mates, showing the strong general preference of the white clouds for desert areas, are also included in the histograms.

The correlation between degree of darkness and absolute values of reflectivity is more obscure, however. The degree of darkness of each region was estimated on a scale of 1 (bright deserts) to 10 (darkest areas), and these values were then compared with reflectivity values scaled from the radar curves. The resulting correlation coefficients for the data at 12.5 cm (1963), 70 cm, and 12.5 cm (1965) were only +0.38, +0.28, and +0.22, respectively. This is due largely to the systematically higher reflectivities of all areas on one side of the planet, as seen in the figures.

A few dark or semidark longitudes did not appear to be well correlated with radar maxima (for example, Syrtis Major in Fig. 2), but in each such instance the area was also characterized by a cloud factor which was higher than average for such areas. Thus the relation between cloud areas and the radar minima appears to be somewhat stronger than the relation between dark areas and radar maxima.

The only maximum clearly occurring in a desert area was the one at longitude 275° (Fig. 1) in 1965. This is the Isidis Regio, which has the appearance of a typical desert on Mars. The existence of a radar maximum at its central longitude could be due to a mean slope of either (or both) the dark Thoth to the east or the semidark Nilosyrtis on the west side (*4*). On the other hand, if the strength of the quasi-specular radar component is assumed to be principally a function of macroscopic roughness in the subterrestrial region, the implication is that deserts are, in general, rougher than dark areas. The anomalous maximum in Isidis Regio may be interpreted as evidence of smoother terrain there than in other deserts at that latitude.

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References and Notes

1. R. M. Goldstein and W. F. Gillmore, *Science* **141**, 1171 (1963).
2. R. M. Goldstein, *ibid.* **150**, 1715 (1965).
3. R. B. Dyce, G. H. Pettengill, A. D. Sanchez, *Astron. J.* **72**, 771 (1967).
4. C. Sagan, J. B. Pollack, R. M. Goldstein, *ibid.*, p. 20.
5. Supported in part by NASA grants NsG-142-61 and NGR-32-003-027.

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Fauna of Çatal Hüyük: Evidence for Early Cattle Domestication in Anatolia

Abstract. *Analysis of the remains of cattle from Çatal Hüyük indicates that cattle were domesticated in Anatolia by 5800 B.C., and strongly suggests that they were probably domestic at least 500 years earlier. This is the earliest known evidence for the domestication of cattle in the Near East.*

Çatal Hüyük, on the Konya Plain in central Anatolia, is the largest known preliterate site in Asia (*1*), and it is now clear that Anatolia was an area of cultural elaboration comparable to other centers of developing civilization in the Near East. Çatal Hüyük was occupied for approximately 1000 years, from the middle of the 7th millennium B.C. This was a critical period in the development and spread of animal husbandry elsewhere in the Near East, but this phase is heretofore unknown from excavations in Turkey. Although the site has yielded a rich collection of artifacts, shrines, and murals, faunal remains were surprisingly scarce, possibly because the excavation seems to have been done in the priestly quarter of the town, and domestic debris was meager (*2*). However, with the completion of the 1965 season, adequate faunal collections were available from level VI (5800 B.C.) and levels X to XII (6400 B.C.) (*3*), the greater part of which was not from the shrines themselves. The data indicate that domestic cattle were present at Çatal Hüyük early in the 6th millennium B.C., and probably were present there more than 500 years earlier. This is the earliest known evidence for domestic cattle in Asia.

In addition to cattle, the following species were represented in both samples from Çatal Hüyük—Anatolian moufflon (*Ovis orientalis anatolica*), Asian wild goat (*Capra hircus aegagrus*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), onager (*Equus hemionus*), and the domestic dog (*Canis familiaris*) (*4*). A small collection of remains from small mammals, birds, and fish has not been identified.

