First wave of cultivators spread to Cyprus at least 10,600 y ago

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Edited* by Ofer Bar-Yosef, Harvard University, Cambridge, MA, and approved April 6, 2012 (received for review February 1, 2012)

Early Neolithic sedentary villagers started cultivating wild cereals in the Near East 11,500 y ago [Pre-Pottery Neolithic A (PPNA)]. Recent discoveries indicated that Cyprus was frequented by Late PPNA people, but the earliest evidence until now for both the use of cereals and Neolithic villages on the island dates to 10,400 y ago. Here we present the recent archaeological excavation at Klimonas, which demonstrates that established villagers were living on Cyprus between 11,100 and 10,600 y ago. Villagers had stone artifacts and buildings (including a remarkable 10-m diameter communal building) that were similar to those found on Late PPNA sites on the mainland. Cereals were introduced from the Levant, and meat was obtained by hunting the only ungulate living on the island, a small indigenous Cypriot wild boar. Cats and small domestic dogs were brought from the mainland. This colonization suggests well-developed maritime capabilities by the PPNA period, but also that migration from the mainland may have occurred shortly after the beginning of agriculture.

domestication | *Sus* scrofa | food production | prehistoric seafaring | Neolithic mobility

The transition from hunting-gathering to food production is a major step in the history of humanity and the biosphere (1, 2). Humans begun to cultivate morphologically wild cereals and pulses over a wide area in the Near East by ∼11.5 cal kyBP (thousands of calibrated radiocarbon years before present), a period known as the Pre-Pottery Neolithic A (PPNA) (3–7). Early cultivators lived in small villages and continued to hunt and gather in the wild (8–10). By 10.5–9 cal kyBP, during the Pre-Pottery Neolithic B (PPNB), villages increased in size, and the subsistence strategy developed into an established mixed agropastoral economy based on domesticated crops and animals (sheep, goat, pig, and cattle) (11–13). Previous research indicates that the first farmers settled Cyprus during the Early PPNB, beginning ∼10.4 cal kyBP (14, 15), bringing with them domestic cereals, pulses, goat, cattle, sheep, and pig to the island (*SI Appendix*, SI Text S1) (14, 16, 17). Before these settlements, the only known human presence on Cyprus was limited to the small Aetokremnos rock shelter occupied by fisher-trappers dating to 12.5 cal kyBP (18). Recently, three sites dated to ∼11.1–10.6 cal kyBP have been discovered (19–22). The extensive excavations at one of these sites, Klimonas (*SI Appendix*, Figs. S1 and S2), unearthed plant remains, abundant animal bones, thousands of artifacts, and the remains of several buildings, including one communal structure. These finds reveal previously unknown aspects of the social and economic organization of the inhabitants of Cyprus at this early date.

Our analyses of these finds combined with a series of 11 radiocarbon dates demonstrate that Cyprus was settled by Neolithic villagers several centuries earlier than suspected, a phenomenon that has far-reaching implications for a fuller understanding of the Neolithic Revolution in the Near East. The inhabitants of Klimonas cultivated a primitive wheat introduced from the mainland and hunted the only large mammal living on the island—namely, an extinct species of wild boar. The occupation at Klimonas coincides with a period on the mainland when agriculture was still becoming established; it shows that at this time human groups in the eastern Mediterranean could be highly mobile and participated in complex exchange systems. These groups also had the capacity to adapt to new environments with a low density of food animals. The findings from Cyprus reveal unsuspected sea-faring capabilities and provide unique information regarding the beginnings of plant and animal domestication, including that of dogs and cats.

