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On the Domestication of Cattle

Zoology and cultural history both illuminate the view that the original motive was religious, not economic.

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The problem of animal domestication has proved a challenging one to the disciplines concerned with the history of man's economic and social development, for animal domestication has had a revolutionary impact on man's ecumene. Culture historians, geographers, and ethnologists, in particular, have been intrigued by the host of psychological and technological questions inherent in the problem of animal domestication. Necessarily, however, in view of the darkness which shrouds the original achievement, their analysis has depended upon the construction of hypotheses. To the extent that they support one another, these offer a coherent picture (*1*).

The problem of animal domestication has also been of increasing concern to geneticists and zootechnologists. For not only does domestication show the enormous potential variability in a given animal, hardly to be demonstrated in the wild state, but it also poses a whole set of questions, the answers to which could provide fundamental insights into basic problems of general zoology, taxonomy, and other disciplines. Thus, for example, why are there no barriers to crossing in widely differing domestic species of animals and plants which intercross to yield fertile hybrids, whereas natural species often distinguished by only minute differences are intersterile (*2*)? The province of zoology up to the present, in a field beset by problems of verification, has been to define and explain the changes domestication has produced in animals by comparing present-day domestic animals or wild animals raised in captivity with their wild relatives, by studying the fossil record, and more recently by studying modes of inheritance.

Of all the problems of animal domestication, none has been so extensively discussed by culture historians and cultural geographers as that of the domestication of cattle. Moreover, despite great advances in the study of heredity and domestication, the major cultural theory of the domestication of cattle has not required any important revision as the result of zoological study. Zoology, indeed, has little to say about the social conditions of domestication, and for clarification of this problem we must rely on the hypotheses of the culture historians. In the absence of conclusive evidence, they have constructed their theory of the origin and process of domestication of cattle largely on the basis of deductive reasoning (*3–5*; *6*, p. 35).

The cultural thesis which has been most widely accepted is that which asserts that cattle, probably the first of the great herd animals to be domesticated, were originally domesticated in western Asia. The thesis further argues that the domesticators of cattle were sedentary farmers rather than nomadic hunters, that domestication was deliberately undertaken and not haphazard, and that the motive was religious (*7*).

Arguments for Agricultural Origin

There are a variety of suggestive facts which, taken together, support an agricultural origin for domestication.

1) Harnessing methods used by a nomadic society are clearly modifications of harnessing methods of nearby farmers, devised for handling herd animals in the field (*8*, p. 441).

2) All wild bovines that have been domesticated lived in the realm of the ancient peasantry of western Asia, whereas no wild bovines whose range was primarily in the realm of nomadic hunters have been domesticated, despite the fact that these animals (for example, the bison) are easily domesticated (*6*, p. 35).

3) Neither the European elk nor the African eland, both demonstrably easy to domesticate, has been domesticated by nomadic hunters. No deer or antelope species, with the exception of the reindeer, has been domesticated (*9*), and even reindeer do not belong to the oldest group of domestic animals (*10, 11*).

4) Milking practices which have been considered peculiar to pastoral nomads, such as presenting the cow with a straw-stuffed calfskin to stimulate milk flow, blowing into the anal passage, and milking from behind (Fig. 1), are now known to have been common in the realm of West Asian peasants and are presumably derived from that realm (*12*).

5) The problem of feeding captured animals could have been solved only by an agricultural society producing a

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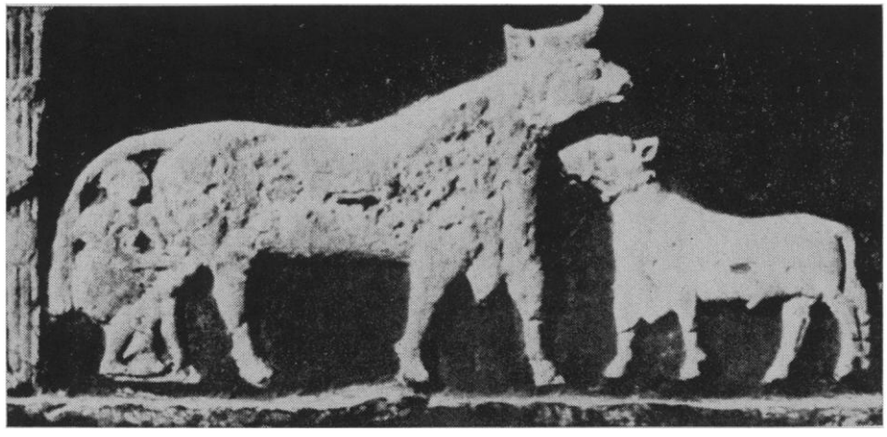


Fig. 1. Milking scene, from al-'Ubaid, Iraq, about 2600 B.C., part of a frieze of limestone on bitumen with copper borders, representing the cattle farm of the goddess Ninkhursag. The milker is seated behind the cow. Height of frieze, about 8⅝ inches; length of entire mosaic, 3 feet 9¼ inches. [University Museum, University of Pennsylvania].

food surplus that might be used to supplement pasture.

6) The pastoral nomad's complete absorption in his herd animals, which has been cited by those who argue that domestication originated from nomadic hunting, has been shown to be irrelevant. American Indian hunters became horse-riding nomads shortly after the Spaniards introduced the horse into North America (*13*).

Arguments for Asian Location

The archeological evidence supports the view that cattle were first domesticated in western Asia (*8, 14, 15*). Unfortunately, osteological study often leaves it unclear whether remains are those of domestic or those of wild animals. For this reason, an increasingly refined statistical approach has been used since the turn of the century. As Dyson observes (*14, 16*), the significance of this approach is that "an analysis of the fauna of a site over a period of time may indicate at some point a shift from reliance on small or 'wild' game to reliance on 'prodomestic' game, by which is meant potentially domesticable . . . i.e., those animals known as domestic in later periods. Subsequently a second shift, this time in the age at which prodomestic animals are killed, may be indicated. When accompanied by a constant increase of the percentage of the prodomestic group in the total these two shifts would seem to be reasonably good evidence for inferring cultural control over the animals in question."

