

# Seasonality and Site Function in Chalcolithic Cyprus

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*Excavations at the small Chalcolithic site of Politiko-Kokkinorotsos in central Cyprus show that it was occupied around 2880–2670 cal BC. Fallow deer (*Dama mesopotamica*) form the major component of the substantial faunal assemblage. The structure of the animal population suggests a seasonal hunting site, an interpretation consistent with the lack of formal architecture and the range of stone tools. In this study, independent odontochronological analyses of deer and caprine are used to test and confirm the model of seasonal culling in spring and summer based on more general indicators. The results suggest a pattern of varied, specialized site-types and activities in different parts of the island and in different ecological zones, and add considerably to our understanding of cultural systems on the island in the early third millennium BC.*

**Keywords:** Cyprus, Chalcolithic, deer, hunting, odontochronology, seasonality

## INTRODUCTION

The evidence for human occupation in Cyprus between approximately 3500 and 2500 cal BC is both limited and patchy. Despite the small size of the island, almost nothing is known outside of an intensively studied area in the south and southwest, where a handful of sites have been excavated. The prehistory of the Middle and Late Chalcolithic is therefore largely based on material from the settlements at Erimi-Pamboula (Dikaïos, 1936; Bolger, 1988), Kalavassos-Pamboules (Clarke & Todd, 1993; Clarke, 2004; Todd & Croft, 2004; Clarke et al., 2007), Kissonerga-Mosphilia, Kissonerga-Mylouthkia, Lemba-Lakkous and Souskiou-Laona, and the cemetery at Souskiou-Vathykakas (Peltenburg, 1985,

1998a, 1998b, 2003, 2006). Small amounts of data from sites in the centre of the island do, however, suggest a broad cultural homogeneity in pottery and symbolic items during the Middle Chalcolithic. By 3000 cal BC, an increase in the number of recorded sites and the presence of substantial circular buildings suggest an island-wide trend to increased sedentism in villages or hamlets. In terms of social organization, this is the first time in Cyprus that modest degrees of status differences are clearly evident in the archaeological record.

For the Late Chalcolithic, a pattern of shifting occupation within the excavated settlements in the south and southwest leaves a patchy and incomplete stratigraphic record so that continuity of site-use is by no means certain. Despite a broad

continuity in architectural form and general evolution of pottery wares, there is a gap in evidence between the Middle and Late Chalcolithic at Erimi, Kissonerga, and Lemba. Similar dates have been suggested for the abandonment of less well-known settlements at Kythrea, Lapithos, and Ayios Epiktitos-Mezarlik in the north (Bolger, 1988: 125–26, Table 9). This could be taken to suggest that sometime about 2900 cal BC there was a significant interruption to, if not more radical dislocation of, the older settlement pattern across the island. Whereas a sudden widespread catastrophic event may have been responsible, disruption at this time is more likely to have been the result of gradual processes, perhaps in response to environmental changes that triggered broader social and economic transformations (see Stanley Price, 1979: 73–77). The recent evidence from Politiko-Kokkinorotsos, while filling this apparent chronological hiatus, leaves this question open, while exposing a broader issue of the nature and variation of site and settlement types during the Cypriot Chalcolithic.

The economy of Chalcolithic villages relied on hoe-based cultivation of wheat and barley and the exploitation of a range of locally available fruits and nuts, together with herded caprines and pig and hunted deer. Although proportions of the different animals fluctuate considerably within each site, in the southwest a long-term reduction in the relative abundance of deer and an increase in that of pig may reflect a progressive shift to meet the demands of an increase in population (Croft, 1998: 315). Deer-focused subsistence economies have also been seen as a feature of residential instability in early prehistoric Cyprus (Croft, 1991; Clarke, 2007a: 11, 2007b; Wasse, 2007: 61–62). Several broad models have been put forward to explain these cycles of dislocation. The first views settlement relocation or fissioning as a

regular process that reduced intra-community tensions and inhibited the development of formal hierarchies during periods of population growth (Peltenburg, 1993, 2003: 272). An alternative economic model argues for the long-term existence on Cyprus of mobile societies engaged in hunting fallow deer and suggests that increasing aridity was responsible for periodic shifts or reversions to hunting in preference to husbandry (Clarke, 2007a; Wasse, 2007: 62). A variant of this model sees settlement relocation as both a regulating response to ecological and environmental constraints and a means to keep settlement size and social hierarchies in check (Held, 1993; Knapp et al., 1992). A fourth possibility is that the archaeological focus on the more substantial village sites provides a limited view of the complexity of Chalcolithic economic strategies in which different, task-oriented sites may always have been a feature of settlement systems. Here, we present evidence from Politiko-Kokkinorotsos, which, interpreted as a special-purpose hunting station, provides the first example of one such site. The nature of the material culture, the lack of, or ephemeral, nature of the architecture, the absence of burials and, most significantly, the faunal assemblage, point to this conclusion.

Politiko-Kokkinorotsos (hereafter Kokkinorotsos) is a small site in the northern foothills of the Troodos range at the interface of the igneous formations of the Troodos and the sedimentary structures of the northern half of Cyprus (Figure 1). It is situated on a mid-Holocene river terrace in the narrow valley of the Koufos River as it flows out of the foothills to join the Pedeios, one of the main rivers which flow across the centre of the island. Today the area has small pockets of arable land surrounded by steep, pine-clad hills (Figure 2). At about 400 m above sea level it is sufficiently high to be noticeably

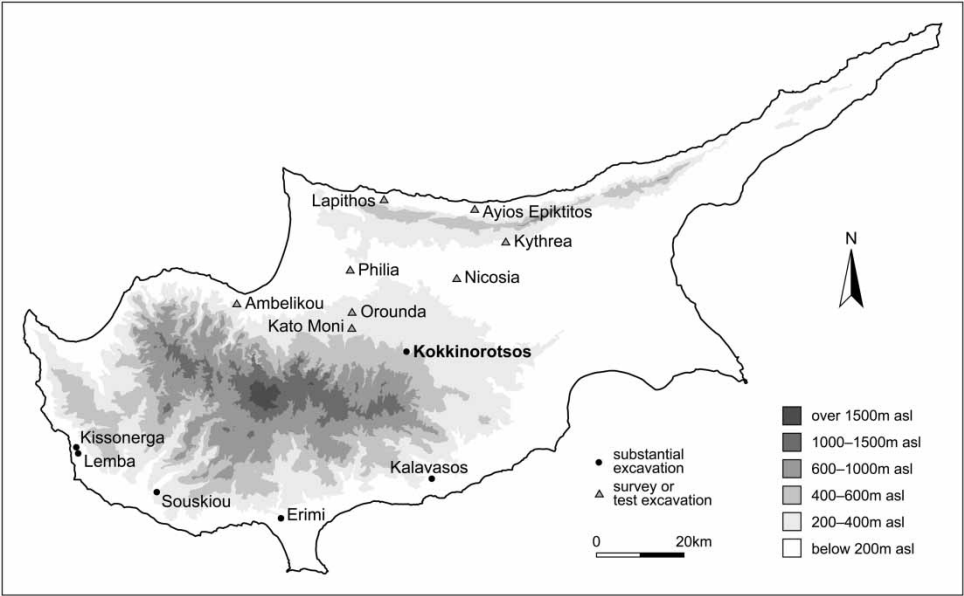


Figure 1. Map of Cyprus showing the location of Politiko-Kokkinorotsos and other relevant sites.