Results

Collective Building. That the inhabitants of Klimonas had a complex society is demonstrated by the discovery of a circular building 10 m in diameter (Fig. 1*A* and *SI Appendix*, Figs. S3–S6). Although the building's upper part had been destroyed, it was possible to show that it was dug into the ancient land surface to a depth of at least 1 m (*SI Appendix*, SI Text S2). This feat would have entailed considerable labor to remove at least 75 m^3 of the geological substratum (*SI Appendix*, Fig. S7). At the outer edge of the building was a foundation ditch, dug for the surrounding wall, and containing its remains at the time of excavations; this wall varied in thickness, perhaps for decorative reasons. The base of the wall contained numerous hidden caches with flint arrowheads and blades; shell pendants; and green stone beads. A series of caches were also found in the floor, along with numerous hearths, pits, and post holes (Fig. 1*B*). These finds, together with the possibility that there was a surrounding interior bench, confirm that this structure ST 10 was a collective building rather than a domestic dwelling. The building is similar in size and plan to Late PPNA sunken buildings in the northern Levant, which were sometimes decorated and contained caches of precious objects suggesting ceremonial use. These buildings have been interpreted as multifunctional communal buildings for collective storage, meetings, and ritual use (8, 23). Early

Author contributions: J.-D.V., F.B., and J.G. designed research; J.-D.V., F.B., A.Z., G.W., T.C., I.C., and Y.F. performed research; J.-D.V., F.B., A.Z., G.W., T.C., S.T., I.C., Y.F., R.T., C. Martin, C. Moreau, and C.C. analyzed data; and J.-D.V., F.B., A.Z., G.W., T.C., S.T., and J.G. wrote the paper.

The authors declare no conflict of interest.

*This Direct Submission article had a prearranged editor.

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This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1201693109/-/DCSupplemental.

