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Earliest Radiocarbon Dates for Domesticated Animals

Europe is added to the Near East as another early center of domestication.

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Ever since V. Gordon Childe termed that particular part of prehistory when food production started the "Neolithic revolution," the interest of many archeologists has centered on the causes of this revolution and the time it began (*1*). With the advent of radiocarbon dating techniques, it became increasingly clear that the Neolithic had started much earlier than had been assumed. Overwhelming evidence found in numerous sites in the Near East convinced investigators that the origin of agriculture and domestication of animals began in the lower hills and adjacent plains of the Zagros Mountains. Here wolves, goats, sheep, pigs, and cattle existed as native animals; indeed, all of them can be found in their wild forms in the lowest levels of many Near Eastern sites. It was for this reason that these species were thought to be the earliest domesticates in the Neolithic.

Radiocarbon dates of charcoal from the lower levels of these sites place the time of domestication for some animals at around 6500 B.C. (expressed in conventional radiocarbon years). All of these early charcoal dates were then applied to stratigraphically associated (found in corresponding strata at different sites) bones of such domesticates as goats, sheep, pigs, and cattle, as well as to some cultivated cereals. The oldest non–Near Eastern Neolithic charcoal date comes from a ceramic level at the Argissa-Magula in Greek Thessaly (5500 B.C., conventional radiocarbon years) (*2*). This was an obvious indication that the Argissa-Magula site is actually much older, since it contains several preceramic levels with the bones of domesticated animals below. Other sites contemporary with the Argissa-Magula, such as Nea Nikomedeia (*3*), have been found in the same area.

Mounting evidence from a variety of sources has shown that conventional radiocarbon dates must be calibrated by tree-ring chronologies such as bristlecone pine in order to give dates that correspond to the Julian calendar. When such an adjustment is made for the previously mentioned conventional radiocarbon dates of 6500 B.C. and 5500 B.C., one finds that the dates actually should be placed roughly one millennium earlier. In this article, except where specifically noted, all radiometric ages are stated as tree-ring calibrated radiocarbon dates (*4*).

Even though previous Near Eastern charcoal dates suggest when and where some animals were first domesticated, we do not rely on these dates because contemporaneity is not always assured in dating by association. Therefore, we date specific artifacts and bones directly.

Sampling Considerations

Several attempts had been made before 1964 to date bones directly, on the basis of their carbonate content, but these attempts were soon abandoned because most dates either proved to be too recent or too old and could not be fitted into the previously established sequence of events based on charcoal dates. The reason for these erroneous dates was that the presence of groundwater had allowed carbonate exchange in the bones to take place. In 1964, Berger, Horney, and Libby published a method for the proper dating of bones—a method based on dating collagen, the organic portion of bones (*5*). Even though the collagen method has been improved since then, it has not, until now, been applied to bones from morphologically recognized domesticated animals of the lowest levels of some of the earliest Neolithic sites in Europe and the Near East (*6*). Our object was to investigate, using reliable methods, the origins of domestication of several animals in these areas (Table 1).

We began our project by dating bones from the preceramic levels of Argissa-Magula; these levels contained the bones of such domesticated animals as goats, sheep, cattle, and pigs (*7, 8*). The project was soon extended to include several Russian sites where domesticated horses were abundant. Finally, some sites in Yugoslavia and one site in southern Germany were added. When material from some Near Eastern sites became available for dating, it opened up the possibility for comparing the bone material of earliest do-

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Table 1. Most important domesticated animals and their areas of origin, including the dates of the oldest samples found.

