Chapter 6

Unio Shells from Çatalhöyük: Preliminary Palaeoclimatic Data from Isotopic Analyses

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Excavations at Çatalhöyük have yielded thousands of mollusc shell remains. These include shells that were deliberately collected by humans, and thousands of others that were inadvertently collected along with the mud for the construction of the mudbrick dwellings at the site (Chapter 5; Chapter 16; Love 2010). Shells that were deliberately collected by humans include those collected for the production of ornaments and were brought from the Mediterranean shores and Taurus Mountains (Bar-Yosef Mayer *et al*. 2010). *Unio* bivalves studied here were also collected from freshwater rivers and lakes in the vicinity of the site, and may have served primarily as food, and secondarily as raw material for making ornaments and other artifacts, although it should be noted that some of the collected specimens are juveniles that were inadvertently collected along with thousands of small gastropods (Chapter 5).

Because *Unio* is found throughout the sequence of Çatalhöyük, and because the genus lives for several years (Aldridge 1999), we can use the shells to gain information on seasonal climate fluctuations that existed during the Neolithic and Chalcolithic periods, and contribute to the debate on the climatic and hydrological variations that may have influenced the economy and society of Neolithic Çatalhöyük. Seasonal activities are expressed at the site in several media, but especially in the faunal and floral remains (Fairbairn *et al.* 2005a). Subsistence strategies at the site were dictated by arid summers and wet winters (otherwise known as the 'Mediterranean climate'). The site existed during the early stages of agriculture, and the resources exploited by its inhabitants are based on both wild and domesticated fauna and flora (Twiss *et al*. 2009). Shell-fishing could have been one of the seasonal activities at the site. Other evidence for seasonal activities is expressed in the construction of bins that served as storage areas for plant food at the site (Twiss 2008; Bogaard *et al*. 2009), and activities pertaining to rearing sheep flocks (Russell & Martin 2005). Another enigma concerns the gradual abandonment of the East Mound and resettlement on the West Mound; it has been suggested that adverse climatic conditions may have caused this change (Marciniak & Czerniak 2007; Biehl & Rosenstock 2009; Roberts & Rosen 2009). Therefore, a closer view of seasonal climatic conditions during the site's occupation is vital for understanding these activities and their impact on the inhabitants' economy.

Climatic conditions that prevailed in this area of Turkey during the late Pleistocene and early Holocene were studied by various teams who worked in and around the site. Most conspicuously, Roberts *et al*. (2001), studying a sedimentological core from Lake Eski Acigöl, suggested that there was a rapid rise in precipitation at the beginning of the Holocene followed by a sustained period of moisture (significantly above modern values) until c. 6500 cal BC. Consequently, Roberts & Rosen (2009) suggested that the inhabitants of the site had to grow cereals many kilometres away from the occupation site. While *Unio* and other freshwater shells found in large numbers at Çatalhöyük confirm that plentiful freshwater was close to the site (Chapter 5), the interpretation of the appearance of freshwaters near the site (lake, rivers, marshes) and how humans adapted to their surroundings has been contested (Volume 9, Chapter 3). Additional regional climate records of the late Pleistocene and early Holocene around southwestern and south central Turkey were published over the last decade that include lake isotopic records (Roberts *et al*. 1999; Leng *et al*. 1999b; Jones *et al*. 2002; Eastwood *et al*. 2007a; Jones *et al*. 2007; Roberts *et al.* 2008, Fig. 6.1) with most agreeing that precipitation levels at the beginning of the Holocene were slightly more elevated than today's records.

Unionidae bivalves can potentially provide a means of assessing seasonal fluctuations and they are particularly important as a potential archive of environmental information because they store isotopic information in their shells as they grow. These bivalves currently occur in a wide range of freshwater habitats, including rivers, lakes and marshes (e.g., Negus 1966; Aldridge 1999; Tchernov 1975; Heller 2009). Research on unionids in Turkey is very limited (e.g. Modell 1951, Geldiay & Bilgin 1969, Bilgin 1980, Falkner 1994, Öktener 2004, Şereflişan *et al*. 2009), and the taxonomy of the region remains poorly resolved (Graf & Cummings 2007). The mussels are inactive, or express reduced activity during cold winter periods when their growth may

Figure 6.1. *Map of Turkey showing Çatalhöyük and lakes mentioned in the text.*

be reduced or cease (Mienis pers. comm.), giving rise to distinct annual growth lines (annuli) within the shell (Goewert *et al*. 2007). In Britain, *Unio* spp. growth maximum is between April and September (Aldridge pers. observ.; Negus 1966). Glochidia, calcareous larvae of *Unio* spp., are released on mucus threads in order to attach to host fish on which they must metamorphose in the UK during May and June (Aldridge & McIvor 2003). Unlike most freshwater bivalves, unionids have a relatively long life span (e.g. Negus 1966; Aldridge 1999), with greater investment in shell lengthening in the first few years. The seasonal variations are expressed in the shell and can be measured.