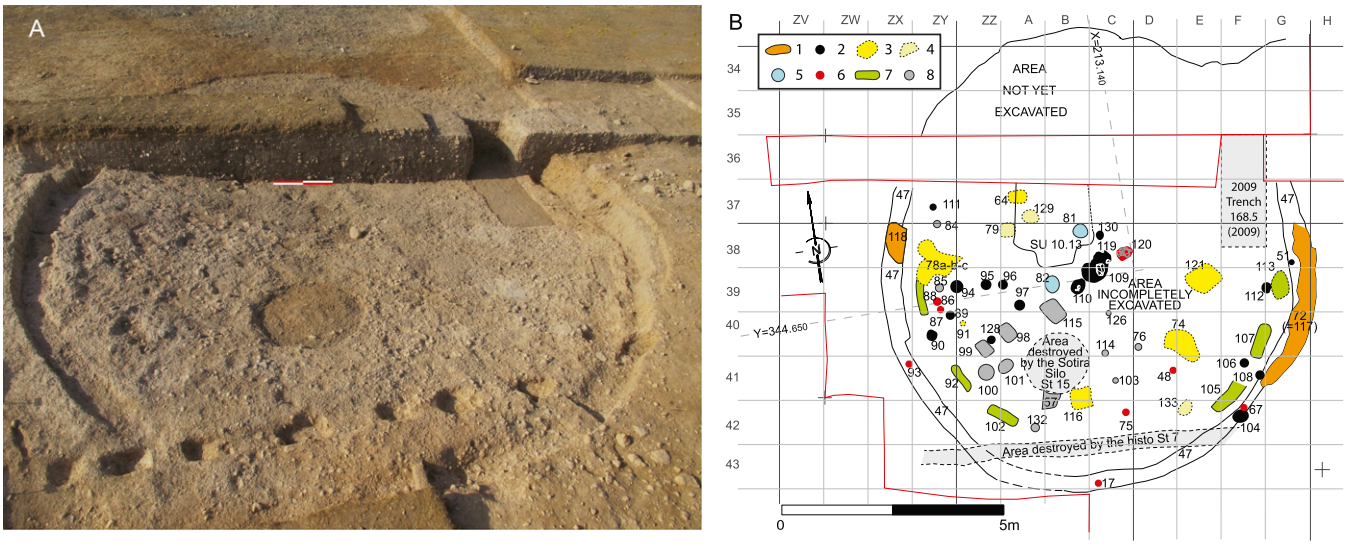

Fig. 1. The communal building found at Klimonas (ST 10). (*A*) General photo taken from the south. The upper part of the building has been eroded. The extreme northern part has not been excavated. In the excavated area, the base of the building can be seen to be cut into the substratum, and is delimited by a circular foundation trench for the outside wall of the building. The latter was preserved on the eastern and western sides, where it was thicker. In the foreground is a line of small pits dating to historical times, and a large circular Pottery Neolithic silo cut into the floor. On the right (east) side and in the background are gray archaeological layers associated with the main building. The scale (1 m) is noted on the photo. (*B*) Plan of features found at the base of building 1: 1, Remains of the surrounding earthen wall; 2, post hole; 3–4, hearths; 5, circular pit with stone mosaic; 6, cache of flint tools or pendant; 7, small pit with cache; 8, undetermined (not yet excavated). (Photo by J.-D.V.; record, R.T.; computer-aided design, R.T., and J.-D.V.)

examples of such structures were subdivided into cells; later ones had built-in benches (8). The Klimonas building might have been of an intermediate type.

Domestic Buildings. In addition, we partially excavated several smaller rounded buildings (4–5 m large) adjacent to and above communal building 1 (*SI Appendix*, SI Text S2 and Figs. S5 and S8). These buildings are associated with hearths and work areas and are arranged around and above the communal building, representing different phases of the village's history. In PPNA villages of northern Syria and southeastern Turkey, houses were also organized around communal buildings and were regularly destroyed, perhaps intentionally, but often rebuilt in the same place (8, 23).

Radiocarbon Dating. Eleven charcoal fragments from building 1 were submitted for radiocarbon dating (Table 1 and *SI Appendix*, Fig. S9). The dates cluster tightly and range from the end of the 12th to the mid-11th millennium cal BP, with the highest probability being between 10.8 and 10.6 cal kyBP. These dates are contemporary with those of the only other PPNA Cypriot site (Asprokremnos; 10,749–10,579 cal BP) (22) and with the late PPNA in the Levant (24) and transition sites between the PPNA and the Early PPNB (8, 10).

Stone Industry. The chipped-stone industry is characterized by prismatic unidirectional cores with preferential production of straight blades with sharp ends (*SI Appendix*, SI Text S3 and Figs. S10 and S11). Some blades were used for making flat arrowheads with short tangs (Fig. 2). The toolkit is dominated by burins and scrapers. Drills and glossed sickle blades are also present. Two fragments of stone shaft-straighteners (*SI Appendix*, Fig. S12) typical of the Levantine PPNA tradition (24) were recovered. The lithics from Klimonas are comparable to those found at the site of Asprokremnos (19, 22) and similar to those on the mainland dated to the early stages of the PPNA from the sites of Mureybet (IIIA) and Sheikh Hassan (24).

Plant Remains. Charred plant remains from the site were poorly preserved due to the shallowness of the archaeological sediment. However, several fragments of building earth hardened by fire

Table 1. Radiocarbon dates from 11 pieces of charcoal found in context at Klimonas

							68.2%, 1 s		95.4%, 2 s	
Lab no.	Sample no.	Species	Structure	SU	$d^{13}C$, ‰	Radiocarbon age	From	To	From	To
Muse35/SacA 25304	12	*Pistacia* sp.	ST10	10.8	−26.2	9,435 ± 45	10,588	10,716	10,523	11,055
Muse42/SacA 25311	24	*Quercus* sp.	ST81	10.14	−25.8	9,440 ± 50	10,588	10,729	10,520	11,062
Muse33/SacA 25302	10	*Pistacia* sp.	ST10	10.8 dec2	−27.5	9,445 ± 50	10,588	10,737	10,522	11,065
Muse31/SacA 25300	7	*Pistacia* sp.	ST10-SE	10.6	−24.4	9,450 ± 60	10,583	10,757	10,518	11,069
Muse36/SacA 25305	16	*Pistacia* sp.	ST10	10.3	−28.6	9,480 ± 50	10,604	11,060	10,582	11,070
Muse32/SacA 25301	8	*Pistacia* sp.	ST10-SE	10.6	−26.1	9,505 ± 50	10,686	11,066	10,592	11,082
Muse39/SacA 25308	21	*Pistacia* sp.	ST10	10.10	−26.3	9,505 ± 50	10,686	11,066	10,592	11,082
Muse34/SacA 25303	11	*Pistacia* sp.	ST10	10.8 base	−25.3	9,510 ± 60	10,689	11,068	10,590	11,090
Muse38/SacA 25307	19A	*Pistacia* sp.	ST10	10.3 dec2	−26.8	9,525 ± 45	10,712	11,067	10,676	11,087
P934/AA88551	—	*Prunus* sp.	ST10	10.3	−27.3	9,544 ± 53	10,741	11,070	10,692	11,104
Muse41/SacA 25310	22	*Pistacia* sp.	ST10	10.10	−26.8	9,590 ± 50	10,787	11,092	10,741	11,144