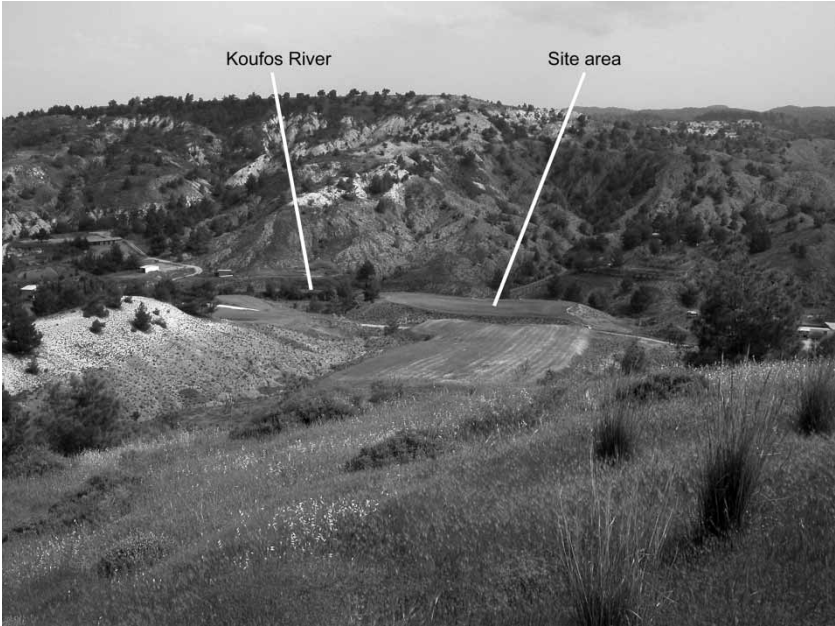


Figure 2. General view of the site and environmental setting of Politiko-Kokkinorotsos from the north.

cooler than the intense summer heat of the central lowlands to the north and cold in winter. Excavations in 2007 cleared about 550 m<sup>2</sup>, and trial trenches suggest that the site did not extend significantly beyond the excavated area (Webb et al.,

2009; Frankel, 2010; Webb, 2011; Figure 3). No traces of stone architecture, burial pits or human remains were located, although a few amorphous lumps of daub suggest the presence of timber and daub structures. One well-preserved oven pit was identified and several areas of burning may be traces of hearths, additional oven pits, or activity areas. Very large quantities of pottery, stone, and animal bone came from the fill of three roughly circular pits (3–5 m in diameter and up to 1 m deep) and a very wide, deep natural hollow over 200 m<sup>2</sup> in area and up to 1.5 m deep. All the material appears to have been redeposited, perhaps a result of shovelling midden dumps into pits and hollows to level the area during a short and deliberate episode of clearance. Eleven AMS radiocarbon dates on single seeds and one conventional radiocarbon date on charcoal are almost identical, and show that Kokkinorotsos was used for a relatively short time between approximately 2880 and 2670 cal

BC. It is the only Chalcolithic site known in the vicinity of Politiko. The nearest, possibly contemporary settlements identified through survey lie 15–20 km to the west at Kato Moni and Orounda (Stanley Price, 1979: 93–94, 99; Held, 1994: 332–33; Given & Knapp, 2003: 265). Limited excavations have been carried out at several more distant sites – at Ambelikou-Ayios Georgios, Philia Site B (Dikaïos, 1962: 141–51) and Nicosia (Dikaïos, 1935: 12; Nicolaou, 1967: 37–52; Hadjisavvas, 1999: 623). Whereas there is evidence of substantial architecture similar to that of the southwest, these sites remain difficult to date and to interpret.

#### MODEL OF SEASONAL HUNTING

The faunal assemblage from Kokkinorotsos is exceptionally large and well-preserved. Paul Croft's analysis of these remains, which include more than 7000



*Figure 3. Excavated area of Politiko-Kokkinorotsos.*

identifiable pieces of large mammalian bone, shows that it was dominated by fallow deer (*Dama mesopotamica*) (Croft in Webb et al., 2009: 220–30; Croft, in press; Table 1). Deer make up three-quarters of the identified fragments in the assemblage (7 per cent by number and 77 per cent by weight). The remainder are primarily caprine, mainly feral sheep (mouflon) but including a few goats (24 per cent of identified fragments and 22 per cent by weight), with pig uncommon at 1 per cent and dog present at less than 1 per cent. Taking relative estimated meat weight yields into account (see Croft, 1991: note b to Table 1), Croft estimated that deer provided 89.9 per cent of the meat at Kokkinorotsos, caprines 8.7 and pig 1.4 per cent (Webb et al., 2009: 231). Whereas deer are a major contributor to the diet at other Chalcolithic sites in Cyprus, they do not dominate to the same extent as at Kokkinorotsos.

In our publication of the excavations at Kokkinorotos we proposed a model of small-scale seasonal occupation and suggested that Kokkinorotsos was a hunting station (Webb et al., 2009: 231–4). This was based in large part on the dominance of fallow deer in the assemblage. Equally, if not more important, was the observation that none of the animals at Kokkinorotsos were herded (Webb et al., 2009: 220–30; Croft, in press). This is to be expected with fallow deer, which

were not domesticated in Cyprus, but also appears to be the case with the other species. Two sets of observations point towards this. One is based on estimates of the ages at which animals were killed. The age profiles of caprines and deer are very similar to one another, matching those of hunted deer at Bronze Age Marki-Alonia, and significantly different from those expected of herded animals (Webb et al., 2009: 221, 225, Figure 35; Croft, in press). The other is the representation of body parts. Despite some variation between them, the similarity of the recovered skeletal elements of caprines to those of deer fits with patterns characteristic of hunting, where those elements with less meat (such as the head and lower limbs) are normally left at the kill-site and therefore under-represented in settlement assemblages (Webb et al., 2009: 220–21, Figure 34).