Since the isotopic composition of freshwater bivalve carbonate generally reflects that of water where they reside, shells are potentially useful as tools for investigating changes in lake water related to the local climate (Leng & Marshall 2004; Goewert *et al*. 2007). Whole-shell isotope data provide an integration of seasonal change over a few years or so, while inter-seasonal information can be gained by sampling at short intervals along the growth axis of the shell (Leng *et al*. 1999a). Here we present preliminary results of isotopic composition of *Unio* shells from Çatalhöyük, in an attempt to gain palaeoclimatic data relevant to human activities at and around the site during the critical period of early agriculture. We previously tested the isotope data from a single modern shell of known date and origin which was then used for comparison (Bar-Yosef Mayer *et al*. 2012). The incremental growth (seasonal) $\delta^{13}C$ and $\delta^{18}O$ data from the shells were similar to today, and clear seasonal patterns were detected in the shells from the Neolithic and early Chalcolithic periods.

Materials and methods

Subfossil shells were collected from the archaeological site at Çatalhöyük. *Unio mancus eucirrus* valves were gathered from 18 levels at the site, and while most of the *Unio* valves from Çatalhöyük were broken at the posterior end, we only collected valves for isotope analysis that were complete from umbo to margin so that isotope samples could be taken from the entire length of the shells representing several years of the mollusc's growth. *Unio* valves were measured using a digital calliper. In complete shells (both valves present, n=7) height, length and thickness/convexity were measured. Complete valves (n=64) were measured for height and length. Broken valves were only measured where the entire height was present (n=260). Minimum Number of Individuals (MNI) was based on counting of umbones of right and left valves, and choosing the larger number of valves (either right or left) in each level.

This study was based on four specimens from representative levels along the sedimentary sequence at the site, which have been dated to early Pottery Neolithic through early Chalcolithic. We selected the best preserved shell specimens (Table 6.1, Fig. 6.2): from the lowermost level of occupation, Level South G at the bottom of the East Mound (5306); from the middle of the sequence in Level South L (1563); from the uppermost levels of the East Mound in Level TP N (17670); and a sample from the Chalcolithic levels in the West Mound (17208) from Trench 5. All shells come from reliable midden contexts that were not re-deposited. Assuming that these shells were collected as living individuals from the

Unit	Archaeological context	Stratigraphic position	Date	Shell height (mm)
Modern		Modern	2008 AD	
(17208)	Ceramic cluster & groundstone tools	West Mound (Trench 5)	Early Chalcolithic (ECA IV), 6th millennium BC (1 date: 5900 cal BC)	25.11
(17670)	Midden, faunal remains, clay balls, 2 broken *Unio* 'beads'	Level TP N	Late Neolithic (ECA III)	33.46
(1563)	Midden, including phytoliths	Level South L (Sp.115)	End Early Pottery Neolithic (ECA II) *c.* 6500 cal BC	33.31
(5306)	Midden	Level South G (Sp.181)	Early Pottery Neolithic (ECA II) *c.* 7000 cal BC	31.48

Table 6.1. *Shells collected from the archaeological site at Çatalhöyük and the modern environment. The sedimentary sequence at Çatalhöyük was sampled in four points along the occupational phases from the lowermost level of occupation, Level South G at the bottom of the East mound, in the middle Level South L, the uppermost levels of the East Mound in the TP Area, as well as one Chalcolithic sample from the West Mound.*

nearby freshwater sources, they represent four points in time between ca. 9200 cal BC and 7000 cal BC.