For details of methods, see *Materials and Methods*. SU, stratigraphic unit; s, standard error. The unit for the last five columns of the table are years.

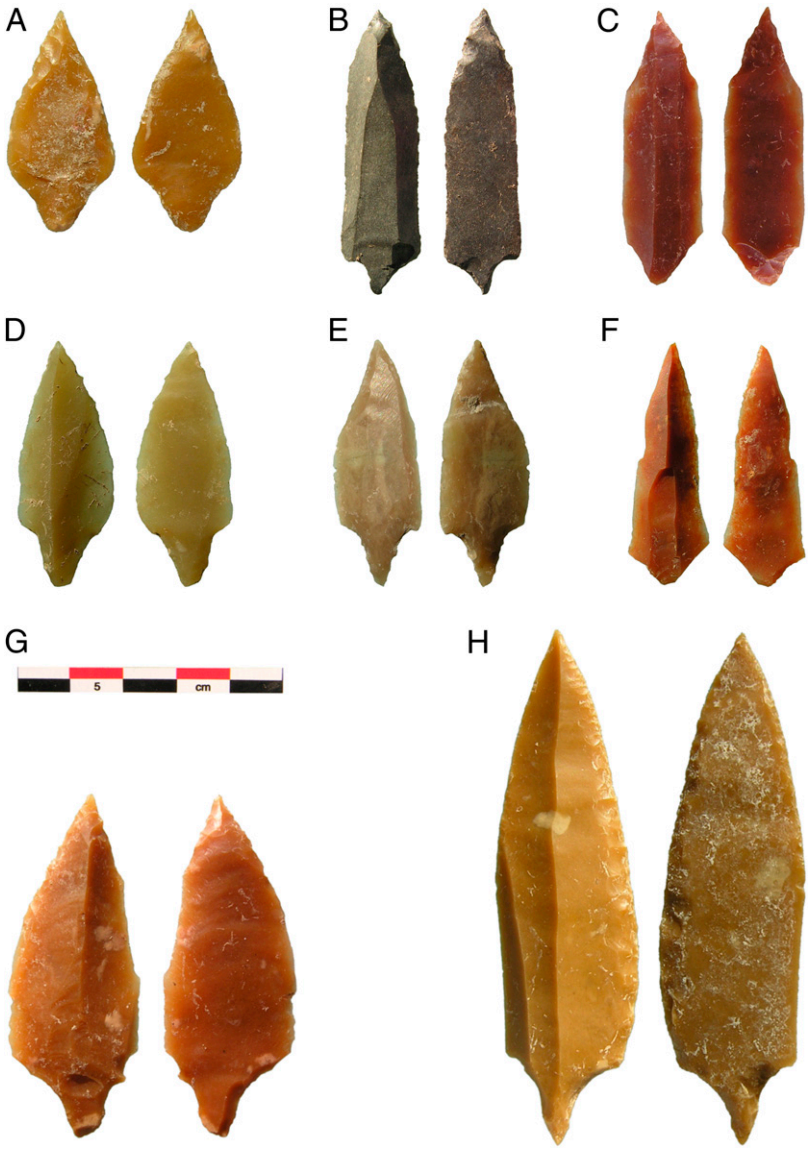

Fig. 2. Different types of arrowheads found in building 1 of Klimonas. (*A, B,* and *D*) SU (stratigraphic unit) 10.3; (*C*) SU 10.11; (*E* and *F*) SU 10.6; (*G*) SU 10.8; and (*H*) foundation trench. (Photo by F.B.)