Area	Approximate date (B.C.)	UCLA sample number	Site	Level
		Goat (Capra hircus)		
Central western Iran	8050	1714F	Asiab	150 to 160 cm
Central western Iran	7900	1714B	Asiab*	140 cm
Central western Iran	7700	1714C	Asiab* (dom?)	120 to 140 cm
Eastern Palestine	7200 range†		Jericho	Older preceramic village
Northern Iraq	7000	1714E	Jarmo	J-I/7
Eastern Turkey	Before 7000†		Catal Hüyük East	Below level X
Central western Iran	6900	1714A	Sarab	S-I/4
Southwestern Iran	6900 range†		Ali Kosh	Brick wall zone
Western Macedonia	6900†		Nea Nikomedeia‡	
Northern Iraq	6800	1723A	Jarmo	PQ-14/5a
		Dog (Canis familiaris)		
England	7500§		Star Carr‡	
Thessaly (Greek)	7000	1657D	Argissa-Magula	Preceramic Neolithic
Eastern Turkey	7000 range†		Hacilar	Preceramic
Central western Iran	6900	1714A	Sarab	S-I/4
Eastern Palestine	6800 range†		Jericho	Younger preceramic village
		Sheep (Ovis aries)		
Thessaly (Greek)	7200	1657A	Argissa-Magula	Preceramic Neolithic
Northern Iraq	7000	1714E	Jarmo*	J-I/7
Eastern Turkey	Before 7000†		Catal Hüyük East	Below level X
Central western Iran	6900	1714A	Sarab	S-I/4
Western Macedonia	6900†		Nea Nikomedeia‡	
Northern Iraq	6800	1723A	Jarmo*	PQ-14/5a
Southeastern Yugoslavia	5950	1705A	Anzabegovo	282 to 274 cm
Southeastern Yugoslavia	5750	1705C	Anzabegovo	262 to 274 cm
		Cattle (Bos taurus)		
Thessaly (Greek)	7000	1657D	Argissa-Magula	Preceramic Neolithic
Eastern Turkey	7000–6000†		Catal Hüyük	Level IX-O
North central Yugoslavia	6300	1605I	Obre I	Level 12
Northern Iraq	6300	1723B	Jarmo*	PQ-14/2
Northern Iraq	5600	1723D	Jarmo*	K-21/3
Northeastern Iran	6000–5000†		Hotu Cave	Older painted pottery Neolithic
Northern Baluchistan	Mid-5th millennium†		Kili Ghul	Mohammad I
Ukraine	4210	1642C	Luka-Vrublevetskaja	Pre-Cucuteni
Lower Egypt	5000†		El Omari‡	
Southwestern Sahara	3750	1685	Adrar Bous‡	
		Pig (Sus domesticus)		
Thessaly (Greek)	7000	1657D	Argissa-Magula	Preceramic Neolithic
Northern Iraq	6500 range†		Jarmo	Level 5-I
Northwestern Iran	5500 range†		Hotu Cave	Older painted pottery Neolithic
Northwestern India	3000†		Mohenjo Daro-Harappa‡	
Denmark	1st half of 3rd millennium§			
		Onager (Equus ?)		
Northern Iraq	7000	1714E	Jarmo*	J-I/7
Southwestern Turkistan	4800†		Anau	Level I
		Ass (Equus asinus)		
Lower Egypt	4th millennium†		Maadi‡	
		Horse (Equus caballus)		
Ukraine	4350	1466A	Dereivka‡	
West Ukraine	3730	1671B	Evminka	Tripolye C_1
Ukraine	3720	1671A	Dereivka‡	
Bavaria (Germany)	3670	1657G	Polling*	Linear Ceramic

* Animal presumed to be, but not certainly, domesticated. † Date based on radiocarbon date(s) from materials other than bones. ‡ Level not available. § Date based on all known archeologic evidence.

mesticates of the Near East with such bone material from southeastern Europe. The dates we present give some idea of the distribution of earliest domesticated animals. It is emphasized, however, that the data are not complete and simply provide a good indication of possible nuclear areas of domestication. An exact picture can only be presented after all of the Neolithic sites in Europe and the Near East, as well as in other nuclear areas, and the bone material of domesticated animals found there have been dated.

In recent years, the dating of charcoal from early sites in the Near East has become one of the prime targets of archeologists and dating specialists. Many of the dates in the stratigraphy of some sites showed quite a regular sequence. But if one examined the dates from the same stratigraphic levels in sites such as Jarmo, Ali Kosh, and Jericho, one could easily understand criticisms of radiocarbon dating and its accuracy. The dates from Jarmo, for example, many of which were determined in the early days of radiocarbon dating, differ in the same stratigraphic level by as many as 3000 years (*9*).