Students using this method have found that a shift from a reliance on wild animals to a reliance on domestic animals had taken place in the Near East by the beginning of the 5th millennium B.C. (*17, 18*). In Europe, similar shifts in faunal deposits occur at least one millennium later, while in central, eastern, and southeastern Asia the shift occurs closer to two millennia after that in the Near East.

Support for the conclusions of the statistical approach lies in the discovery of evidence that it was in West Asia that cattle were first used as a source of animal power. It is here that sledge, wagon, yoke, and plow are first found (*8*, pp. 441, 449, 478; *19, 20*). Wagons and representations of wagons are found at Tell Halaf, the ancient Gossan, in the extreme north of Mesopotamia and at Ur in the southeast (*21, 22*). In Mesopotamian sites the burial of wheeled vehicles is firmly associated with royal funerals by 3000 B.C. (*23*). At Susa, in Elam, a wagon was unearthed and dated to 2500 B.C. (*21*). By the beginning of the 2nd millennium cattle and wagons are always associated on representations of the Indus culture. The sledge was apparently the earliest vehicle to be developed, and records of sledges are found in Mesopotamia in pre-Warka IV layers. By the Warka IV period (3000 to 2800 B.C.), an ideograph for "wagon" was in use; thus, the wagon must have been in use by the end of the 4th millennium. Indeed, that cattle were used in Mesopotamia for traction, at least from the late 5th millennium onward, is indicated by the symbolism of the zodiac, which can be traced that far back. The constellation Taurus was then already interpreted as a bovine harnessed to a sledge or wagon. The earliest representations of plows show a similar regional distribution. They are found in Warka IV and in Egypt from about 2700 B.C. on. Plow figurines dated 2300 to 1900 B.C. have been recovered from Vounous Bellapais on Cyprus. Sumerian seals of uncertain date also depict plows. Representations of plows are more recent than those of wagons or sledges, but to which of these vehicles animal traction was first applied is not certain (*8*, pp. 412, 436).

The oldest type of harness strongly suggests that cattle were the first animals to be used for traction. This is the double neck yoke, with which it is possible to control and utilize the great muscular power concentrated in the cervicothoracic region in cattle. This yoke has been found in Mesopotamia, associated first with wagons and later also with plows. The earliest representations of plowing, also from Mesopotamia, show that cattle were attached either by ropes tied directly to the horns or by ropes attached to a beam lashed to the horns (*8*, pp. 412, 436). The neck yoke was not known in Egypt until about 1600 B.C., and only the more rudimentary methods of harnessing (methods also used in Mesopotamia) were employed up to that time. When, subsequently, the onager was used for traction, the cattle harness, although inappropriate, was used (*8*, p. 431; *19*).

Only One Ancestral Strain

Zoological study of remains has cast little light on the question of when or where cattle were first domesticated. Zoology asserts that present-day types of domestic cattle are all derived from one ancestral strain, *Bos primigenius* Bojanus, or the wild urus, an animal which survived in Europe until the late Middle Ages (the last known remaining specimen died in 1627). *Bos namadicus* Falconer et Cautley, whose relics are found in Asia, and *Bos opisthonomous* Pomel, found in North Africa, are assumed today to be the same animal. The urus formerly ranged from the Pacific through Asia and Europe and from the Eurasian tundra to the Indian Ocean and into North Africa. The vast range occupied by the urus from the

Pleistocene to the 17th century A.D. could well account for minor differences in the animal, and hence the names denote little more than its geographic range (*24*).

Early cattle remains reveal considerable differences in size. Fossil remains indicate that the wild urus, whose presence in Europe is first proven in the Riss glacial, was a large, long-horned and powerful animal (Fig. 2) (*25*). Remains of individual urus have been found, for the whole period of early domestication, which indicate that the animal stood over 2 meters high at the withers. But alongside remains of these enormous animals, fossil remains of considerably smaller cattle have been found (*26*). Similarly varied finds have been made throughout North Africa and western Asia. The diversity in size has been interpreted in more than one way. It has been asserted that the smaller animals represent a dwarf urus, that they represent a separate ancestral strain of contemporary longifrons or brachyceros types, or that the size difference is due to the great sex dimorphism of the urus, the small animals being females, as in the case of the Tibetan yak. Certainly, dwarf varieties of other wild animals are known, especially in isolated locales—for example, dwarf elephant, crocodile, hippopotamus (*Hippotamus liberiensis*), buffalo (*Syncerus caffer nanus*), and antelope (*Neotragus pygmaeus*). In all cases, however, the animals are found in relatively restricted habitats (*27*) and do not have the wide range that the small bovine evidently had. The view that the smaller animal is indicative of a non-urus bovine has found least favor among zoologists. It seems fairly clear that animals domesticated between, roughly, 2000 B.C. and the present, including animals domesticated in this century, are of monophyletic origin (for example, the cat, rabbit, silver fox, and nutria), and the argument goes that it is unlikely that cattle and other old domestic animals should be of polyphyletic origin (*28*). Although this argument constitutes no proof, recent studies have confirmed the view that the small animal was probably the female of the urus, the size difference largely disappearing in domestication (*29*).

As to the social or economic conditions under which domestication of cattle arose, zoology has not made any serious attempts to critically analyze the postulates of culture history. Some—Herre, for example—accept the conclusion of culture history (*11*), while others, such as Zeuner, content themselves with a general statement concerning the inevitability of symbiotic relationships developing between animal and man, who is assumed to be "an integral part of his physico-biological environment" (*30*).

In the last 50 years great strides have been made in the comparative study of domestic and wild individuals of a species, and many changes which are the result of domestication, including changes in the soft parts of the body reflected in skeletal remains, have been clearly established, so that theoretically it should be possible to distinguish between wild and domestic animals in early finds and representations (*31*). But the usefulness of the criteria which have been established in the examination of skeletal remains from the dawn of domestication is severely limited in that cultural domestication must have antedated any impact upon the osteological components of the animal. The difficulty is aggravated by the fact that osteological elements to which such diagnostic criteria might be applied are unfortunately missing in most of the earliest archeological finds, and one cannot exclude the possibility that the changes occurred in wild mutants, for in fact almost all the changes that occur in domestication are known to occur (though rarely, to be sure) in wild individuals (*32*). Thus, for all the progress that has been made in determining characteristics which develop in domestication, these criteria are insufficient for determining whether domestication had in fact occurred in the earliest sites in which prodomestic animals are found. Indeed, as Epstein, a leading student of African domestic animals, has pointed out, the study of anatomic characteristics has been inadequate even for determining the racial history of long-horn cattle (*33*).