Alongside the argument that the large assemblage represents a hunted population is the related and equally significant issue of seasonality: several lines of evidence suggest that hunting at Kokkinorotsos was confined to the warmer months. The first is the absence of male sheep over 3 years of age in the faunal sample. This is linked by Croft to the behavioural ecology of mouflon (Webb et al., 2009: 228). Mouflon social organization is characterized by periodic segregation of the sexes and variability in the age/sex composition of mouflon groups (Le Pendu et al., 1997: 142). A study conducted in southern France found that groups of females and young (including males up to 3 years) were the most frequently observed type throughout the year. During the rut (mating period), from the end of October to the beginning of January, mixed groups including adult males were almost as common, but during the rest of the year, males tended to form single sex groups, mixed groups being comparatively rare

**Table 1.** *Identifiable pieces of larger mammalian bone from Politiko-Kokkinorotsos*

|         | NISP | Percentage |
|---------|------|------------|
| Deer    | 5385 | 74.1       |
| Caprine | 1769 | 24.3       |
| Pig     | 92   | 1.3        |
| Dog     | 20   | 0.3        |
| Total   | 7266 | 100        |

*NISP* – number of identified specimens.

from April to September (Cransac & Maublanc, 1997: Figure 1). Females prefer the lower-quality forage of scrubland over meadowland during their spring/early summer period of lactation, as scrubland provides good concealment for lambs (Ciuti et al., 2009). A similar pattern of sexual segregation and seasonally variable group composition seems to prevail among mouflon in Cyprus (Hadjisterkotis & Bider, 1993: 129). The lack or scarcity of adult male sheep at Kokkinorotsos suggests, therefore, that hunting took place in the spring and summer when males separated from the herds of more easily hunted females and young.

Further evidence for hunting in the warmer months, although not excluding other seasons, comes from the significant presence of foetal and neonatal bones (Webb et al., 2009: 222), showing late winter and early spring kills, respectively. Similarly, some 67 unshed antler bases attached to the bony pedicles of the skull, as well as one pedicle that had been snapped through to remove an unshed antler, also indicate hunting in the warmer seasons (Webb et al., 2009: 223), while 22 shed bases show that shed antlers were also collected to supplement this supply of raw material (Webb et al., 2009: 222; Croft, in press). The growth and shedding of deer antlers normally coincide with a fairly broad seasonal schedule for high latitude and temperate zone Cervidae (Goss, 1983). Fallow deer typically grow new antlers in the spring as day length increases. They shed the velvet when the days become shorter in late summer and, depending on their age and health status, shed them any time after the autumn rut throughout the winter (Goss, 1983).

Plant remains from Kokkinorotsos show the use of both wild and cultivated species, with cereals (wheat and barley), nuts, and legumes and smaller quantities of fruits (olive, fig, and grape) present among 382

items collected (Webb et al., 2009: 219–20, Table 14). Nut, olive, and grape were exclusively found in the heavy fraction, only 10 per cent of which was sorted compared with 100 per cent of the light fraction. They are therefore likely to be considerably underrepresented in the total sample. The relative quantity of nut fragments, nevertheless, is high and together with other fruits suggests a significant use of wild plants alongside domestic cereals.

The chipped stone artefact assemblage comprised 5704 artefacts (Webb et al., 2009: 209–18). McCartney's study of the material demonstrates that the full range of activities associated with core reduction and tool production is represented, attesting to on-site tool manufacture, refuse from which was dumped into the pit and hollow features or left on the surface. Tools, however, comprised 26.5 per cent of the assemblage, in sharp contrast to Chalcolithic assemblages elsewhere, where tools account for only 5–8 per cent of assemblage totals. This shows a strong focus on tool use as opposed to manufacture. Whereas most of the raw materials used are available in the immediate vicinity of the site, some less common chert types occur predominantly as tools, suggesting that they were produced elsewhere and brought to Kokkinorotsos in finished form (Webb et al., 2009: 210).

McCartney's analysis shows that the chipped stone assemblage is heavily dominated by three major tool classes: *pièces esquillées*, scrapers, and burins (Webb et al., 2009: 212–16, Table 9). *Pièces esquillées* are the most common, representing over a quarter (27.8 per cent) of the total sample. Although frequently found in Cypriot Neolithic assemblages, *pièces esquillées* are rarely reported from other Chalcolithic sites. They were probably used as small wedges for splitting bone. The second most common tools are scrapers (19.4 per cent). All show visible

polish and sometimes linear striations perpendicular to the tool edge. One likely function is hide scraping. Burins (11.8 per cent of the tool sample) provide the third element of the primary formal tool trio. Like scrapers, they are frequently associated with processing animal products, particularly the grooving of bone or antler (cf. Keeley, 1980: 58). Glossed tools, normally interpreted as sickles, and perforators are notably rare. Activities associated with these tool classes were clearly not common at Kokkinorotsos. The relative paucity of blades, elsewhere an important component of Chalcolithic assemblages, is also striking. Indeed, the chipped stone assemblage at Kokkinorotsos is highly specialized in comparison to assemblages from larger, more complex

coastal sites. Its unique composition lends itself most readily to functional interpretations, suggesting a more specialized occupation than at the large settlements of Kissonerga-Mosphilia and Lemba-Lakkous.

Though a variety of uses has been demonstrated for scrapers, burins and *pièces esquillées*, these tools appear to have been frequently employed in animal processing and at Kokkinorotsos may be viewed as a 'tool kit' of functionally related types (Figure 4). The large number of *pièces esquillées*, in particular, demonstrates an intensive focus on bone splitting. This high proportion of chipped stone tools used for butchery or to process animal products might be expected at a site with a faunal assemblage dominated by animals