contained impressions left by cereal chaff (*SI Appendix*, Fig. S13). The practice of using cereal chaff as tempering material is common at PPN sites on the mainland as well as on Cyprus (4, 16). Barley (*Hordeum spontaneum*/*distichon*) and emmer wheat (*Triticum dicoccum*/*dicoccoides*) were identified from the impressions. The impressions do not permit distinction between wild and domestic varieties at this stage (25). Wild emmer is not considered native to Cyprus because (*i*) it does not grow there today, and (*ii*) edaphic conditions are not suitable; it must have been introduced from the mainland (5, 16). Einkorn wheat has been found on later Cypriot sites, suggesting more than one wave of introductions (26). Given that the chaff was available in sufficient quantities to be used as building material, it is probable that cereals were cultivated locally rather than imported. Additional evidence for the harvesting and processing of cereals comes from glossed flint sickle blades and from oval querns, respectively. At contemporary continental sites, these tools are known to have been used for cereal harvesting (7). The combined evidence indicates cereal consumption and probably cultivation only five centuries later than the earliest evidence of cultivation of predomesticated wild cereals and pulses on the mainland (11.5 cal kyBP) (3, 4, 6).

Animal Bones. The numerous and well-preserved animal remains in the fill of building 1 are predominantly food refuse (*SI Appendix*, SI Texts S4–S6). Marine food resources and bird bones are rare (*SI Appendix*, Table S1 and Figs. S14–S17). Meat consumption was dominated by a small wild boar. Morphological analyses demonstrate that this boar is similar to the small Cypriot wild boar first present at the site of Aetokremnos, dated to 12.5 cal kyBP, and presumably introduced to Cyprus before that date with the aim of developing wild game resources (27). Osteometric data confirm that wild boars were 10–16% smaller than PPN Near Eastern suids, either wild or early domestic, but that they did not differ in size from the small domestic pigs present later, during the 10th to 9th millennia BP in Cyprus (Fig. 3 and *SI Appendix*, SI Text S4, Table S3, and Figs. S18 and S19) (28). However, the wide range of slaughtering ages, including a high proportion of very old individuals together with the abundance of arrowheads (>100 in the filling of building 1) suggests hunting or herd control, rather than