Arguments for Religious Motivation

The geographer Eduard Hahn, in a series of writings at the turn of the century, posed the basic questions involved in study of the domestication of cattle (*4*). These are the questions still raised today, and they are still answered by culture historians substantially in the way he answered them. Hahn pointed to the exceptional position of cattle among animals that have been domesticated. In the case of some animals, domestication may have come

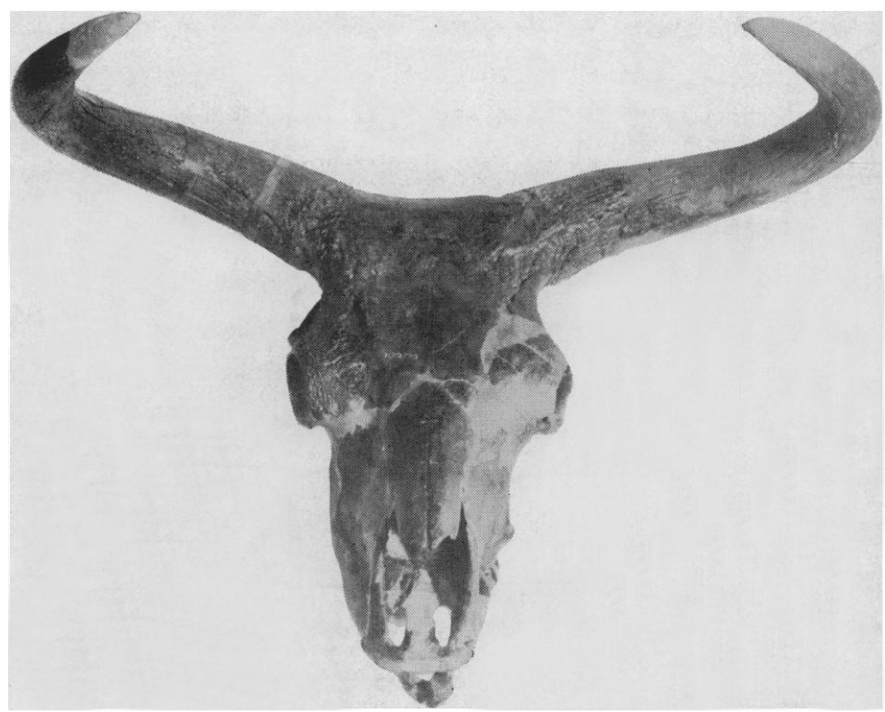


Fig. 2. Urus skull from Burwell Fen near Cambridge, England. Length of horns along horn contour and across forehead, 5 feet 9 inches. [American Museum of Natural History]

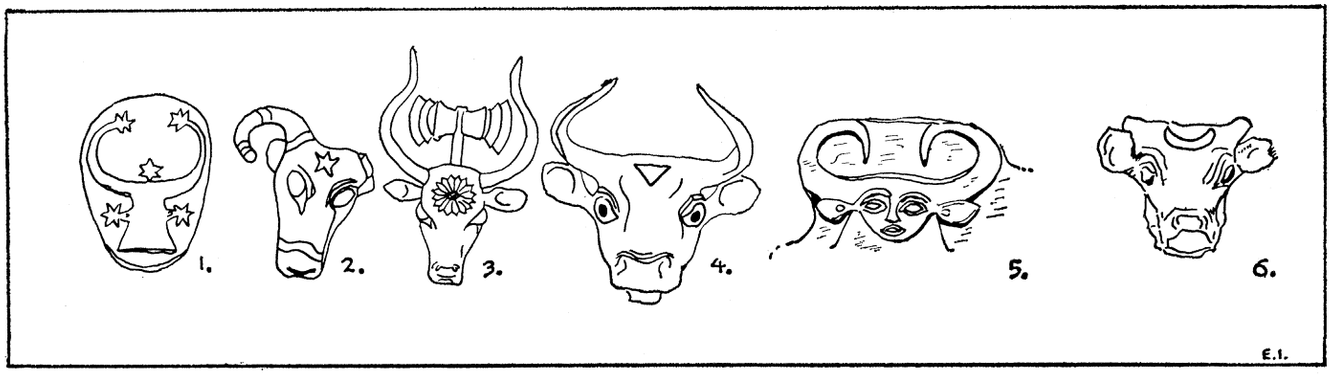


Fig. 3. A group of heads indicating the ritual significance of cattle. 1, Gerzean slate palette with the head of Hathor as the heavenly cow, about 3300 B.C. 2, Clay bull's head with astral symbol, Old Kingdom period, Egypt. 3, Bull's head with rosette, Mycenaean period, Greece. 4, Bull's head from Tell Khafaje, Iraq, with pearl triangle, about 2800 B.C. 5, Head of Hathor with cow's ears and horns on a votive plate of King Narmer, Hierakonpolis (Kom el Ahmar), about 3200 B.C. 6, Bull's head with lunar crescent, al-'Ubaid, about 3100 B.C.

about spontaneously. For example, the ancestor of the dog as well as that of the domestic pig probably, as scavengers, sought out man, and gradually man assumed the leadership in the relationship. One may indeed ask, "Who then initially domesticated whom?" (*34*). Domestication, again, may have been furthered by instincts which make us cherish our own infants and which are aroused by young mammals of somewhat similar bodily proportions. Piglets and dog pups are nursed by women in some primitive societies. But the domestication of wild cattle cannot be explained as an inadvertent process. Wild cattle presumably did not seek human company, and the initiative must have come from man (*6*, p. 33). Furthermore, man must have had a strong motivation, since the wild urus was a powerful, intractable animal of whom it is said in Job (*35*): "Will the urus be willing to serve thee, or abide by thy crib? Canst thou span him into a plowing harness or will he harrow the valleys after thee?"