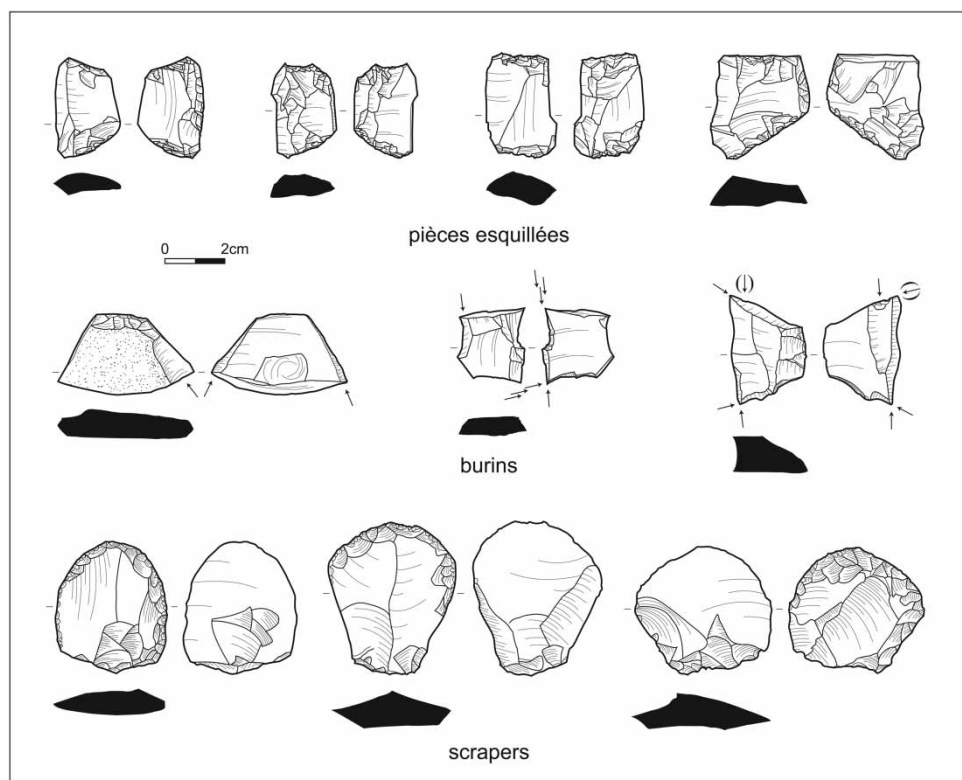


**Figure 4.** Examples of chipped stone artefacts from Politiko-Kokkinorotsos, forming components of a butchery tool-kit.

obtained by hunting. The low number of woodworking tools at Kokkinorotsos is also exceptional and the extreme rarity of glossed tools, elsewhere well-represented in assemblages with an emphasis on agricultural activities, suggests that agriculture was of little or no importance at the site.

The ground stone tool assemblage of 112 items is also instructive. Rubber/quern combinations and heavy pounders were the most numerous types, at 27 and 21 per cent of the total, respectively (Webb et al., 2009, Fig. 27). Both suggest on-site processing of cereals and wild foods. Other tool types and vessels were present in significantly smaller quantities with a surprisingly small number of cutting tools. This is particularly relevant as axes, adzes, and chisels are among the most common items on other Chalcolithic sites in Cyprus (e.g. Elliott-Xenophontos, 1998: 196, Table 19.2; South & Todd, 2004: 185–91; Connelly & McCartney, 2004: 29). These differences in the relative numbers of tools in major functional categories (cutting, grinding, percussion and polishing/rubbing) at Kokkinorotsos from those at Kissonerga and Lemba are likely to reflect differences in site function and location. Overall, the Kokkinorotsos assemblage suggests a bias toward activities involving grinding and heavy percussion, rather than chopping, splitting, or specialized woodworking.

Other finds include two terracotta anthropomorphic figurine fragments, 102 perforated, partly perforated and unperforated sherd disks of uncertain purpose, seven *Dentalium* shell beads, two-holed marine shells, ten pieces of worked antler and seven bone tools (Webb et al., 2009: 218–19, Figure 33). The bone tools include spatulate implements and points showing evidence of the application of considerable pressure during use, and a needle. The worked antler is comprised principally of cut sections of beam and

antler base fragments with evidence of concentric grooving and snapping to facilitate beam removal. Whereas these clearly indicate on-site processing, the number of worked fragments is very small in comparison to the size of the faunal sample, suggesting that antler-working was not a major activity at Kokkinorotsos.

These data strongly reinforce the suggestion of site-specific economic activities based on hunting at Kokkinorotsos. The lack of substantial architecture and the absence of burials further suggest that the site was intermittently or seasonally occupied. This has important implications for developing models of overall settlement patterns, seasonal movement, and economic systems. In order to test this model of seasonal hunting, an independent and more direct analysis of the fauna was undertaken.

#### SKELETOCHRONOLOGY AND SEASONALITY STUDIES

The oldest and most widely used approach for establishing site seasonality draws on the presence/absence of seasonally exploited animals (see Monks, 1981; Pike-Tay, 1991a). The presence of certain species or neonatal/foetal bones may point to occupation during a particular season, although their absence does not preclude occupation during other seasons. Skeletochronology, or incremental growth structure analysis, provides another, more direct, indication of seasonality. The value of this approach was first brought to the attention of archaeologists by Monks (1981: 193):

Incremental structures are distinctive, self-contained additions to the previous growth of an organism. These structures result from varying rates of growth, the most recent growth increment resting on

its immediate predecessor. Changes in the rate of growth are influenced primarily by seasonal growth cycles, thus knowledge of the factors that influence these growth cycles, such as spawning periods, migration, nutrition, and temperature, plus observations on the point in the cycle at which growth was terminated provides information on which seasonality inferences can be based.

Skeletochronology has been increasingly used to investigate site use and human mobility, where seasonality and faunal mortality patterns, in conjunction with other taphonomic and technological indicators, can shed light on behaviours behind assemblage formation processes. Recent applications to major prey species from Middle, Upper, and Epi-Palaeolithic sites (e.g. *Rangifer*, *Cervus*, *Equus*, *Capreolus*, *Gazella*, *Bos*, *Sus*, and *Macropus*) have been successful in determining variability in hunter-gatherer subsistence, season of site occupation and degree of mobility in Eurasian and Australian Late Pleistocene and Early Holocene sites (e.g. Pike-Tay, 1991a, 1993, 2000; Burke, 1993, 1995; Lieberman, 1993a; Pike-Tay & Bricker, 1993; Stutz et al., 1995; Burke & Pike-Tay, 1997; Stutz, 1997; Miracle & O'Brien, 1998; Pike-Tay et al., 1999, 2008; Pike-Tay & Cosgrove, 2002; Castel et al., 2005; Rendu, 2007; Pike-Tay & Ma, 2011). It has also been used to investigate Neolithic societies involved in animal husbandry (Pike-Tay et al., 2004; Whittle, 2007; Pike-Tay & Ma, 2011), where season of death and age at death information allows the reconstruction of culling practices.