It has been suggested that such differences might be rooted in bitumen contamination of charcoal (*9*). Apart from natural contamination, another problem, more archeological in nature, should be considered and the specialist cautioned against trying to apply carbon-14 dates based on charcoal to stratigraphically associated bones of domesticates. Sometimes there is a discrepancy in age between separately, and accurately, measured charcoal and bones taken from the same level. The weight and compactness of bones allow them to intrude into lower strata. Long, vertically positioned bones may penetrate several excavation units and thus literally extend over a considerable period of time. Heavy objects located above bones may also push them into lower levels. It must be assumed, then, that bones found in sites occupied continuously and densely over long periods of time would be prone to intrude into lower levels.

Unlike bone, charcoal crushes easily and does not intrude readily into lower levels, except when rodent and root holes exist. Thus, most charcoal remains can be assumed to have remained in the location in which they were deposited. Consequently, the assumptions of those early excavators who attempted to date some of the earliest domesticated animals must be evaluated with care, since they posited that the age of bone found in a given stratigraphic level must be equal to that of the charcoal found there. To avoid stratigraphic errors, we decided to date bones directly.

Unfortunately, some of the bones we studied had been contaminated by preservatives. All preservatives are mainly composed of organic compounds and if not removed will give rise to erroneous dating. The few bones we had from early excavations were usually covered with preservatives (which are difficult to remove completely) and thus could not be subjected with confidence to radiocarbon dating. Moreover, since most bones from early excavations had been thrown away, investigators had unknowingly disposed of the only available material for dating, given that environmental conditions in many sites did not allow for the preservation of any other organic material for dating.

With these considerations in mind, we selected our samples [now at the University of California at Los Angeles (UCLA)] on the basis of certain stringent conditions. All bone selected was positively identified on morphological grounds as being from fully domesticated animals (with the exception of some sheep bones) and was handled in such a way that no contaminants would affect the dating. All samples came directly from the excavator or bone specialist. Each is positively from either the lowest level of its particular site or the lowest level containing morphologically defined domesticated animals, except in those sites where the total stratigraphy or several levels were dated to check the accuracy of dates in a stratigraphic sequence.

The total of 35 samples of bone in our study came from 19 sites in 6 different geographical areas: the Ukraine, Greek Thessaly, Bavaria, Yugoslavia, the Near East, and the Saharan Niger. Not all of the sites contained the bones of domesticated animals, but those that did not were selected for study because they seem to be important in solving such questions as when the terminal phase of a hunting and gathering economy occurred or, for that matter, if there even existed a transition stage from hunting and gathering to domestication. Bones selected for dating were from goats, sheep, horses, and cattle; pigs and dogs were dated indirectly.

Dating Procedures

Before processing the bones for carbon-14 dating, we made microanalytical tests to assess the organic carbon present (*5*). In addition, we used the fluorine and nitrogen content for relative placement in time, as suggested by Oakley (*10*). Such tests were mainly devised for checking the relation between the age of a bone and the age of the deposit in which it was found, or to which it was attributed. The relative age of the bone in question is usually determined by comparing its fluorine, uranium, and nitrogen composition with that of other fossils which were found in the same stratum (UCLA-1714A: sheep, goat, dog; UCLA-1657D: cattle, pig; UCLA-1714E: sheep, goat, onager; UCLA-1657G: deer, horse) and which appeared to have been preserved under similar conditions.

All bones were treated for contamination because some archeologists who had collected several samples many years ago could not recall whether or not they had used preservatives. Treatment included the removal of 0.5 millimeter of primary (dense) bone by scraping the bones and soaking them for several days in a solution of warm distilled water and acetone. The bones were then treated with hydrochloric acid in order to dissolve the inorganic portion while retaining the organic portion. To eliminate numerous pollutants and to obtain purer collagen, the organic portion of all samples was converted to gelatin (*11*). Those samples, however, that were from sites or strata where previous carbon-14 dates on charcoal had yielded spurious and confusing results were processed differently. They were treated according to a liquid-chromatography method in order to separate out amino acids with the same specific radioactivity from bones impregnated with isotopically inactive petroleum compounds (bitumen) (*12*). Indeed, for Jarmo, collagen dates provide an internally consistent chronology superior to charcoal-derived dates (collagen dates are given in Table 2). We believe that bones from sites such as Jarmo, Jericho, or Ali Kosh should always be processed by the collagen method, since inventories of bones from these sites indicate that the bones may contain bitumen.