Eduard Hahn has postulated that the motive for capturing and maintaining the urus in the captive state was to have available a supply, for sacrificial purposes, of the animal sacred to the lunar mother goddess worshipped over an immense area of the ancient world. The economic uses of the animal would then have been a by-product of a domestication religious in origin. Why the urus was selected as the animal sacred to the deity is uncertain, but this was probably because its gigantic curved horns resembled the lunar crescent (Fig. 3). Studies in prehistoric and early historic religion have shown that the bovine was early regarded as an epiphany of the goddess or her consort and was slain in the ritual reenactment of the myth of her death. This myth involves the notion of the death and resurrection in new life of the deity. Of course, if cattle were domesticated because the horns of the urus resembled the moon's crescent, it is possible that other horned animals, such as sheep and goats, were also domesticated for their horns. Again, it is possible that an unsuccessful attempt to domesticate crescent-horned gazelles (*17*, *18*) was made for the same reason. On the other hand, the bison, domesticable but lacking crescent-shaped horns, was never domesticated (*36*). The old 19th-century theory that animals were domesticated through being corralled for food was dismissed by Hahn as raising more problems than it answered (*37*). It failed to explain the choice of certain animals and the rejection of others equally abundant, more easily captured, and more easily raised in captivity (*38*). Hahn's theory, moreover, has the merit of fitting current attitudes toward cattle of many African and Asian peoples.

Conjectures on Domestication

Hahn's followers have conjectured that the process by which the urus was transformed into a domestic animal was as follows. The captured animals were kept in corrals, for sacrificial use. Types different from the original strains of captured urus developed, since the sacrificial stock, protected from predators and free to multiply, would have been either more inbred or more outbred than under natural conditions. As every zoo keeper knows, this factor alone would produce deviations from the wild parent stock (*39*). Obviously, animals with more infantile characteristics, such as foreshortened heads, long legs, and relatively straight backs, as against the high withers and massive build of the wild cattle, could grow to maturity under the protective conditions of the sacred corral. Indeed, the selection of mature long-horned animals as epiphanies of the deity and thus the best animals for sacrificial purposes perhaps initially encouraged the survival of such individuals. Moreover, pied coats, which occur among many species as the result of domestication, developed in cattle as a result of breeding in confinement. Thus, the argument runs, *Bos taurus longifrons*, the first cattle to be economically exploited, emerged. On the other hand, the desirability for sacrificial purposes of the massive long-horned animal led to the perpetuation of a urus-like animal in the well-known sacred primigenius herds of the ancient Near East.

The development of infantile-appearing strains of sacred cattle more tractable than the parent stock widened the range of ritual uses to which the animal could be put. Representations indicate that the first known harnessing of cattle was to sleighs or wagons in religious processions. Mesopotamian frescoes show priests plowing and performing other tasks of husbandry. Priests are also shown performing rites involving cattle, either in the sacrifice of an animal or in processions in the temple

precincts. The notion of using cattle for secular labor seems to have been derived from the use of cattle to pull sacred vehicles. Castration of the bull, which led to one of the most significant of agricultural developments, the ox, also had a religious origin. Neither the taming effect of castration nor its effect in improving the texture of meat could have been foreseen (*6*, p. 37). Human ritual castration, a reenactment of the fate of the deity in certain cults of Near Eastern ritual mythology (Tammuz, Attis, and so on) probably served as the model for the castration of bulls.

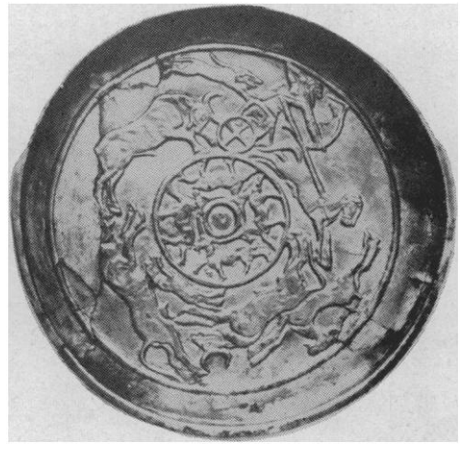
The earliest indication, apart from the osteological record, of the development of a domestic type distinct from the wild urus lies in representational art. From representations we find that the earliest strains of domestic cattle strongly resembled the urus. In many cases, of course, it is difficult to determine whether the animal portrayed was wild or domestic. On the famous standard of Ur, a bull is shown, and that it was probably domestic may be inferred from the ring through its nose. Certainly, some reliefs leave no doubt that the animal was domestic, as, for example, the copper relief of the temple of Mesannipadda (*6*, p. 43), founder of the first dynasty of Ur (about 3100 B.C), which shows priests milking. Other representations, such as the well-known victory tablet of King Narmer of Hierakonpolis (Kom el Ahmar, Egypt), undoubtedly depict wild bulls. However, much of the representational evidence, especially that which shows hunting scenes, is ambiguous (Figs. 4–6). We may infer that the scenes depicting the hunt of cattle by Ashur-nasirpal (884–860 B.C.) show the hunting of wild cattle, from the existing lists of the game killed and captured. On a single hunt this king killed 50 urus bulls and captured eight live ones. From other Assyrian texts we learn that young cattle captured in the hunt were bred in captivity. In the existing lists, different symbols are used for wild and for domestic animals; the representations alone would not tell us conclusively that the animals were wild and not semidomestic cattle kept on the open range. Even when a hunt is shown, or where the scene is that of an animal trapped in nets or trapped through the use of decoy cows, the capture that is shown may well be of animals from a semidomestic herd on the range. Boettger stresses that the capture of bulls depicted on two gold cups found in a tomb of Vaphio near Sparta and dating back to about 1500 to 1250 B.C. is very probably a capture not of wild bulls, as was previously supposed, but of bulls kept in a state of semidomestication. Again, the long-horned massive cattle depicted in the bull-game scenes of Cretan frescoes probably are semidomestic animals, for they are pied. Indeed, on a picture of late Minoan times a cow of the same massive configuration is shown being milked in the old (and dangerous) Mesopotamian fashion—through her hind legs. This method is employed even today in Africa (*6*, pp. 35, 47, 49).