In assessing the fauna's contribution to the economy, the relative frequency of each species important in the diet must be determined. Often this has been done by listing the number of identifiable specimens from each species and giving their percentages of the whole sample. An apparently more sophisticated method is to determine the "minimum number of individuals," a calculation based on a count of the most frequent diagnostic skeletal part. Both methods are predicated on several questionable or unwarranted assumptions. (i) The pattern of bone survival is the same for all species; (ii) the number of identifiable skeletal elements is the same for all species; (iii) each species is exploited in the same manner; and (iv) butchering techniques are the same for each species.

I developed a technique that attempts to take these factors into account. (i) The number of diagnostic elements in the skeleton of each species is determined. This does not correspond to the number of bones in the skeleton, for bones are seldom found intact in an archeological context, and, in any case, not all bones are assignable to species. For the cattle and sheep at Çatal Hüyük there appears to be a standard pattern of bone survival for the limb and foot bones, comprising 30 diagnostic elements. For the equid remains, on the other hand, there were only 16 diagnostic elements (*5, 6*). (ii) The identifiable bone fragments from each species are counted. (iii) The relative frequency (F) of occurrence of each species is calculated (*7*) by multiplying the number of specimens per species by the reciprocal of the number of diagnostic elements per species. The calculated frequency is a quantity similar to the calculation of minimum number of individuals because it is also based on a fixed number of identifiable elements in the skeleton of a given species. Its advantage is that it enables one to use a far larger proportion of the collection, and is less affected by chance distortion.

After F has been determined for each species, the differences in average size for individual species are considered. This is done by multiplying the relative frequency of each species by the average edible meat weight per individual (50 percent of the average live weight) (*8*), the result being the total meat weight per species. The live weights for each species at Çatal Hüyük are based on figures given for Old World mammals by Walker (*9*). I assumed that the cattle from level VI were approximately the size of medium-size modern domestic cattle. Certainly they were smaller than the wild ox (*Bos primigenius*) and comparable in size to the earliest known domestic cattle in Asia. The cattle from layers X through

Table 1. Comparison of the distal width of the humerus of cattle from prehistoric sites in Anatolia; S.D., standard deviation.

Site	Date (B.C.)	Specimens (No.)	Mean	Range	S.D.	Wild or domestic
Beycesultan	ca. 4000	5	82.4	76.5– 90.8		Domestic
Fikirtepe	ca. 5500	16	83.0	75.5– 97.5	7.66	Domestic
Çatal Hüyük						
Layer VI	5800	33	86.3	63.0–105.0	11.90	Domestic
Layers X–XII	6400	12	102.0	85.3–108.0	7.40	?
Suberde	6500	2	101.9	100.9–102.9		Wild

XII, by contrast, appear to have been the size of *Bos primigenius* (Table 1).

As the data show (Table 2), cattle provided more than 90 percent of the meat diet during both the occupation sites under study. The almost exclusive reliance on a potentially domesticable species at this date in the Near East raises the question of whether it was, in fact, domesticated. To answer this question, I looked for evidence of morphological differences between the Çatal Hüyük cattle and the wild ox and compared the pattern of bone survival of the cattle remains with those of known domestic and wild cattle collections from the nearby sites of Can Hasan and Suberde. Can Hasan was occupied later than Çatal Hüyük and Suberde was roughly contemporary with the earliest levels at Çatal Hüyük (*10*).

A single skull fragment of the so-called *Bos brachyceros* type was recovered from level VI. However, there is evidence to suggest that the female of *Bos primigenius* may have had this skull configuration (*11*). Additionally, there is more persuasive evidence from level VI that cattle were domestic. The most common bone fragment, other than foot bones, was the distal end of the humerus. Inasmuch as the forelimbs support most of the weight of the animal, the size of the humerus reflects the size of the animal itself. The humeri of known domestic cattle from prehistoric sites in Anatolia are smaller than those of wild cattle. Those from level VI at Çatal Hüyük are comparable in size with domestic cattle (Table 1). The cattle of level VI, therefore, were certainly domestic—the earliest known from Asia.