Incremental growth structures occur in molluscs, fish, reptiles, and marine and terrestrial mammals. These have been analysed by biologists and some zooarchaeologists for information regarding environment, seasonality, and/or mortality profiles. The evolution and

processes of skeletal biomineralization responsible for these incremental structures across a wide range of taxa have been widely reviewed (for the microstructure and mineralization of vertebrate skeletal tissues including dental structures, see Carlson, 1990; Francillon-Vieillot et al., 1990; Lieberman, 1993b; Klevezal, 1996). An in-depth literature review and a critical comparison of methods for assessing seasonality in shells from archaeological sites, including isotopic and incremental-growth structure analysis, are provided by Claassen (1993, 1998). The work of Klevezal & Kleinenberg (1969) is the long-standing major scientific reference for investigations into the incremental structures of mammalian bone and teeth, and includes summaries of data on the presence of annual/cyclical layers in the bone or tooth tissues of mammalian species at the time of publication (see also Klevezal, 1980, 1996).

'Adhesion lines', the most common incremental structures in bone, form during winter in many high latitude and temperate zone mammals and are often most visible in the mandible (cf. Klevezal & Mina, 1973; Klevezal et al., 1985; Francillon-Vieillot et al., 1990). The potential of the incremental structures of bone for the archaeological assessment of age or season of death has not been explored as thoroughly as that of teeth. However, the success of Klevezal et al. (1985) in differentiating seasonal generations of field voles (*Microtus agrestis*), and of similar observations of mandibular bone adhesion lines on recent and archaeological mandibles of Bennett's wallaby (*Macropus rufogriseus*) (Pike-Tay & Cosgrove, 2002), demonstrates the potential of this category of bone growth for seasonal estimates. Similarly, Stallibrass (1982: 112) has suggested that analysis of periosteal layering in long bones may prove more exacting and useful to zooarchaeologists than ageing by

epiphyseal fusion, although this too remains to be evaluated.

In this study, skeletochronology (odontochronology) of mammalian teeth has been used to assess the season of capture and age at death. A yearly cycle is marked in the mineralized tissues of the teeth of most high latitude and temperate zone mammals by one wide (growth) *zone*, temporally corresponding to the warmer seasons, in addition to one narrow *annulus* (slow growth) and/or a 'line of arrested growth' (LAG), temporally corresponding to 'winter', and observable in the dental cementum and/or dentine (cf. Mina & Klevezal, 1970; Castanet, 1981; Francillon-Vieillot et al., 1990; Lieberman, 1993a, 1993b; Pike-Tay, 1995; Klevezal, 1996; Pike-Tay & Cosgrove, 2002). Therefore, wildlife biologists have long used counts of these annular increments to age individual animals (e.g. Laws, 1952; Klevezal & Kleinenberg, 1969; Morris, 1972; Spinage, 1973; Grue & Jensen, 1979; Klevezal, 1996).

The physical and optical expressions of the growth increments in tooth cementum result from differing patterns of collagen fibre organization, cell content, and mineralization (Castanet, 1981; Francillon-Vieillot et al., 1990; Lieberman, 1993a, 1993b; Klevezal, 1996). Lieberman (1993a, 1993b) argued that differentiation of growth layers in dental cementum results from seasonal rhythms of cementoblast activity as well as from occlusal strain. His controlled experiments with goats point to at least two major causal factors in the formation of dental cementum increments: (1) nutritional quality of diet, which accounts for the width of the growth band and (2) food hardness, which affects occlusal strain, resulting in fibrillar angle changes in the extrinsic and intrinsic collagen fibres (responsible for the different optical qualities of the growth zone and annulus under the microscope)

(Lieberman, 1993a, 1993b). Pike-Tay's (1995) and Weinand's (1997) studies of well-documented *Rangifer* and *Odocoileus* herds, whose forage quality and coarseness varied seasonally, support Lieberman's conclusions. However, the contributions of endogenous factors triggered by photoperiodicity or seasonal changes in basal metabolic rates cannot be ruled out (Pike-Tay, 1991a, 1991b). As these microstructural variations in teeth result from seasonal differences in the forage characteristics of herbivore diets, odontochronology provides zooarchaeology with a valuable tool in the reconstruction of site seasonality and prehistoric subsistence strategies.

## METHODS

### Sample

A total of 48 first and second molars (M1 and M2) of *Dama* and caprines were selected by Paul Croft from the excavated faunal assemblage from Kokkinorotsos and exported to the USA under a licence from the Department of Antiquities of Cyprus. These were taken from complete mandibles to avoid the possibility of using teeth from the same animal. Twenty of these proved to be too mineralized or degraded to be analysed, leaving a sample of 28 teeth suitable for analysis (Table 2).

### Techniques

The odontochronological analyses were carried out by Pike-Tay in the Department of Anthropology at Vassar College. The techniques used follow the protocol described by Pike-Tay (1995). These include preparation and use of radial 'dry' thin sections (about 30  $\mu$ ) taken at the mesial-distal midline of the tooth, and