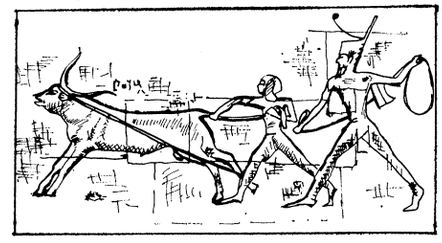
There is still another reason why one cannot rely completely on representational art as a source of information: styles in art may have persisted when they ceased to convey an accurate picture of the cattle of the period. The maintenance of conventions characterizes religious art in particular. In Austrian churches, until recent times, peasants offered little statuettes of long-horned cattle, although such cattle had been unknown in Austria for many centuries (*40*). Herre's comparative study of skeletal remains, and of pictures of domestic animals contemporary with the remains, from medieval Hamburg revealed that very different conclusions would be drawn from the study of either alone (*41*). That Egyptian representational art was characterized by the same maintenance of artistic conventions has been pointed out by Boessneck (*42*).

Although there are thus difficulties in judging from early representational art what kind of cattle were in fact used, it is possible to distinguish domestic cattle in later representations, when the specifically domestic characteristics are stressed—in representations of cattle with pied coats or extremely large udders, or of short-horned or polled cattle (*Bos taurus akeratos*) such as we find represented on the mural relief of King Ti and Queen Neferhotpes at Saqqara (25th century B.C.).

Primigenius and Longifrons Emerge

From the wild urus two races of domestic cattle emerged early. The heavy horns of the urus caused the develop-





Figs. 4–6. Fig 4 (left). Bull hunt on painted sunk relief carved on the mortuary temple of Rameses III at Medinet Habu, western Thebes. The king dispatches wounded (probably wild) bulls in papyrus thickets on a stream bank, about 1150 B.C. (× 1/60) [Oriental Institute, University of Chicago]. Fig. 5 (center). Urus and gazelles hunted by charioteer. The figures are embossed in prominent relief on a gold bowl from Ugarit, 14th century B.C. [Schaeffer, Collège de France]. Fig. 6 (right). Rameses II and a prince lasso a bull (probably semidomestic), temple of Sethos I at Abydos (Farshut), about 1300 B.C. [E. Isaac]

ment of wide and flat parietal bones, so that the top of the skull, when the animal is seen head on, appears almost horizontal. Domestic cattle which retained a urus conformation of skull and body are called "primigenius" cattle, descendants of *Bos taurus primigenius*, the earliest domestic cattle. When shorter-horned domestic cattle developed, the frontal and parietal bones, released from the excessive weight of horns, became domed; this is, of course, most evident in polled animals. This type of animal, because of its characteristic long and narrow face and upward convex parietals, is called *Bos taurus longifrons* (Figs. 6–9) (*43*).

Longifrons cattle, differing markedly from primigenius cattle, like the latter first appear in Mesopotamia. While it is difficult, in the early Mesopotamian representations, to distinguish between urus and primigenius cattle, in the case of longifrons it is clear that a domestic type is represented. Generally, moreover, longifrons cattle are depicted in association with agricultural performances or symbols. Probably the first representation of longifrons is on a bowl of the Jemdet Nasr period, and subsequently longifrons cattle are depicted more and more often, although never so frequently as primigenius types. Boettger has proposed that the distinction between longifrons and primigenius was one between an economically exploited breed and a strain maintained primarily for ritual purposes. The distribution of longifrons cattle outside the Near East is taken by Boettger to indicate that longifrons was spread intentionally and did not originate independently in a number of places. In spite of the fact that longifrons cattle appear much later than primigenius in Mesopotamia, their docility, their manageability, and their overall usefulness account, according to Boettger, for their having reached both the Atlantic and the Pacific peripheries of the Old World continents before primigenius cattle did (*6*, p. 52).

With the spread of longifrons into the European periphery, a number of dwarf varieties appeared, constituting, in the view of the culture historian, a deterioration of the introduced strain. This deterioration may have been initially the result of inexperience in handling, and of inadequate feeding before a proper balance of feed crops was grown or before pasture systems were developed. Dwarf longifrons cattle, formerly called *Bos taurus brachyceros*, occur in the Swiss Neolithic, and in the Balkans and Caucasus in the 2nd millennium B.C. (*44*). Certain present-day cattle (still kept under relatively poor conditions of husbandry) are counted among the modern representatives of this type—for example, the Polish Maydan and Hutsul cattle, Polesian and Polish Red, Spanish Mountain, Italian Piedmont, Brown Mountain (Austria), and Bulgarian Rhodope cattle. Eventually, animals larger than longifrons or its dwarf varieties developed. Crosses with wild cattle undoubtedly occurred, and the products of such crosses resembled in conformation the primigenius types of West Asia. These were favored in some areas and through selective breeding gave rise to *Bos taurus frontosus*, a broad-faced type which is represented today by some economically very important European breeds such as the Dutch Friesian and the Meuse-Rhine-Yssel, the Swiss Fribourg and Simmentaler, the German Yellow Hill, and the Austrian Pinzgau. Elsewhere, cattle with a dwarfed primigenius conformation but a short skull developed—*Bos taurus brachycephalus* Wilkens, whose modern representatives include the French Tarentaise, the Swiss Hérèns, and the Austrian Tux-Zillertal (*45*).

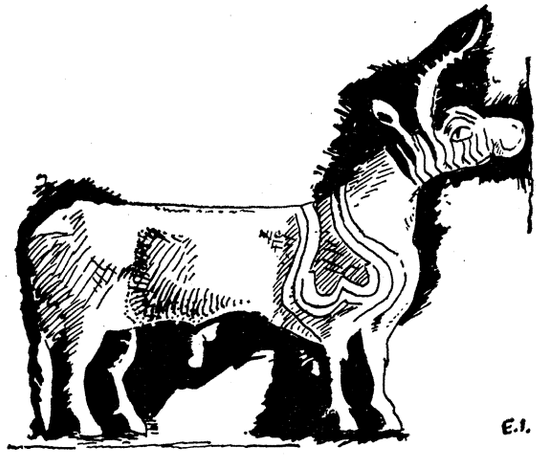


Fig. 7. Urus from a seal impression from the Indus Valley, about 2500 B.C.