The pattern of bone survival suggests that the cattle were domestic not only from level VI, but also from levels X to XII. At Suberde, where no domestic animals were found except the dog, the pattern of bone survival for large game, such as the wild ox, was quite different from that of smaller game, such as wild sheep and goat. Suberde was a permanent occupation site and not a hunting encampment, and limb bones of the wild ox were rare. The wild ox was a large animal, probably weighing a ton or more, and carrying the meat from the kill site to the occupation site presented a problem. Apparently the Suberde hunters' practice was to strip the meat from the limb bones at the kill site and leave the limb bones behind. The carcasses of smaller game animals are easily transportable, and limb bones from these animals are found in abundance. The percentages of limb bone fragments from animals of intermediate size, such as the red deer and the wild boar, are in between (*6*). However, at Çatal Hüyük the high percentage of limb bone fragments in level VI and levels X to XII is comparable with the situation at Can Hasan, where the cattle are known to be domestic, in contrast with the sample from Suberde, where the cattle are known to be wild (Table 3). From this I infer that the cattle from levels X to XII were domestic, but if not, then the high percentage of limb bone fragments strongly implies that they were slaughtered close by. Hunting wild cattle in the vicinity of Çatal Hüyük would have been extremely difficult. The surrounding Konya Plain is an ancient lake bed, and there is no natural place in which to trap the animals. The wild ox has been extinct since the 17th century, and knowledge of its behavior pattern can only be inferred from historical records and the behavior of semiwild park cattle, but apparently it was fierce, swift, and agile (*12*). It is most unlikely that hunters from Çatal Hüyük, on foot since no riding animal had been domesticated, could have driven such a large and powerful animal—presumably irritated—close to the site and dispatched it.

The possible presence of domestic cattle in Anatolia at this early date (6500 B.C.) is not surprising, even though they would be the earliest known in the Near East. Archeologists have often assumed that all the developments that led to civilization, including the domestication of animals, took place in the Tigris-Euphrates drainage basin or the highlands surrounding it. Although a highly sophisticated and essentially modern farming economy probably first flourished in Mesopotamia, there is no reason to suppose that the separate components of that economy were not developed

Table 2. Dietary importance of the main food animals from Çatal Hüyük; *N*, number of specimens that can be assigned to species.

Animal	*N*	Percentage	*F*	Percentage	Average meat weight per individual (kg)	Meat weight ratio* (species)	Percentage†
			Layer VI				
Bos	255	69.8	6.72	66.6	350	2352.0	91.2
Ovis	89	24.4	2.34	23.2	35	81.9	3.2
Cervus	8	2.2	.21	2.1	100	21.0	.8
Equus	13	3.6	.81	8.1	150	121.5	4.8
			Layers X–XII				
Bos	267	79.4	7.02	70.7	450	3159.0	90.0
Ovis	20	6.0	.53	5.3	35	18.5	.5
Cervus	19	5.7	.50	5.0	100	50.0	1.4
Equus	30	8.9	1.88	18.9	150	282.0	8.0

* *F* × average meat weight per individual (in kilograms). † Of available meat from each species.

Table 3. Pattern of appendicular skeletal survival of cattle bones at Suberde, Çatal Hüyük, and Can Hasan.

Site	Long bone fragments (No.)	Sample (%)	Foot bone fragments (No.)	Sample (%)
Can Hasan	130	38.0	212	62.0
Çatal Hüyük				
Layer VI	112	43.9	143	56.1
Layers X–XII	95	35.5	172	64.5
Suberde	23	16.8	114	83.2

elsewhere. In fact, data from Nea Nicomedia, a site on the Macedonian plain in northern Greece, suggest that domestic cattle were present there by 6200 B.C., the earliest known until now (*13*). The question arises: If the cattle from layers X to XII were domestic, could they have been introduced from Europe, or were they developed from the local wild population? The domestic cattle from Nea Nicomedia were apparently much smaller than the wild ox (*13*), whereas the Çatal Hüyük specimens were from an animal similar in size to their wild ancestor (Table 1). Therefore the small European race of domestic cattle does not seem to have been introduced into Anatolia, and the domestic cattle at Çatal Hüyük were developed indigenously.