After being processed, all samples were counted in a 7.5-liter proportional counter as carbon dioxide at 1 atmosphere and analyzed for at least 1000 minutes to a statistical accuracy of one standard deviation (*13*). The radiocarbon age of each sample was calculated on the basis of a carbon-14 half-life of 5568 ± 30 years and was then calibrated by bristlecone-pine ages.

Table 2. Chronologies of four sites. Based on collagen dates, these chronologies exhibit internal consistency and give very reliable dates in the stratigraphic sequence. Collagen dating is particularly useful for locations where charcoal contamination by bitumen can be a problem, as it is in some Near Eastern sites.

UCLA sample number	Animal	Level	Carbon-14 age (years)	Approximate calibrated age (B.C.)
		Jarmo		
1723C	Cattle*	K-21/1	6180 ± 300	5100
1723D	Cattle*	K-21/3	6550 ± 200	5600
1723B	Cattle* Domesticated goat Sheep*	PQ-14/2	7270 ± 200	6300
1723A	Domesticated goat Sheep*	PQ-14/5a	7800 ± 120	6800
1714E	Domesticated onager Domesticated goat Sheep*	J-I/7	7980 ± 140	7000
		Palegawra		
1714D	Wild goat and sheep	80 to 100 cm	13600 ± 460	—
1703A	Wild cattle and sheep	120 cm	14350 ± 280	—
		Asiab		
1714C	Goat and sheep*	120 to 140 cm	8700 ± 100	7700
1714B	Goat and sheep*	140 cm	8900 ± 100	7900
1714F	Goat and sheep*	Below 140 cm	9050 ± 300	8050
		Obre I		
1605H	Domesticated cattle	8	6150 ± 60	5050
1605G	Domesticated cattle	11	6710 ± 60	5750
1605I	Domesticated cattle	12	7240 ± 60	6300

* Animal presumed to be, but not certainly, domesticated.

Dates of Domestication

The wild ancestor of domesticated cattle was distributed widely throughout the Near East and Europe. Since most specialists identified both wild and domesticated forms of cattle primarily on the basis of size, the smaller cattle in the Near East were usually identified as domesticates. Specialists soon became aware, however, that these small cattle might be a wild form; some specialists even suggested the possibility of sexual dimorphism. The cattle found at Jarmo, which are rather small, are identified by Stampfli as wild (*14*), but it is claimed that the cattle in other early Neolithic sites, such as Tepe Sabz in Iranian Khuzistan or Banahilk in northern Iraq are fully domesticated (*15*). If these cattle are indeed domesticated, only direct dating of their bones can determine their exact chronological position. Until such time, the dates presented here for domesticated cattle in Europe are the earliest anywhere in the Neolithic. The very early date of 7000 B.C. (UCLA-1657D) for the bones of domesticated animals at the Argissa-Magula site also applies to the preceramic layers there. The dates of these preceramic levels should not differ much from those of the preceramic levels of Nea Nikomedeia. A site farther north, Obre I, supplied a date of 6300 B.C. (UCLA-1605I) from level 12, under which are two levels containing the bones of domesticated cattle, yet to be dated. Judging from the thickness of the underlying strata, it is possible to suggest as an earliest date in this location approximately 6500 B.C. Consequently, it is possible that the earliest domesticated cattle in central Europe existed some 1000 years later, if domestication of cattle diffused from Greece through Yugoslavia into central Europe and then at a later stage into Russia, with perhaps completely independent development in the Near East. Or did the domestication of cattle take place independently in each of the above-mentioned locations?

The domestication of cattle appears to have occurred very late in Russia. The site of Luka-Vrublevetskaja shows dates from 4210 B.C. to 3950 B.C. for domesticated cattle, while other sites, such as Novo-Rozanovka II, still contain wild cattle a few hundred years later, around 3700 B.C. (*8*). We also know, by looking at the date of Ambrosievka, that the European bison still existed in this area around 6300 B.C. (*8*). On the continent of Africa, a quite early date of 3750 B.C. (UCLA-1685) was determined for domesticated cattle at Adrar Bous in Saharan Niger (*16*). If other sites are found on the northern fringes of Africa, with dates between 7000 B.C. and 3750 B.C., perhaps one could conclude that domestication of cattle radiated out from Greece through the Near East to Africa. This possibility, of course, depends on whether or not those remains found at sites such as Jarmo are actually remains of domesticated cattle.