Thesis Consistent with Zoology

There is no fundamental disagreement between zoology and culture history on the question of how domestic breeds of cattle developed, even though the notion of a religious motive is not germane to zoological analysis. Of course, to find out if there was even a possibility that the urus voluntarily joined human society, zoologists would have to recreate the animal by backcrossing. Apparently successful attempts to recreate the urus have been made. Both H. Heck, at the Hellabrunn Zoo of Munich, and his brother L. Heck, at the Berlin Zoo, were able from different breeding stock to create bovines which bore a remarkable resemblance to medieval representations of the urus. Unfortunately, however, we have no precise knowledge of the physiology and psychology of the urus, so that even if one produced an animal that looked exactly like the urus (and medieval representations are generally stylized), it would not be possible to know whether the animal behaved like the urus (*46*).

The zoologist, like the culture historian, asserts that new strains would almost necessarily appear as a result of the accidental capture of foundation stock from different breeding groups and the establishment of larger breeding units. Even under wild conditions, where there are animals heterozygous for numerous genes, segregation of deviating individuals occurs constantly. But although as a rule deviant individuals are eliminated by natural selection, the protection against predators afforded by the simplest enclosure would suffice to allow deviating animals to develop and reproduce. Polled cattle, whose senses are poorly developed in comparison to those of wild individuals and who lack a primary defense, would survive. Even in the case of nonsocial animals, such as cats, living in a human settlement, the increase in population density has the effect of increasing variability (*11*).

The history of the domestic rabbit

is known with some completeness and shows the same pattern of changes taking place under conditions of enclosure. In fact, the rabbit is taken by students of domestication to illustrate the process of change in a wild animal under the influence of domestication (*47*). The domestic rabbit is derived from wild rabbits, imported from Spain during the period of the Roman Empire, which were enclosed in leporaries where they lived as in the wild but were accessible to hunting parties. From old engravings it is apparent that hunting rabbits in leporaries was held to be a suitable and safe pastime for ladies. Not until the 17th century had the rabbit changed by mutation from wildness to tameness and assumed the characteristics of the present-day rabbit. That the urus differentiated under conditions of domestication into primigenius and longifrons is thus not unlikely, even if the degree of control and selection was less than the thesis of religious motivation assumes.

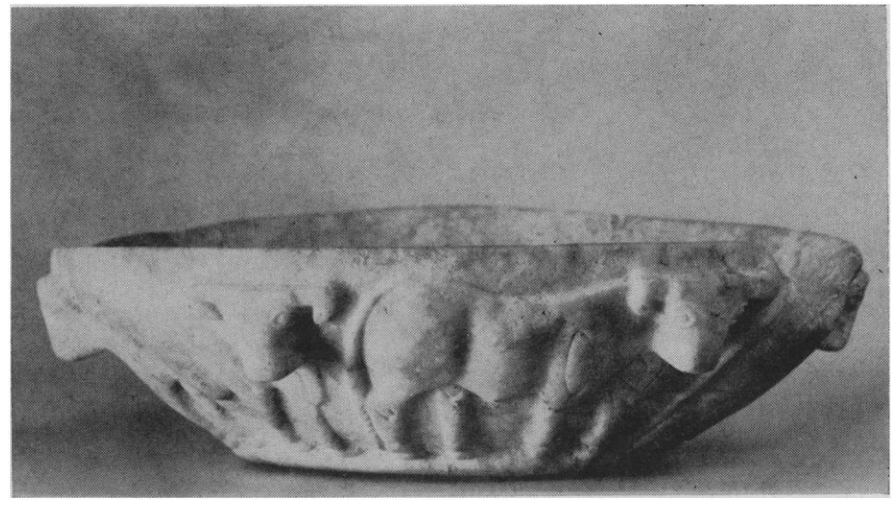


Fig. 8. Sumerian marble bowl with primigenius bulls carved in relief, about 2700 B.C. [Metropolitan Museum of Art, Fletcher Fund, 1939]

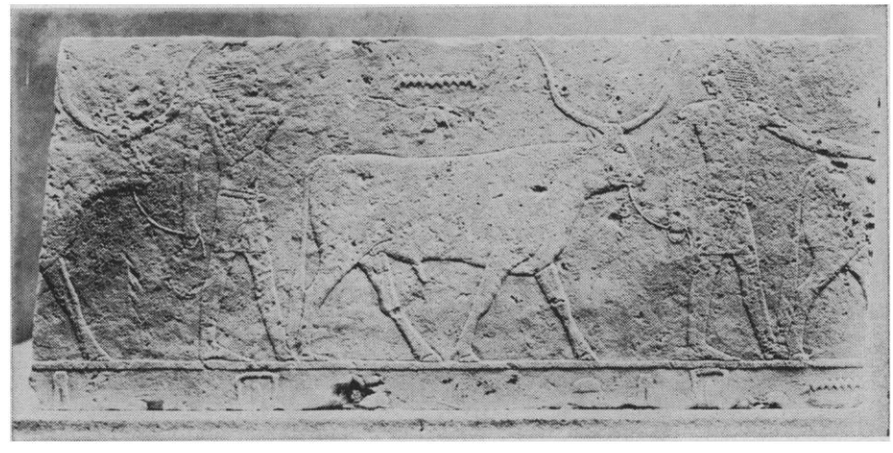


Fig. 9. Relief of longifrons cattle from the tomb of Ra-em-kai, Saqqara, Egypt, Vth Dynasty. [Metropolitan Museum of Art, Rogers Fund, 1908]