It is interesting to compare the composition of the faunal sample from Çatal Hüyük with the animals represented in the frescoes and the plastic relief figures from the site. For example, relief figures of leopards and paintings of human figures in leopard skins are common, but not a single bone of a leopard was found in the collection. Similarly, the red deer is frequently represented in murals of hunting scenes, but the bones of the red deer are relatively uncommon, with the exception of shed antlers. There are figurines and paintings of the wild boar and the onager, and both of these animals are rare in the faunal collection. This presents a point that the student of prehistory should bear in mind: The plastic or graphic representation of an animal may have little relation to its economic importance. That the red deer, the onager, and the wild boar were hunted at Çatal Hüyük is beyond question, but fundamentally the people were cattle raisers (*14*). For this there is no known parallel in the Near East.

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References and Notes

1. For a description of the site, see J. Mellaart, *Anatol. Stud.* **12** (1962), and following years.
2. The total faunal sample from Çatal Hüyük is less than 2000 identifiable specimens. In contrast, the much smaller site of Suberde, situated approximately 80 km west of Çatal Hüyük and roughly contemporary with the latter's earliest levels, yielded a faunal sample of over 20,000 identifiable specimens.
3. Mellaart divided level VI into levels VIa and VIb. Many of the faunal samples from these layers have not been separated, so I have dealt with the sample from layer VI as a whole. When I was in Ankara in the summer of 1967, I found that not only had the samples from layer VI been mixed, but also those from layers X to XII.
4. The domestic dogs were identified by Miss B. Lawrence (Harvard University).
5. The 38 diagnostic elements of the artiodactyls included two necks of the scapulae, two distal ends of the humeri, four proximal and distal ends of the radii, two proximal ends of the femora, four proximal and distal ends of the tibiae, two astragali, two calcanei, four distal ends of the metapodials, eight first phalanges, and eight second phalanges. The 16 diagnostic elements for the equid material included two astragali, two calcanei, four distal ends of the metapodials, four first phalanges, and four second phalanges. The smaller number of equid diagnostic elements is due to the smaller number of elements in the equid manus and pes, and the almost total absence of limb bones. The lack of the latter is due to what I call the Schlepp effect (*6*): The limb bones of the larger game animals are left at the kill site and therefore are not found at the occupation site.
6. D. Perkins, Jr., and P. Daly, *Sci. Amer.* **219**, 5 (1968).
7. The method of calculating the relative frequency of each species is the same as the one I used in my analysis of the Shanidar fauna [D. Perkins, Jr., *Science* **144**, 3626 (1964)]. However, the number of diagnostic elements for a species may vary from site to site, depending on butchering techniques, reliability of identification, and the like. For example, the number of diagnostic elements of *Cervus elaphus* at Shanidar was 72, whereas at Çatal Hüyük the number was 38. The smaller number at Çatal Hüyük was due in part to the presence of *Bos primigenius*, which has elements in its skeleton that cannot be distinguished from *Cervus elaphus*.
8. For the method of calculating the average edible meat weight per individual, see T. E. White, *Amer. Antiquity* **17**, 4 (1952), et seq. Unfortunately, White's techniques of analysis are rarely used in the New World, and are either unknown or ignored in the Old World.
9. E. P. Walker, *Mammals of the World* (Johns Hopkins Press, Baltimore, 1964), vol. 2.
10. For a description of Can Hasan, see D. H. French, *Anatol. Stud.* **12** (1962), and following volumes. For a description of Suberde see D. Perkins, Jr., and P. Daly (*6*).
11. F. E. Zeuner, *A History of Domesticated Animals* (Hutchinson, London, 1963), p. 212.
12. See R. Lydekker, *The Ox and Its Kindred* (Methuen, London, 1912), pp. 39 and 66; F. E. Zeuner (*11*, p. 205).
13. E. S. Higgs, *Proc. Prehist. Soc.* **28**, 424 (1962).
14. Mellaart's description of the fauna from Çatal Hüyük [J. Mellaart, *Çatal Hüyük: A Neolithic Town in Anatolia* (Thames & Hudson, Bristol, 1967), p. 223] conveys a different impression. He says that domestic sheep and goats occur even in the lowest layers. In fact, there is no evidence for domestic sheep or goat at any level. There are a few sheep specimens from levels I to III that are apparently from an animal smaller than the Anatolian moufflon, but the sample is too small to be surely indicative of domestication. The remains of goats, either wild or domestic, are conspicuous by their extreme rarity in all levels. He further suggests that the hunting of wild boar and red deer was important, but neither of these animals formed a significant component of the faunal sample.