The chosen shells show limited signs of surface abrasion or dissolution. They were gently brushed in de-ionized water to remove adhering sediment. For the incremental growth analysis, between 31 and 66 samples were taken at *c.* 0.5mm intervals along the shells' exterior surface from the umbo to the ventral margin, using a 1mm diameter drill. For isotope measurement of the incremental growth, 100μg samples were analyzed using a GV IsoPrime mass spectrometer and multiprep system together with similarly-sized samples of a laboratory calcite standard. Analytical precision (1 SD), based on the laboratory standard, is typically <0.1‰ for both carbon and oxygen isotope ratios. Isotope values ($\delta^{13}C$ and $\delta^{18}O$) are reported as per mil (‰) deviations of the isotope ratios ($^{13}C/^{12}C$, $^{18}O/^{16}O$) from VPDB.

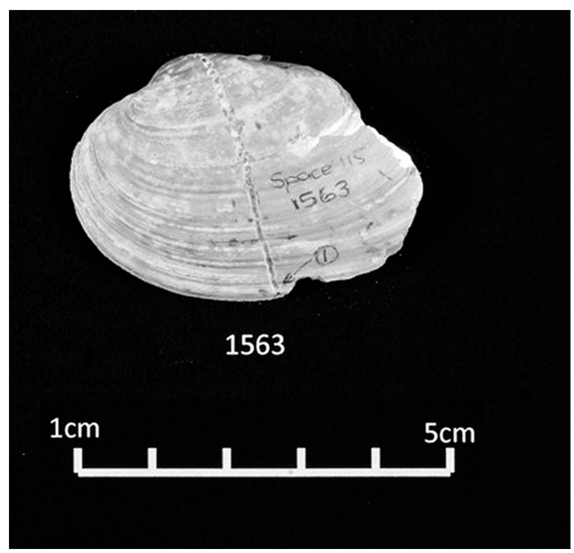

Figure 6.2. *One of the* Unio *shells sampled for stable isotopes. Over 30 samples were taken at* c. *0.5 mm intervals along the shells outer margin (resulting in a trench like feature) from the umbo to the ventral margin, using a 1mm diameter drill.*

Results and discussion

A modern shell that was tested as a control sample validated our procedures and interpretations. The analysis of $\delta^{13}C$ and $\delta^{18}O$ values of the modern shell (Fig. 6.3) collected from a lake near Adana had $\delta^{13}C$ values that range between *c.* –12 and –5‰ and was consistent with the bivalve utilizing a mixed carbon pool from the water's inorganic pool, as well as dietary organic carbon (Fritz & Poplawski 1974). The data suggest that the bivalves utilized carbon from both organic (food) and inorganic (debris) sources, but dominantly from the ^{13}C-depleted organic component.

The oxygen isotopic composition of freshwater mussel shells is predominantly dependent on the isotopic composition of the water in which the carbonate formed and on temperature to a lesser extent (Leng & Marshall 2004). Inter-seasonal information can be gained by sampling at short intervals across the growth lines of freshwater bivalves (e.g. Koike 2008), although in general, the rivers and open lakes are less sensitive to seasonal variation than ponds and lakes.