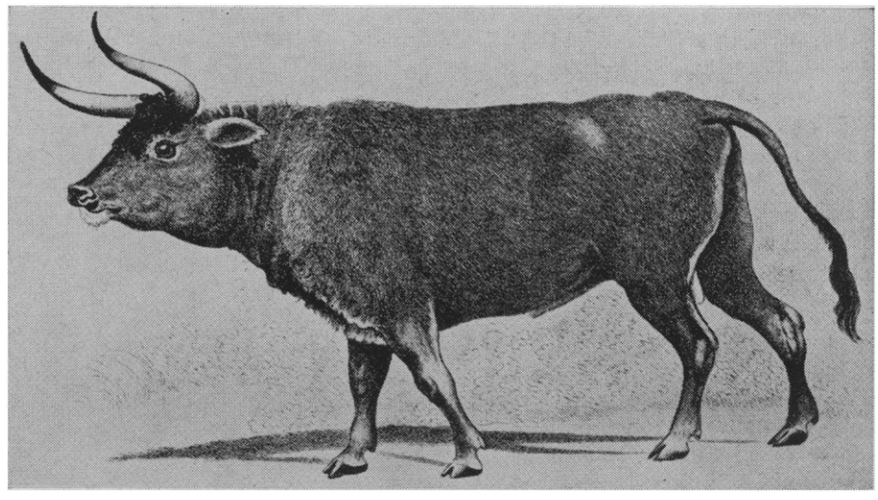
What Was Transmitted—Animal or Idea?

Although the culture historian assumes that the small cattle which are the first to appear in Old World strata outside West Asia were longifrons which West Asian migrants brought with them, all that zoology can state with certainty is that a pronounced diminution in size differentiates this animal from the urus; such diminution could, of course, come through local domestication. In fact, in Europe a steady diminution in size continued until the Middle Ages. While the urus had stood at more than 2 meters at the withers, the average height at the withers in the Iron Age is given by Herre as 1.10 meters, and the average in the Middle Ages, as 1 meter or less. Herre asserts that domestication must have been local, since the earliest domestic cattle in Europe, occurring long after domestic characteristics were well developed in Near Eastern cattle, were transitional forms with respect to the local representatives of the urus (*48*). Herre does not deny that domestication first occurred in the Near East but asserts that the technique and idea of domestication were transmitted rather than actual domestic animals. He supports his view with reference to "substitute" domestications (*"Ersatzhaustieren"*)—animals domesticated outside the range of the wild form of an already domesticated animal, such as the ass (*Asinus africanus* Fitzinger 1857) in place of the horse (*Equus cab. przewalski* Poliakov 1881), the yak (*Bos Poëphagus grunniens* Przewalski 1883) in place of the urus, and so on (*11*).

There are additional weighty arguments put forth in support of the thesis of local domestication of the urus in disparate areas. The general average decline in size of the early European cattle was accompanied, as the osteological record shows, by a great overall variability in size and conformation. Such remarkable multiplication in conformational types and increase in the growth range of adult animals follows, even today, upon the domestication of wild animals, as practical work with domestic fur-producing animals has shown. Thus, the silver and blue fox, themselves mutants of the red fox, have in a short time given rise to a series of other types: platinum, white-faced, golden platinum, pearl, perlatina, glacier blue, Washington platina, radium, and pastel fox (*47*). Similar results have been achieved with mink and nutria. The great variability observed in early European domestic cattle remains a strong argument against the thesis of the introduction of a developed domestic strain.

Should, then, the thesis of the introduction of longifrons into Europe be thrown out? Were it not for the appearance simultaneously with domestic cattle of tools, pottery, and art stylistically related to and often demonstrably imported from the prehistoric and early historic Near East, the thesis of actual introduction of the earliest domestic cattle would undoubtedly receive even

Ro. Jſidor⁹. Uri ſunt bouꝭ agreſtes adeo fortes vt arboꝛes ⁊ armatos milites i cornibꝫ eleuẽt. Jdẽ vri dicti ſũt aporon oꝛion. i. a montibꝫ. Sũt boues ãũ agreſtes i germania bũtes coꝛnu in tantum pꝛenſa: vt regũ mẽſis inſigni capacitate ex eis gerule fiant. ¶ Helynandus libꝛo viceſimoſexto. In hꝛcinia ſilua germanie ſunt vri. Hi ſunt magnitudine paulo elephantoꝭ: ſpecie ⁊ coloꝛe ⁊ figura tauri. Magna vis coꝛũ eſt ⁊ magna velocitas neq; homini neq; fere quã aſpexerint parcunt. Hos ſtudioſe foueis capꝛos interficiunt.



Figs. 10 and 11. Fig. 10 (left). Woodcut of a urus, highly stylized, in Johan Prüss' *Hortus sanitatis*, published in 1495 by Jacob Meydenbach in Mainz. The text reads: "Isidor says of the urus: urus are wild cattle so strong that they can lift trees as well as armed knights with their horns. They are called urus from the Greek word oros meaning mountain . . . Helynandus says . . . In the Hercynian Forest of Germany the urus is found. These animals are nearly as large as elephants: in appearance, color and conformation they are like cattle. The force of their horns is great and their speed is great. They spare neither man nor animal. One catches them in pits and kills them." Fig. 11 (above). Drawing of urus copied from a 16th century oil painting found in 1827 by the English zoologist Hamilton Smith in an Augsburg antiquities shop. The painting was subsequently lost, but this drawing was widely reproduced. [American Museum of Natural History]

less attention than it does in current treatment of the racial history of European cattle. And, of course, even where contact, trade, and migrations have occurred, actual movement of cattle cannot be proven. Nonetheless, there remains much to support the introduction thesis. Ersatz domestication, while it has occurred in many instances, has taken place in areas where the domestic animal cannot be introduced because of conditions of excessive physiological strain and stress, local bacterial faunas, dangers of worm infestation, and so on. Such conditions make it economically unfeasible to introduce many of the classical domestic animals into tropical or high-altitude areas even today, but there was never any bar to the introduction of cattle into Europe. Moreover, although local wild strains (Figs. 10 and 11) undoubtedly contributed to the formation of the earliest European domestic cattle, accounting for the "dwarf urus" which appears rather abruptly in stratigraphic layers (*49*), unless domestic cattle were brought into Europe and crossed with the local urus, the difficulty of domestication would have been scarcely less in Europe than it had been millennia previously in West Asia. It is conceivable, in fact, that the European wild urus played a smaller part in the formation of frontosus and primigenius types than was formerly assumed. Certainly in historic times efforts have always been made to prevent cross breeding between the urus and domestic cattle so as not to increase the wildness of the domestic races (*6*, p. 48). Perhaps the locally occurring European primigenius and frontosus races are, after all, products of selection from the early introduced longifrons, and from the subsequently introduced West Asian or Mediterranean primigenius cattle.