**Table 2.** Sample of 48 M1 and M2 teeth from Dama and caprine mandibles from Politiko-Kokkinorotsos

| No. | Square-context | Taxon        | Side  | Overall wear | Number of annuli                              | Zone state of completion                  | Magnification | Season of death estimate |
|-----|----------------|--------------|-------|--------------|-----------------------------------------------|-------------------------------------------|---------------|--------------------------|
| 1   | G5-199         | <i>Capra</i> | Left  | Medium       | Too mineralized to analyse                    |                                           |               |                          |
| 2   | G5-199         | Caprine      | Left  | Heavy        | Too mineralized to analyse                    |                                           |               |                          |
| 3   | F4-94          | <i>Dama</i>  | Right | Light        | 2 annuli                                      | F = beginning zone                        | 40 ×          | Spring                   |
| 4   | F5-101         | <i>Dama</i>  | Right | Medium       | c. 4 annuli                                   | F = just beginning zone                   | 100 ×         | Early spring             |
| 5   | F5-24          | Caprine      | Left  | Heavy        | 7+ annuli                                     | F = c. 1/2 + zone                         | 100 ×         | Summer                   |
| 6   | F5-90          | <i>Dama</i>  | Right | Medium/heavy | Too mineralized to analyse                    |                                           |               |                          |
| 7   | F5-90          | <i>Dama</i>  | Right | Heavy        | Too mineralized to analyse                    |                                           |               |                          |
| 8   | F5-91          | Caprine      | Left  | Light        | 3 annuli                                      | F = just beginning zone                   | 40 ×          | Spring                   |
| 9   | E5-0           | <i>Dama</i>  | Right | Medium       | 4 annuli                                      | F = complete annulus                      | 40 ×          | End of winter            |
| 10  | G5-190         | <i>Dama</i>  | Right | Light        | 2 annuli                                      | F = complete annulus, possible new growth | 100 ×         | End winter/early spring  |
| 11  | G5-190         | <i>Dama</i>  | Right | Medium       | c. 4 annuli                                   | F = beginning growth zone                 | 100 ×         | Spring                   |
| 12  | G5-190         | <i>Dama</i>  | Right | Light        | 2 visible annuli                              | F = 1/3 growth                            | 100 ×         | Spring/early summer      |
| 13  | G5-190         | Caprine      | Left  | Heavy        | 5+ annuli (too mineralized to see early ones) | F = in growth zone                        | 40 ×          | Warm season/not winter   |
| 14  | G5-190         | <i>Dama</i>  | Right | Medium       | c. 6 annuli                                   | F = complete annulus                      | 100 ×         | End of winter            |
| 15  | G5-190         | <i>Dama</i>  | Right | Unworn       | 1 annulus                                     | F = complete annulus, possible new growth | 40 ×          | End winter/early spring  |
| 16  | G5-190         | <i>Dama</i>  | Right | Light        | c. 3 annuli                                   | F = 2/3 growth zone                       | 40 ×          | Summer                   |
| 17  | G5-129         | <i>Dama</i>  | Right | Medium       | 3–4 annuli                                    | F = 2/3 growth zone                       |               | Summer                   |
| 18  | F4-58          | <i>Dama</i>  | Right | Light        | Too mineralized to analyse                    |                                           |               |                          |
| 19  | F4-119         | <i>Capra</i> | Left  | Light        | Too friable to count annuli                   | F = in growth zone                        | 40 ×          | Not winter               |
| 20  | F5-68          | <i>Ovis</i>  | Left  | Medium       | 6 or 7 annuli                                 | F = complete annulus                      | 100 ×         | End of winter            |
| 21  | F5-68          | Caprine      | Left  | Light        | 2 annuli                                      | F = complete annulus                      | 100 ×         | End of winter            |
| 22  | F5-68          | <i>Dama</i>  | Right | Medium       | Too mineralized to analyse                    |                                           |               |                          |
| 23  | F4-198         | <i>Dama</i>  | Right | Heavy        | Too mineralized to analyse                    |                                           |               |                          |
| 24  | F4-198         | <i>Ovis</i>  | Left  | Light        | 1 or 2 annuli                                 | F = c. 1/2 growth zone                    | 100 ×         | Summer                   |

*Continued*

Table 2. Continued

| No. | Square-context | Taxon       | Side  | Overall wear | Number of annuli           | Zone state of completion            | Magnification | Season of death estimate   |
|-----|----------------|-------------|-------|--------------|----------------------------|-------------------------------------|---------------|----------------------------|
| 25  | F4-198         | Caprine     | Left  | Light/medium | Too mineralized to analyse |                                     |               |                            |
| 26  | F4-198         | Caprine     | Left  | Light/medium | Too mineralized to analyse |                                     |               |                            |
| 27  | F4-198         | <i>Dama</i> | Right | Heavy/medium | Too mineralized to analyse |                                     |               |                            |
| 28  | F5-123         | <i>Dama</i> | Right | Unworn       | 1 annulus                  | F in beginning growth               | 200 ×         | Spring                     |
| 29  | F5-89          | <i>Dama</i> | Right | Medium       | c. 5 annuli                | F = edge too degraded to analyse    | 100 ×         |                            |
| 30  | G5-126         | <i>Dama</i> | Right | Heavy        | 6+ annuli                  | F = complete zone                   | 100 ×         | End winter                 |
| 31  | F4-140         | <i>Dama</i> | Right | Light/medium | 2 or 3 annuli              | F = in growth zone, poor visibility | 100 ×         | Warm season/not winter     |
| 32  | G5-177         | <i>Dama</i> | Right | Medium       | 3 or 4 annuli              | F = beginning growth                | 100 ×         | Spring                     |
| 33  | F4-113         | <i>Dama</i> | Right | Light/medium | Too mineralized to analyse |                                     |               |                            |
| 34  | F4-113         | <i>Dama</i> | Right | Heavy        | 8+ annuli                  | F = complete annulus                | 100 ×         | End of winter              |
| 35  | F5-35          | <i>Dama</i> | Right | Heavy        | 6 or 6+ annuli             | F = complete annulus                | 100 ×         | End of winter              |
| 36  | F4-196         | <i>Dama</i> | Right | Light        | Too mineralized to analyse |                                     |               |                            |
| 37  | F4-193         | <i>Dama</i> | Right | Heavy        | Too mineralized to analyse |                                     |               |                            |
| 38  | G5-167         | <i>Dama</i> | Right | Unworn/light | Too mineralized to analyse |                                     |               |                            |
| 39  | G5-167         | <i>Dama</i> | Right | Light/medium | c. 3 annuli                | F = beginning to 1/3 growth         |               | Early spring/spring        |
| 40  | F5-86          | Caprine     | Left  | Light/medium | 1 annulus                  | F = c. 1/2 +                        |               | Summer                     |
| 41  | F5-53          | <i>Dama</i> | Right | Heavy        | Too mineralized to analyse |                                     |               |                            |
| 42  | F5-86          | <i>Dama</i> | Right | Heavy        | Too mineralized to analyse |                                     |               |                            |
| 43  | F5-86          | <i>Dama</i> | Right | Heavy        | Too mineralized to analyse |                                     |               |                            |
| 44  | F5-53          | <i>Dama</i> | Right | Medium       | Too mineralized to analyse |                                     |               |                            |
| 45  | F5-53          | <i>Dama</i> | Right | Heavy        | Early annuli obscured      | F = complete annulus/beginning zone | 40 ×          | End of winter/early spring |
| 46  | F4-198         | <i>Dama</i> | Right | Heavy        | Too mineralized to analyse |                                     |               |                            |
| 47  | F4-198         | <i>Ovis</i> | Left  | Medium       | 5 or 6 annuli              | F = complete annulus/beginning zone | 100 ×         | End of winter/early spring |
| 48  | F4-198         | Caprine     | Left  | Heavy        | Final 3 annuli visible     | F = complete annulus/beginning zone | 100 ×         | End of winter/early spring |

viewing and recording of thin-section slides under polarized transmitted light to measure consecutive growth zone widths at two or three cementum transects per tooth.

### Seasonal attribution

The attributions of season of death to the sample of fallow deer and caprines from Kokkinorotsos are based on the following observations of comparative samples and the zooarchaeological one: (1) the dental cementum is deposited at a regular rate only in areas of acellular cementum, for example, nearest the tooth cervix; (2) no overlap exists between the early and late segments of the warm season and (3) initiation of the winter annulus is not as well synchronized as its cessation (cf. observations by Saxon & Higham, 1969; Rudge, 1976).