Domesticated sheep were dated to 7200 B.C. (UCLA-1657D) at Argissa-Magula, in the level below the one containing cattle. These sheep are undoubtedly domesticated since no wild form has yet been found to have existed in Europe after the close of the Pleistocene. It has been argued, however, that sheep occur in several late Mesolithic Tardenoisian and Azilian sites in western Europe, mainly in France (*17*). Their presence is usually explained as a survival of wild sheep from the final Pleistocene into Postglacial times, not as a reintroduction. The date of 7200 B.C. at Argissa-Magula could, however, be used to argue that the domestication of sheep diffused from Greece into central and western Europe over a period of perhaps 1000 years. These sheep at the Argissa-Magula site had to be imported, and most specialists agree that they must have been brought from the Near East. There is a date for sheep bones from one of the lowest levels at Jarmo, but Stampfli (*14*) was not certain whether these sheep were wild or domesticated. That date of 7000 B.C. (UCLA-1714E) would be, however, later than the one from Greece. The lowest level of Sarab, from which sample UCLA-1714A was taken, yielded bones of definitely domesticated sheep dating to around 6900 B.C. It remains to be seen whether a site such as Cayönü (Turkey) will yield dates several hundred years earlier than those in Greece. The site of Anzabegovo in Macedonian Yugoslavia, only a few hundred miles away from Argissa-Magula, supplies a date for the bones of domesticated sheep in an upper level (262 to 274 centimeters deep) of 5750 B.C. (UCLA-1705C), yet bones of domesticated sheep are also found in the lowest levels. On the basis of an extrapolation from the stratigraphy and a charcoal date of 5950 B.C. in a lower level (UCLA-1705A), we think that sheep arrived in this area around 6400 B.C.

The earliest date for domesticated

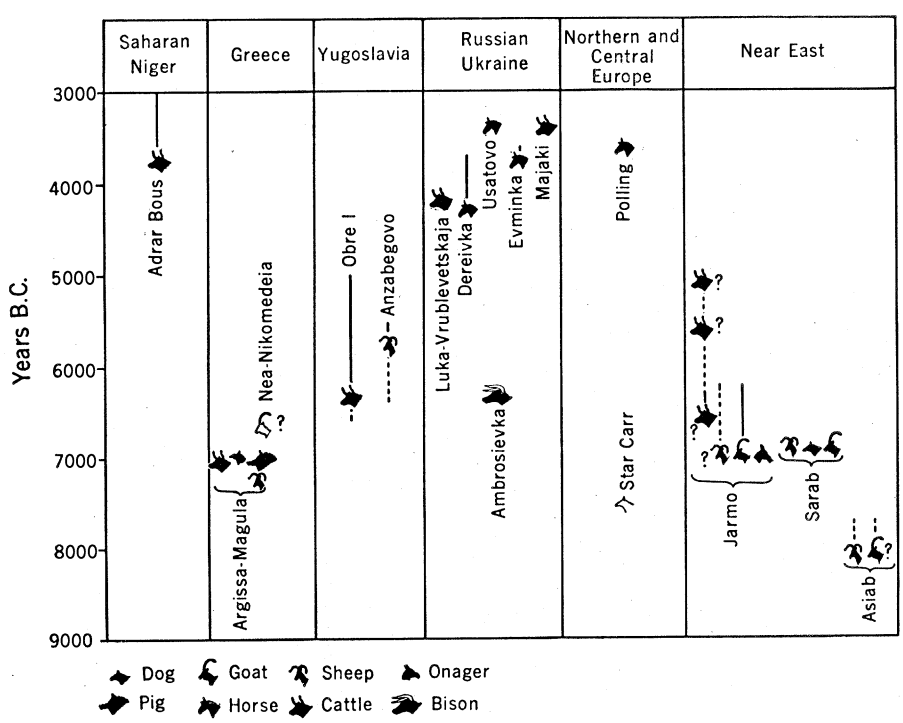

Fig. 1. Comparison of tree-ring calibrated radiocarbon dates (determined at UCLA) based on the organic components of bones from various sites in Africa, Europe, and the Near East.

goats comes from Asiab in central western Iran; these bones have been dated to about 8050 B.C. (UCLA-1714F; depth, 150 to 160 centimeters). Some fractured goat and sheep bones from a depth of 120 to 140 centimeters yielded dates of 7900 B.C. (UCLA-1714B) and 7700 B.C. (UCLA-1714C).

