require leaching suggests that there was easy access to fresh water.

Plant remains from the younger layers above the Late Neolithic–Early Copper Age Horizons were few, except for acorn remains. The sporadic occurrence of wheat grain fragments and a few charred wild/weed seeds indicates that these plants were brought to the cave during the Early and Middle Bronze Age, but the majority of plant processing and consumption was limited to acorns in the later periods. Whether the later occupants of Grapčeva had different plant preferences than the earlier occupants is unknown. Forenbaher and Kaiser (2008) argue that there was a clear change in the function of Grapčeva, at a somewhat earlier date: after Phase 1, Classic Hvar.

The analysis of plant macroremains shows a higher abundance of plants gathered from the wild, rather than domesticated plants. Plant remains from the Late Neolithic Horizons were more numerous and more diverse compared to the paucity of plant remains in the Bronze Age Horizons, a difference already documented in the archaeological record. This too reflects a different use of the cave.

The study of plants from well-dated contexts at Grapčeva is significant because it provides new data concerning the spread of farming and wild plant exploitation in central Dalmatia and the eastern Adriatic. All the crops identified at Grapčeva were already available in domesticated form in the region and have been recovered from the three open-air sites (Tinj, Danilo, and Pokrovnik) in central Dalmatia dating to the Early and Middle Neolithic. While the absence of crops from the Early and Middle Neolithic layers at Grapčeva may indicate that farming was not yet established on the island, it more likely reflects the fact that the cave was rarely visited during those periods. The modest presence of cereal grains and lentils from the Late Neolithic may suggest that small scale farming was practiced on the island of Hvar. Since there are no reports of plant macroremains from sites south of Grapčeva in the eastern Adriatic, it is impossible to fully reconstruct the introduction and adoption of domestic plants associated with the spread of Impressed Ware pottery. The same wheat species have been identified on both sides of the Adriatic during the Early Neolithic, including einkorn, emmer, and bread wheat. Barley seems to be more prevalent on the western side, whereas bread wheat becomes increasingly common in the Late Neolithic. Lentils were identified from both sides, but legumes were more diverse on the western side of the Adriatic. Broad beans have been identified only on the western side of the Adriatic, perhaps indicating that people who brought Impressed Ware pots took different stocks of seed crops when they started their voyages to the two sides of the Adriatic. The difference in species richness, with greater diversity of legumes on the Italian side, may be an outcome of the unequal sample sizes currently available from the opposite coasts. The presence of broad beans and the predominance of barley from the Neolithic sites on the western side of the Adriatic seem to reflect real differences in plant assemblages between the two sides of the Adriatic, however.

The analysis of plant macroremains from Grapčeva provides important results for improving our understanding of different cave functions during the Adriatic Neolithic. It also provides an independent line of evidence for the use of Grapčeva as a ritual site during the Late Neolithic and for changes in activities during the occupation of the cave. Long ago, Novak speculated that the "products of their own fields were brought" to the cave for the purpose of sacrifice to gods or ancestors and that the cave did not serve as a long-term dwelling place (Novak 1955: 333). We can conclude that Grapčeva's occupants often brought products gathered from the wild to the cave for food, fuel, and perhaps ritual and medicinal uses; less frequently, they brought processed products from their fields for consumption in the cave.

Acknowledgments

We would like to thank Margaret Darmanin for organizing and conducting the flotation of sediment samples from Grapčeva—the first such exercise ever on an Adriatic island. We thank also Andrea Nagle (Fisher), a former undergraduate student from University of Alabama at Birmingham, and China Shelton, a current graduate student at Boston University, for help in sorting plant remains and data entry. Mirjana Popović-Žukić, a retired forestry engineer from Zagreb, provided useful information about the forest vegetation of Hvar and put K. B. in touch with Renata Šoštarić, University of Zagreb, who provided important references about changes in vegetation of Dalmatia.

Henry Kesner, former curatorial assistant of the Harvard University Herbaria, offered assistance in sampling plant specimens from their collections. Marko Milošević helped with the editing of seed photos and making graphs. Trina Arpin provided copyediting assistance. Their help and assistance is greatly appreciated.

In Croatia, archaeological research at Grapčeva was supported by grants from the Committee for Field Archaeology of the Royal Ontario Museum, the National Geographic Society, and York University, and by the Ministry of Science, Education and Sports of the Republic of Croatia (project #196-1962766-2740).

The infrared spectroscopy research was supported by a Marie Curie International Fellowship within the 6th European Community Framework Programme (#MOIF-CT-2006-041053) to Francesco Berna, and by a National Science Foundation grant (BCS #0551927) to Paul Goldberg, Micromorphology Lab, Department of Archaeology, Boston University.

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