As the precise rates of cemental deposition vary within and across populations, seasonal designations are necessarily broad. Whereas the dental 'growth bands' of the fallow deer and caprines examined here cannot be subdivided to the degree possible with a highly seasonal species such as *Rangifer* (see Pike-Tay, 1995), the early and later, and often the middle, phases of cementum zone growth do not overlap. It is therefore possible to derive information regarding season of slaughter from this sample, using the following broad categories:

*Winter* is designated when the slow growing, narrow annulus (which differs in width and optical quality from the fast growth zones) is forming.

*End of winter* is designated when the annulus has completed formation, but the new zone has not begun forming (Figure 5).

*Early spring* is designated when the newly forming growth zone is less than

one-third the width of prior years' growth zone layers.

*Spring* pertains to end of winter through early summer when the newly forming growth zone is less than half the width of prior years' growth zone layers.

*Summer* is a general designation when the growth increment is about half the width of prior years' growth zone layers (Figure 6).

*Autumn* is assigned when the growth of the outer cementum layer of the tooth root is greater than half the width of prior years' growth zone (i.e. fast growth) layers.

*Late Autumn/early winter* signifies that the growth zone is equal to the width of prior years' zones.

### RESULTS

The results of the analyses are presented in Table 2 and summarized in Figure 7. It is clear that all the teeth studied come from animals killed during the warmer months, between the end of winter and the end of summer. This, together with the presence of neonatal/foetal bones, provides an independent confirmation of the more indirect observations and arguments for seasonal hunting at Kokkinorotsos and leaves little doubt that the site was used for only part of the year. Although we cannot entirely exclude any cold season activity at the site, there is no evidence to suggest it. In contrast, there are multiple lines of evidence for warm season occupation.

Both the location of Kokkinorotsos and a spring/summer hunting regime fit well with the ecology of deer herds. Fallow deer are grazers rather than browsers and their preferred habitat is mixed woodland and open grassland, both of which would have been available in the immediate area of Kokkinorotsos. Fallow deer have seasonal synchronization of birth (early spring),

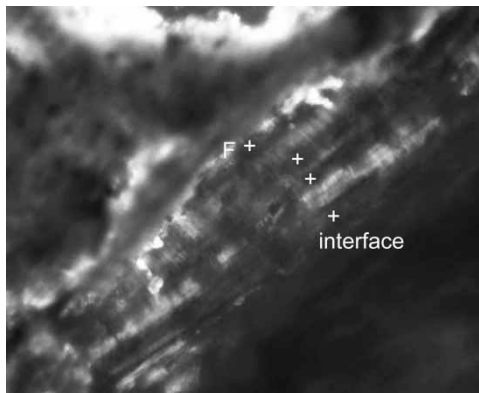


**Figure 5.** Magnified (x40) thin section of sample no. 9 (Dama), showing dental cementum 'growth bands' indicating end of winter slaughter. Interface shows the dentine-cementum boundary, + indicates winter annuli, and F the final growth stage.

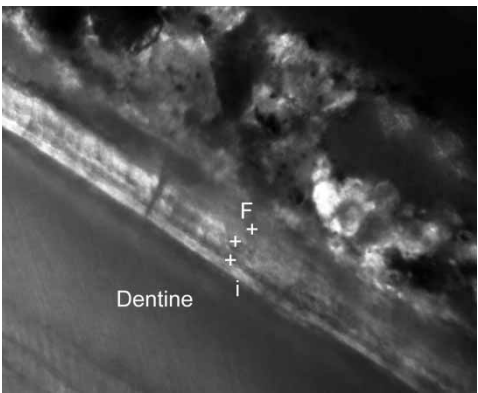


**Figure 6.** Magnified (x40) thin section of sample no. 16 (Dama), showing dental cementum 'growth bands' indicating summer slaughter. i shows the dentine-cementum boundary, + indicates winter annuli, and F the final growth stage.

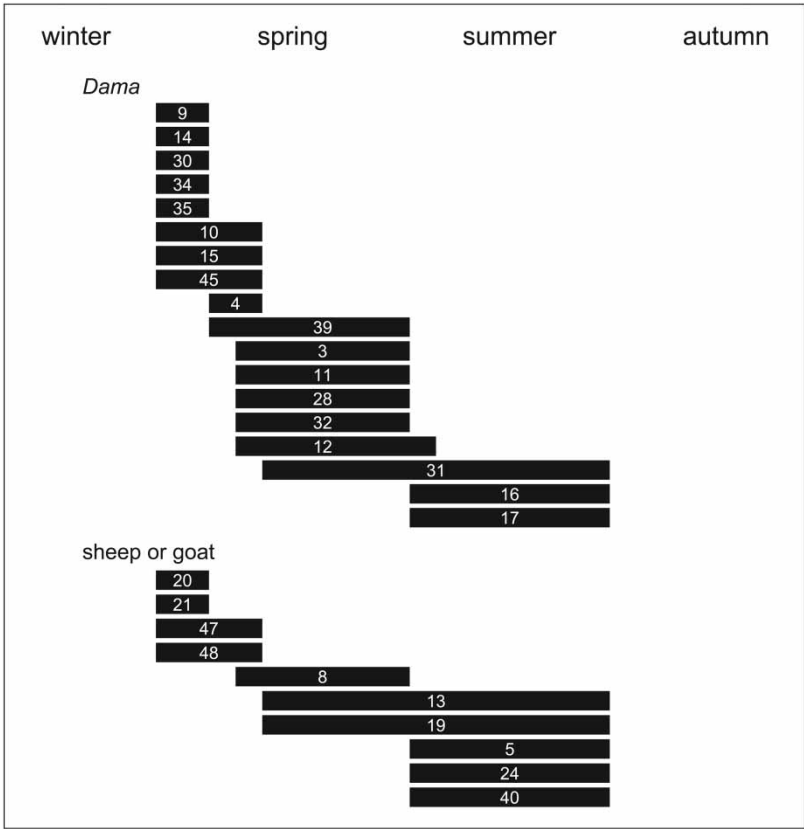


**Figure 7.** Summary of results of odontochronological analysis showing seasonal indicators of time of slaughter for 28 samples from Politiko-Kokkinorotsos. The shading gives a visual impression of relative probability.

body growth and activity cycles corresponding to feed quantity, quality, and availability. Females tend to stay in predominantly single sex groups through much of the year with the lowest levels of female segregation during the autumn reproductive period. During the autumn, rut bucks will spread out and females move between them. At this time of year, the deer are relatively ungrouped compared with the rest of the year, when they form large groups (of 12–150 depending on the size of available preferred habitat). In winter and spring, mixed-sex groups are largely comprised of young males that join female feeding aggregations (Thirgood, 1996; Focardi & Pecchioli, 2005). Late winter, spring, and early summer are therefore likely to have provided hunters with suitable weather conditions and the greatest access to mixed-sex groups of fallow deer, which were clearly their principal quarry.