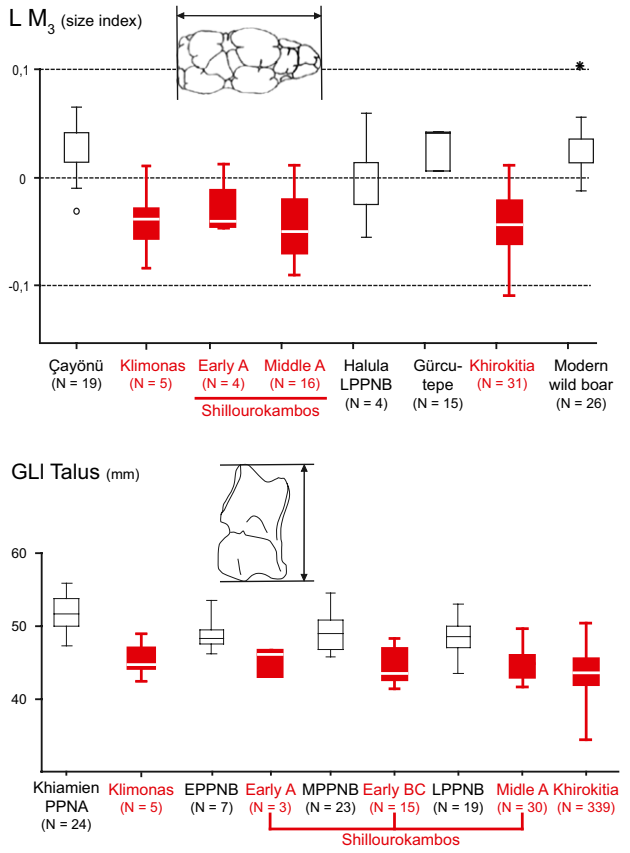

Fig. 3. Comparison of the measurements of the Klimonas boar lower third molar (M_3) and talus with those of various suids from Cyprus and the mainland. Sites are arranged in chronological order with the oldest on the left. Klimonas and other Cyprus (28) samples are shown in red; mainland series are represented by empty black symbols. For the M_3, log-size indexes were calculated with reference to the average length of that tooth in modern Israeli wild boar (29), i.e., 38.5 mm; the 25–75% quartiles are drawn as a box, the median is shown as a horizontal line inside the box, and the minimal and maximal values are represented by "whiskers" parallel to the *y* axis. For the mainland, the dental series are wild/domestic suids of Çayönü (Tigris watershed, Turkey, PPNA to Late PPNB; open circle represents an outlier); domestic pigs from Halula (Euphrates valley, Syria, Late PPNB, 9.5–9.0 cal kyBP) and Gürcutepe (Euphrates Valley, Turkey, Late PPNB). The mainland talus series are compilations of measurements from the Euphrates valley for the Khiamian-PPNA (12.0–10.5 cal kyBP), the Early PPNB (EPPNB, 10.5–10.0 cal kyBP), the Middle PPNB (MPPNB, 10.0–9.5 cal kyBP), and the Late PPNB (LPPNB, 9.5–9.0 cal kyBP). The Cypriot data are from the Early A (10.4–10.0 cal kyBP), Early B-C (10.0–9.6 cal kyBP), and Middle A (~9.5 cal kyBP) phases of Shillourokambos and from Khirokitia (9.0–8.0 cal kyBP). References are provided in *SI Appendix*, SI Text S4.

husbandry (*SI Appendix*, SI Text S4). Finds of small domestic dogs (1.7% of the faunal remains; *SI Appendix*, Table S4) are the earliest evidence for this animal on Cyprus (17). Dogs could have been used to participate in the hunting of wild boar. Mice remains were also recovered, but it has not been possible thus far to identify whether they belong to the wild endemic Cypriot species (*Mus cypriacus*) or to the commensal house mouse (*Mus musculus domesticus*) introduced to Cyprus at least by 10.4 cal kyBP (30) and already present on the mainland at that time (31). Remains of cat (*Felis lybica*) demonstrate that this animal was already introduced from the mainland. This evidence predates any known interaction between cats and humans by 1,500 y (17, 32).

Human Remains. Two human teeth and small bone fragments from Klimonas are so far the earliest human remains from Cyprus.

Discussion

Our findings demonstrate that human groups occupied villages in Cyprus during the first half of the 11th millennium cal BP. These groups cultivated plants and hunted the local wild boar, the sole ungulate species on the island at that time. The chipped-stone industry of Klimonas displays significant similarities with the Levantine PPNA. The 10-m diameter sunken circular building, which contained a rich complex of internal features and, in particular, hoards of artifacts, evokes the Levantine PPNA communal buildings. Klimonas is the earliest known Cypriot village and predates the Cypriot Early PPNB settlements by several centuries; its close contemporaneity with the site of Asprokremnos, located 30 km to the north, on the opposite slope of the Troodos Mountains, demonstrates that several villages had been established in different regions of the island by the first half of the 11th millennium BP.

In conclusion, the geographic range of the earliest cultivators in the Near East was wider than previously suspected (9–10), extending beyond the mainland to Cyprus. The occupation of the island was a consequence of two characteristics of the transition to farming that have been identified in other regions of the world: geographic expansion driven by strong demographic growth (33), and an increase in exchange systems (34). Settling on Cyprus implies frequent, successful sea crossings of >70 km, suggesting that navigation was more advanced than previously suspected (35, 36). The absence of any evidence of introduction of ungulates from the mainland is in accordance with the absence of domestic ungulates in the immediately neighboring region of the mainland, even during the Late PPNA or the beginning of the Early PPNB (1, 2, 12, 13), though an alternative possibility may have been the limited capability of PPNA seafaring vessels. Finally, the introduction of the dog and a species of cat demonstrates that the domestication process of these two carnivores preceded that of ungulates. Dogs were possibly used in hunting activities, and cats could have helped to protect stored crops from rodent pests.