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Adsorption of Alkyl Trimethylammonium Chlorides at a Porous Glass–Potassium Chloride Solution Interface

Abstract. *The adsorption of dodecyl, tetradecyl, hexadecyl, and octadecyl trimethylammonium chlorides at an interface between porous glass and potassium chloride solution has been characterized by measurements of membrane potentials. The specific potential* ϕ *is 0.97* kT *per methylene group (where* k *is the Boltzmann constant and* T *is the absolute temperature) or 580 calories per mole at 23°C.*

A knowledge of the characteristics of the interface between dielectric and solution is necessary for an understanding of several phenomena, for example, flotation of mineral ores, clarification and filtration of waste materials, poisoning of ion-exchange materials, reverse osmosis, and biological membranes.

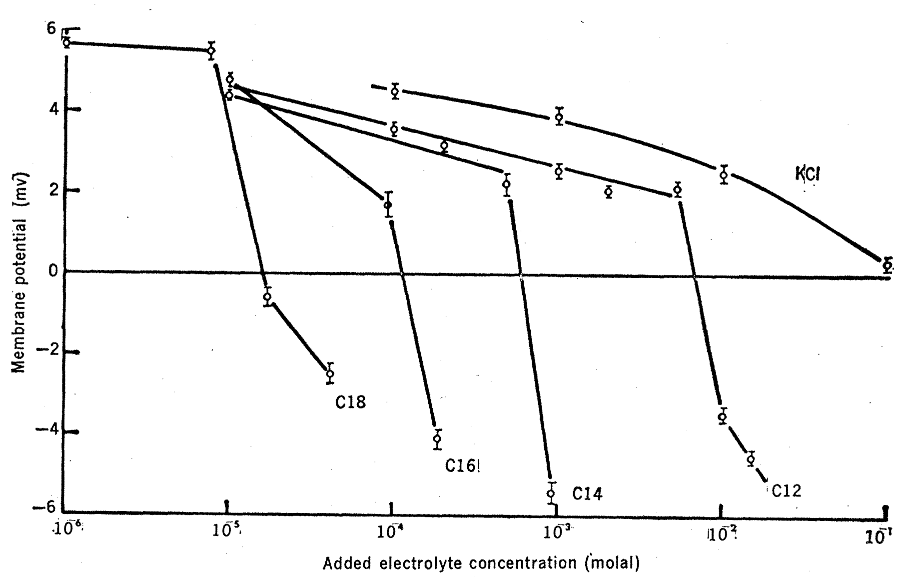

Fig. 1. Membrane potential E_M of concentration cell containing 0.05 and 0.025 molal KCl and varying concentrations of alkyl trimethylammonium chlorides plotted against concentrations of dodecyl (C12), tetradecyl (C14), hexadecyl (C16), octadecyl (C18) trimethylammonium chloride, and KCl at 23.0° ± 0.5°C and *p*H 5.8 ± 0.2.