Whereas some doubt remains as to the authenticity of domesticated sheep at Jarmo, goats were identified without doubt as domesticated. Jarmo's earliest date for domesticated goats is 7000 B.C. (UCLA-1714E). Sarab, a site in central western Iran, yields a similar date of around 6900 B.C. (UCLA-1714A) in the same level (S-I/4), which also yielded domesticated sheep.

The comparison of these dates is interesting because the archeological assemblages at Sarab are more advanced typologically than those at Jarmo (*18*). No direct dates exist yet for European goats, but Nea Nikomedeia, which contains goat bones in its lowest levels, seems to indicate that these animals were probably in this area around 6900 B.C.

The domestication of the dog took place rather early among European Mesolithic peoples (*19*). This suggests that the dog was domesticated by people still in a hunting and gathering economy. The date for the lowest level at Sarab, 6900 B.C., is based on the stratigraphic association of dog bones with sheep and goat bones dated to about 6900 B.C. (UCLA-1714A). The question of whether the bones of these different animals were indeed associated with each other was solved by chemical microanalysis, which showed matching composition among the different bones.

Pigs from the preceramic layers of Argissa-Magula have been dated by stratigraphic association to around 7000 B.C. (UCLA-1657D), the same date as that for domesticated cattle. It has been pointed out by some specialists that pigs in the lower levels at Jarmo were still wild and probably only became domesticated during the time represented by the upper levels (*20*). It will be interesting to see dates for domesticated pigs found at Cayönü, since they seem to appear in levels relatively dated several hundred years earlier than the levels in which pigs are found at Jarmo. The date for these pigs could rival the very early date at Argissa-Magula. As it appears now, domestication of pigs occurred in both southeastern Europe and Asia Minor at approximately the same time, 7000 B.C.

One of the most recently domesticated of today's major herd animals is the horse. The earliest suggested domestication of the horse ranges from 2000 B.C. to 4000 B.C., estimates that are based strictly on archeological finds. A sketchy representation of a horse from Khafaje (near Baghdad) is dated to the Jamdat Nasr period, around 3000 B.C. The first actual osteomorphological find was two molars from Sialk (in central Persia) that have been dated to somewhat before 3000 B.C. The most abundant finds of horses' bones in the last few decades have been made in sites of the Tripolye and Srednij-Stog cultures, in the Russian Ukraine. Two samples of bones of domesticated horses were dated from the sites of Dereivka and Evminka. Undoubtedly the earliest date is one from Dereivka, 4350 B.C. (UCLA-1466A), followed by another date at the same site, 3720 B.C. (UCLA-1671A). Evminka yielded two roughly contemporary dates, 3730 B.C. and 3640 B.C. Surprisingly, horses seem to have existed at the same time, around 3670 B.C., at Polling (in Bavaria) (UCLA-1657G) (*21*), even though there seems to be some doubt as to whether they were domesticated. For comparison, Table 1 also contains dates on domesticated onager and asses. Domesticated onager may have existed in about 7000 B.C. at Jarmo (UCLA-1714E), while domesticated asses found in lower Egypt date from the 4th millennium B.C.

Conclusions

Our dates show that cattle and pigs were first domesticated in Europe. Sheep, which were thought to have become extinct in Europe during the terminal Pleistocene, also appear first in Europe. However, there remains little doubt that sheep were first domesticated in the Near East or Turkey, since no wild sheep appear to have existed in Europe at the beginning of the Holocene. Dogs were domesticated in both the Near East and Europe at virtually the same time. In the Near East, Asiab, at around 8000 B.C., qualifies as the first center of goat domestication. It is also the earliest center of domestication for all animals we have dated here. Horses were first domesticated in the steppes of the Ukraine, perhaps even earlier than our dates indicate, since all of the samples found at Polling are virtually contemporaneous (Fig. 1).

Undoubtedly, future research will alter the details of our overall impressions, especially after bones at earlier sites such as Nea Nikomedeia have been dated directly. But, on balance, there can be no doubt that southeastern Europe was as much an early center of domestication as the Near East was.

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