Materials and Methods

Excavation. In 2009, we excavated 11 small test-trenches at Klimonas (21). Three of these trenches provided a significant series of lithic and animal remains, together with remains of buildings, and allowed us to delimit the area where prepottery deposits are preserved. In May 2011, we mechanically stripped >700 m^2 of the site and excavated 212 m^2 (*SI Appendix*, Figs. S2 and S8). Below three modern colluvial stratigraphic units (SU), excavation of successive layers and the study of two sections enabled us to describe in detail the communal building (ST 10; Fig. 1 and *SI Appendix*, Fig. S3 and S4). The fill was composed of 20 SU above two different types of substratum (Pleistocene calcrete and colluvium; *SI Appendix*, Fig. S5). Topographical records were recorded with a total station (TCR1203+ R400). Every SU and feature is described in detail in the excavation report that was presented to the Department of Antiquities of the Republic of Cyprus (DARC) in June 2011 (37). Together with all of the photos and drawings, the records have been entered into a Stratifiant database from which a Harris matrix can be automatically generated and possible discrepancies detected (38). This database will be given to the DARC at the end of the excavation. Only parts of the structures at the base of building 1 have been excavated at the present time.

Osteoarchaeological Analyses. The eight principal stratigraphic units of buildings 1 and 2 (SU 10.2, 10.3, 10.5, 10.6, 10.8, 10.10, 10.11, and 10.13) yielded 5,300 vertebrate remains. All of these remains were subject to preliminary taxonomic identification, including those collected by wet sieving >450 L of sediment. Comparative osteological criteria used for cat determination are detailed in *SI Appendix*, SI Text S5. Virtually all of the measurable teeth and bones of suids and carnivores were measured. The number of indeterminate fragments, the frequency of the skeleton parts (*SI Appendix*, Table S2), and preliminary age and sex determinations for suids were recorded for a subsample representing 62% of the entire collection (943 identified vertebrate specimens). Bone measurements were taken according to international standards (39) and are presented in *SI Appendix*, Tables S3 and S4.

Radiocarbon Dating. Ten charcoal fragments from the 2011 campaign were botanically identified (*SI Appendix*, Table S5), prepared at the Muséum

National d'Histoire Naturelle using an acid-alkali-acid pretreatment, and measured at the Artemis accelerator mass spectrometry (AMS) laboratory of Saclay. One charcoal sample from the 2009 campaign had previously been sent to the AMS laboratory in Tucson, AZ, for ^{14}C dating (16) and was added to the list. Raw dates are corrected for isotopic fractionation and calibrated at 1 and 2σ (standard error) using Intcal09 (40) (*SI Appendix*, Fig. S9).

ACKNOWLEDGMENTS. The French School of Athens (A. Muller) provided the archaeological facilities at Ayios Tychonas; the Department of Antiquities of Cyprus (M. Hadjicosti) granted us the necessary permits; and the Museum of Limassol (Y. Violaris) served as the supervising authority under the Department of Antiquities and provided logistic support. D. Stordeur, K. Dobney, and four anonymous reviewers provided valuable advice. K. Debue [Centre National de la Recherche Scientifique (CNRS)], C. Guilaine, and S. Hubert (CNRS) were responsible for material and financial aspects during the excavation season. J. Daujat, N. Delsol, L. Mano, P. Mylona, I. Papadopoulou, M. Puluc-Delsol, and N. Tardy contributed to the excavation. The excavations were financed by the French Ministry of Foreign and European Affairs, the French School of Athens, the National Museum of Natural History (Action Thématique Biodiversity), the Ecology and Environment Institute of the CNRS (Site d'Etude en Ecologie Globale Limassol project), and the International Training Network LeCHe (Marie Curie Actions, European Research Council).

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