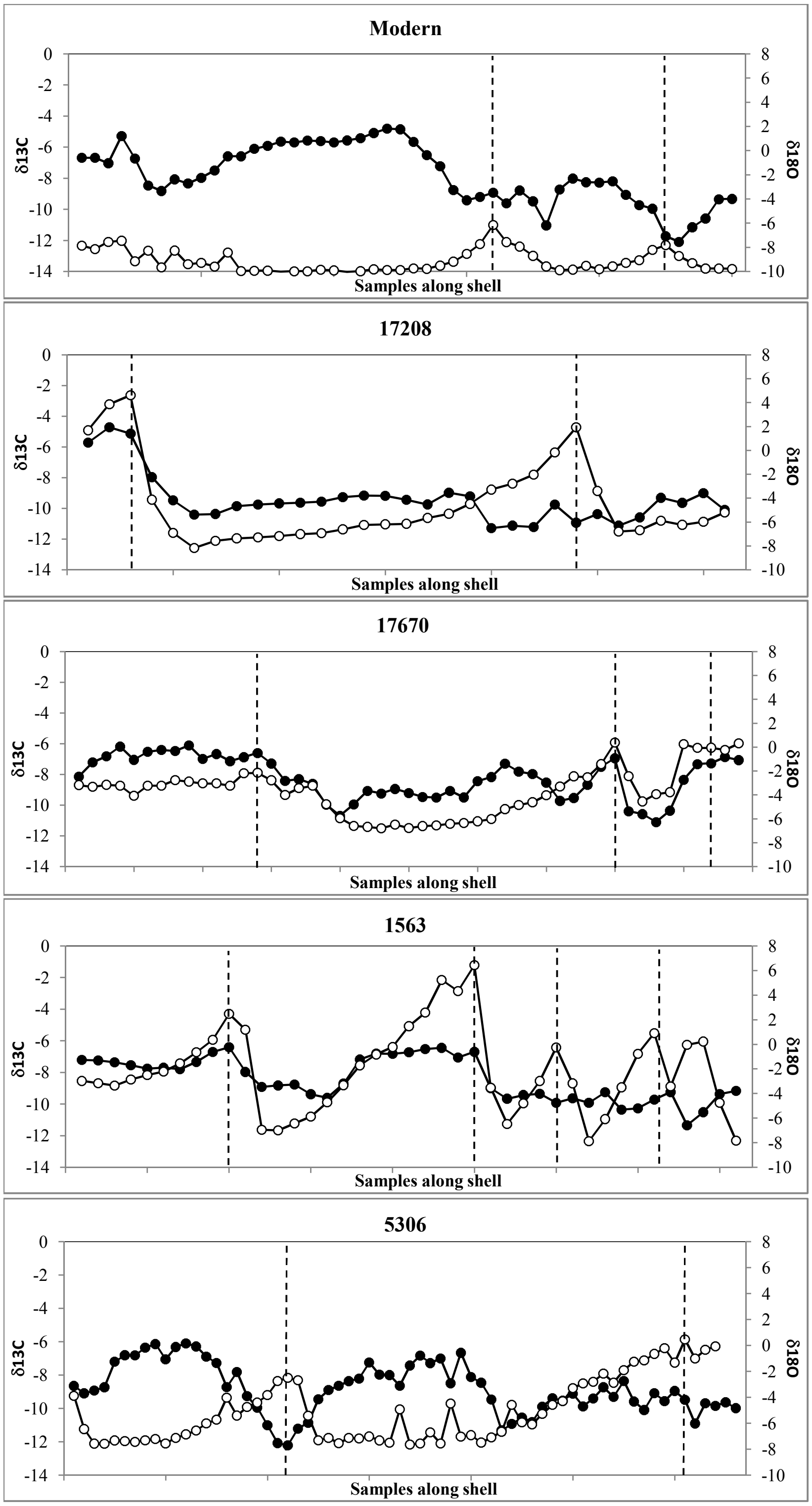

Figure 6.3. *O and C isotope data from sequential analysis along the growth axis of the modern and four archaeological shells. Open symbols represent the oxygen isotope data, and closed symbols the carbon isotope data. The dashed lines represent the summer maximum (July/August) evaporation periods allowing an estimation of the amount of time (years) represented in each shell. The umbo (youngest part) of the shell is on the left of the y axis. Note the saw-toothed shape of many of the cycles, with a rapid fall in δ18O followed by a gradual rise.*

$\delta^{18}O$ values of the modern shell suggested that there were three summers resolved within the modern shell and three winter periods. The winter carbonate $\delta^{18}O$ of *c.* –10‰ would have precipitated from isotopically low and very fresh water, probably close to mean weighted annual precipitation (isotopically equivalent to groundwater, $\delta^{18}O$ *c.* –12‰, Leng *et al*. 1999b). This is not surprising given the provenance of this shell, a river water-fed lake, and gave us confidence that the fossil shells also record hydrological information.

The range in $\delta^{13}C$ from the Çatalhöyük shells is similar to the modern shell between –12 and –5‰ (Fig. 6.3). The similarity suggests that there were no significant differences between the diet and C contributions for each of the bivalves. In other words, the source of the carbon measured is from the molluscs' food, and their diet sources remained the same between the early-mid Holocene and during the present. However, the correlation between $\delta^{13}C$ and $\delta^{18}O$ is variable. In shell (5306) (from Level South G) there is a weak negative correlation (r2 = –0.3) between the two isotope systems (more organic carbon incorporated into the shell in the summer months), while (1563) (Level South L), (17670) (Level TP N) and (17208) (West Mound Trench 5) tend to show a positive correlation (all r2 = +0.3), suggesting the bivalve ingested more ^{12}C in the winter/early spring months perhaps due to respiration in a localized ^{12}C rich (decaying organic) environment. The relationship between diet (C supply/source) and seasonality is likely to be both opportunistic and habitat related.