### IMPLICATIONS

The limited extent of occupation at Kokkinorotsos, the absence of substantial structures and burials, and the lack of agricultural and timber-working tools suggest that the site was not permanently occupied, and the exclusive presence of wild animals and a chipped stone toolkit associated with butchery suggest that hunting was the main activity. The new evidence presented here further supports seasonal use of the site in the spring and summer and allows a more confident consideration of its broader context.

Kokkinorotsos is best understood as a hunters' camp: a seasonal base used for forays into the surrounding scrub and woodland and for preparing meat, hides, antler, and other products from the resulting quarry. That other activities also took place at the site is, however, demonstrated by the presence of storage vessels, spouted

jars, bowls, and fineware eating and drinking vessels with painted decoration (which comprise 6.7 per cent of the ceramic assemblage), as well as domesticated cereals and cereal grinding equipment. These clearly indicate the storage and consumption of food and drink at the site and possibly some form of feasting. The earth oven may point in the same direction. Earth ovens are rare in Chalcolithic Cyprus and have elsewhere been associated with the preparation and consumption of special foods (notably meat) and with public display and feasting (Peltenburg & Thomas, 1991; Peltenburg, 1991: 88–89, 1993: 14). The two anthropomorphic figurine fragments and a number of apparently zoomorphic vessels with well-burnished black surfaces and relief decoration hint at a more formal ritual dimension (Webb et al., 2009: 203, Figure 21, Fabric e). The zoomorphic vessels in particular, although fragmentary and not attributable to species, raise the possibility of rituals explicitly associated with hunting practices, especially as such vessels are not yet evident elsewhere.

The sheer quantity of pottery (over one tonne) and other material recovered at Kokkinorotsos suggests that the site was intensively used, possibly for several weeks or even months at a time over many generations and perhaps by family groups, rather than by hunters alone. The pottery is likely to have been brought to Kokkinorotsos along with agricultural produce and other supplies from a larger, permanent agropastoral settlement or settlements, either closer to the coast or in the more open and productive floodplain of the Pedeios River. Little comparative material from the region, however, is available at present. Kokkinorotsos is the first Chalcolithic site to be excavated in the centre of Cyprus, with the exception of a small-scale sounding at Nicosia (Dikaïos, 1935: 12; Nicolaou, 1967: 37–52; Hadjisavvas, 1999: 623). Sites with

equivalent ceramics are known at Ambelikou-Ayios Georgios and Philia (Dikaïos, 1962: 141–55), but neither has been extensively investigated and, given their respective locations, in the north-western Troodos and the Ovgos valley, neither is likely to have had a specific connection with Kokkinorotsos.

Kokkinorotsos may be viewed, then, as one component of a Chalcolithic economic and settlement system involving larger, more permanently occupied agropastoral villages and seasonally used special-purpose outstations (see also the discussion in Croft, in press). Small-scale, periodically inhabited hunting camps like Kokkinorotsos may always have been part of the Chalcolithic landscape and are likely to have been one of a number of site types in use in the central lowlands and foothills. In the absence of comparative evidence, it is not possible to know whether the Kokkinorotsos data suggest an increased emphasis on hunting and on the exploitation of forested piedmont locales on Cyprus in the period between 2900 and 2700 cal BC. It is likely, however, that hunted fallow deer were always a highly ranked resource on the island, yielding more meat than any feral competitors without the higher energy inputs associated with the husbandry of domesticates (Wasse, 2007: 62).

Kokkinorotsos, although currently the only non-village site known for the Chalcolithic period, opens up the possibility of a complex and variable cultural system on Cyprus during the first half of the third millennium BC, with community territories made up of a series of sites, each the focus of particular activities appropriate to their ecological setting. The odontochronological data presented here provide important confirmation and extend our initial understanding of the site. Similar analyses have considerable potential to address issues of

seasonality on other sites in Cyprus and elsewhere.

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## Saisonnalité et fonction d'un site chalcolithique en Chypre

*Les fouilles du petit site chalcolithique de Politiko-Kokkinorotsos en Chypre centrale ont montré qu'il était occupé autour de 2880–2670 cal BC. Le daim (Dama Mesopotamica) constitue la majeure partie de l'important inventaire faunistique. La structure de la population animale indique qu'il s'agit d'un site de chasse saisonnier, interprétation en accord avec l'absence d'architecture formelle et avec la gamme d'outils lithiques. Dans cet article, on utilise des analyses odontochronologiques objectives de cervidés et de capridés afin d'évaluer et de confirmer le modèle d'abattage saisonnier de cervidés au printemps et en été, modèle basé sur des indicateurs plus généraux. Les résultats suggèrent un schéma d'activités et de types de sites variés et spécialisés dans différentes parties de l'île et dans différentes zones écologiques, et contribuent considérablement à notre compréhension des systèmes culturels de l'île au début du 3<sup>e</sup> millénaire BC. Translation by Isabelle Gerges.*

*Mots clés :* Chypre, Chalcolithique, cervidés, chasse, odontochronologie, saisonnalité

## Saisonalität und Funktion von kupferzeitlichen Fundplätzen Zyperns

*Ausgrabungen des kleinen chalkolithischen Fundplatzes Politiko-Kokkinorotsos in Zentralzypern zeigen, dass er etwa zwischen 2880 und 2670 cal BC besiedelt war. Der Dambirsch (Dama mesopotamica) bildet dabei die Hauptkomponente des umfangreichen Fauneninventars. Die Struktur der Tierpopulation legt nahe, dass es sich um einen saisonalen Jagdplatz gehandelt hat – eine Interpretation, die mit einem Fehlen regulärer Architektur und der Typenspanne des lithischen Inventars übereinstimmt. In diesem Beitrag werden unabhängige Analysen des jährlichen Zuwachses von Zahnzement und Dentin (Odontochronologie) von Hirschen und Ziegen genutzt, um das Modell einer jahreszeitlichen Schlachtung im Frühjahr und Sommer, das auf verschiedenen allgemeineren Indikatoren beruht, zu überprüfen und zu bestätigen. Die Ergebnisse deuten auf eine Struktur von verschiedenartigen, spezialisierten Fundplatztypen und Aktivitäten in bestimmten Teilen der Insel und verschiedenen ökologischen Zonen hin und tragen so wesentlich zu unserem Verständnis der kulturellen Systeme der Insel im frühen 3. Jt. v. Chr. bei. Translation by Heiner Schwarzberg.*

**Stichworte:** Zypern, Chalkolithikum, Hirsch, Jagd, Odontochronologie, Saisonalität