There are other differences between *Unio* shells in Level South G and the levels above it: Level South G yielded the most *Unio* shells at the site, with an MNI of 689 (76 per cent), out of a total site MNI of 898. It is the densest concentration of shells at the site, which causes us to believe that molluscs were consumed at this level (see Chapter 16). Furthermore, height measurements of the valves indicate that the shells were larger in Level

South G (average height 32mm, SD 4.09) than in subsequent Neolithic levels (average height 21mm, SD 9.22). It is worth noting that during the Chalcolithic, in the West Mound, the average height increases to 28mm, SD 4.65. These data might suggest that the population of *Unio* shells around the site was over exploited at the time that Level South G existed, and caused a decrease in their size (a well-known archaeological phenomenon, e.g. Claassen 1998, 45–49), and that subsequently, in the Chalcolithic, the *Unio* population recovered somewhat and became larger again.

The range in $\delta^{18}O$ of the subfossil shells is different from the modern shell, being between –8 and +6‰. However, the lowest value is only slightly higher than the winter $\delta^{18}O$ of the modern shell and may indicate that the isotopic composition of the early Holocene winter rainfall (or winter groundwater recharge of the lakes) in the area around Çatalhöyük was similar, but slightly enriched compared with that of today. The high values in the archaeological shells are most likely to be a function of intense summer evaporation, suggesting there was no (or little) summer rainfall, conditions similar to today in this region. When comparing these results to the previously studied cores of Akgöl and Süleymanhaci (Leng *et al*. 1999b), it seems that the lakes around Çatalhöyük during its occupation had a smaller surface, thus reducing evaporation. Alternatively, winter rainfall around the occupation site, or as rain and snowfall in the mountain catchment area, was much higher in the early Holocene allowing for either river flooding and/or a complete winter recharge of the lakes that the bivalves inhabited. Doherty's reconstruction of a mosaic of many small streams surrounding the site suggests the former (Volume 9, Chapter 3). The clear, saw-toothed shape of the $\delta^{18}O$ data displays a rapid fall and a gradual rise in $\delta^{18}O$ which may relate to a late season (i.e. late autumn) cessation in growth which then resumes the following spring. These results confirm a winter hiatus in the shells' growth.

Summary and conclusions

The abundance of *Unio* shells at Neolithic Çatalhöyük allows us to analyze them as a proxy for climate and seasonal fluctuations during the site's occupation. Incremental growth of bivalve shells provides inter-seasonal environmental data which complements other environmental studies at the site. The shells enable resolution of between three and five seasonal cycles each. The carbon isotope variations within all studied shells (modern and archaeological) are similar in most shells, being intermediate between carbonate and organic matter derived C. There is some co-variation in shells (1563), (17208), (17670) from Levels South L, TP N, and West Trench 5, respectively, suggesting a possible link between molluscan diet and seasonality, i.e. more uptake of organic matter in the winter/early spring months. These isotope data complement Roberts & Rosen's (2009) evidence that water bodies near Çatalhöyük were replenished by river flooding in the springtime. However, while their interpretation suggests water bodies were shallow or standing, and then became progressively smaller and shallower due to seasonal evaporation during the dry summer months, it is also possible that what they see is evidence for winter ponds. Because *Unio* shells are dependent on constant oxygenation of the water, even during the winter months when they are inactive, we cannot say that those were collected from shallow or standing water bodies.

The archaeological shells show a distinct seasonality (summer to winter) expressed in all four shells. The winter values suggest high recharge by winter precipitation at the lake or delivered by river floods of the lake(s); this enables lake waters to return to a $\delta^{18}O$ composition that is typical of regional groundwater, while the summer values are indicative of intense aridification during the summer months (similar to today). The return of lakes to typical groundwater isotopic composition in winters suggests very high water table levels.

The data presented here are limited; however, in the one level where we feel confident that people were gathering shellfish as a food source, Level South G, the data also suggest that the shell was collected in the autumn. Although we are aware that further sampling is necessary, this is a significant contribution to the study of seasonal activities at Çatalhöyük (Fairbairn *et al.* 2005a). This preliminary investigation of *Unio* from Çatalhöyük demonstrates the great potential of palaeoclimatic information from these shells. Bivalve isotope analysis is one of the few methods for investigating seasonal fluctuations in the past, and can provide information on the effects of seasonality on human activity due to climate.

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