Of interest in this connection is the fact, pointed out by Nobis, that in regions dominated by the Roman camps of the European *limes*, primigenius or "pseudoprimigenius" cattle are found (*50*). These may be introductions from the Mediterranean world, or products of the application to local stock of the more expert Roman husbandry, or the result of both. There was no lasting improvement in the near-dwarfed local cattle of the surrounding areas, and after Roman times pseudoprimigenius all but vanishes from the osteological record of these areas. It is tempting to draw an analogy with the more recent history of cattle in southern and central Africa. After the disastrous rinderpest epidemic of 1896, there were massive introductions of European stock (*51*), but in spite of large-scale cross-breeding, the contribution of the European stock to the conformational characteristics and productive capacity of native cattle was all but negligible. Under the rigorous conditions of the African veld, natural selection operated in favor of animals of overall ruggedness rather than of animals of indifferent stamina though of higher potential as a source of meat and milk (*52*).

Explanation of Variability

Great variability in size and even in conformation of a herd may be taken to imply a low level of animal-husbandry skill and does not necessarily mean that domestication has been recent. African domestic cattle today are almost entirely derived from repeated introduction of West Asian domestic races (*51, 53*). Yet among Sanga cattle, the most important breed type in central and southern Africa and represented as far west as Nigeria and as far north as the Sudan, the variation in conformation, in animal size, and in horn size is enormous. Often gigantic-horned, long-horned, short-horned, and polled animals occur in a single herd

(*54*). Some Sanga, such as the Shona or Karanga cattle of Southern Rhodesia, have truly dwarfed and short-horned representatives (*55*), whereas another Sanga, Bechuana cattle, includes gigantic specimens (*56*) whose enormous horns approach and even exceed in length those of Indian Pliocene ancestors of the urus (*57*). The fact is that where, for whatever reason, the herder selected for small size, a small Sanga appeared. Similarly, megaloceratic horns in African Sanga herds persist only because of continued careful selection for gigantic horns. Where there is no selection for special points, the Sanga herds are made up of generally small, although widely divergent, individuals. This state of affairs obviously does not prove that the Sanga was locally domesticated. Thus, perhaps the dwarfing and variability of European neolithic cattle indicates that an introduced race—longifrons—deteriorated under conditions where a desire for a large number of animals outweighed considerations of carrying capacity and productive potential of the individual animal—as it so often does in African husbandry.

It is noteworthy that recent and more sophisticated methods of investigation have tended to support the thesis that cattle were introduced into Europe from western Asia. Electrophoretic studies of the distribution and mode of inheritance of different types of hemoglobin in cattle (*58*) support the thesis that Jersey (*59*) (a brachycephalus type) as well as Guernsey and South Devon cattle (the former brachyceros, the latter brachycephalus) had an African, and ultimately a Mesopotamian, origin. The superior performance of Devon and Jersey cattle at high temperatures, demonstrated in studies at agricultural research centers in Africa, as well as the exceptionally high butter-fat content of milk from these breeds, characteristic also of milk from cattle native to tropical regions, tends to reinforce the argument that these types had a western Asian origin.

Conclusion

The thesis of Eduard Hahn and of those who have followed his lead has stood up well in the light of progress made in zootechnology, animal psychology, the comparative anatomy of domestic and wild species, and the study of non-European native cattle. On the other hand, Hahn's hypothesis can in no way be said to have stimulated work in the zoology of domestic species, although such work has gone far to confirm its plausibility. But if Hahn's thesis has had no particular bearing on the zoological study of domestication, in what can its value be said to lie? Like all cultural theses, it provides an insight into historical processes. Specifically, Hahn's thesis also constituted a protest against the materialistic assumptions underlying 19th-century German social and economic theories. Hahn affirmed the importance of irrational forces in major technological advances of mankind. His thesis, moreover, has stood up better than most of the broad and more spectacular cultural theses of our day, where close examination by experts in any specific and relevant area has led to steady erosion of the overarching argument. In the study of domestication the scientist and the cultural historian join forces, each playing a role which the other discipline, by its very nature, cannot fill.

References and Notes

1. This article grew out of research in the larger problem of the origin and distribution of the breed groups of domestic cattle. I am indebted to the Ford Foundation, which supported a year's study in Africa devoted in part to the study of African animal husbandry and breeds.
2. A. Müntzing, *Proc. Am. Phil. Soc.* **103**, 190 (1959).
3. The classical statement of the theory is that of E. Hahn (*4*).
4. E. Hahn, *Die Haustiere and ihre Beziehungen zur Wirtschaft des Menschen* (Duncker and Humblot, Leipzig, 1896); *Die Entstehung der Pflugkultur* (Winter, Heidelberg, 1909).
5. The most recent statement is that of C. R. Boettger (*6*).
6. C. R. Boettger, *Die Haustiere Afrikas* (Fischer, Jena, 1958).
7. The old ethnological view, dating back to the Greek geographer Dicaearchus (about 310 B.C.), that cattle were domesticated by nomadic hunters has been shown to be untenable, notably by Georg Cancrin (1774–1845), Alexander von Humboldt (1769–1859), and Eduard Hahn (1856–1928). None of the steppes of the New World gave rise to herding complexes, although they were occupied by hunters and wild herd animals for an extensive period of historical time. The nomadic complexes of the Old World steppes were always contiguous to land areas of sedentary farmers who had the same domestic animals as the nomads. Conversely, in no steppes not adjacent to areas occupied by animal-using peasantry has pastoral nomadism developed from hunting nomadism (the steppes of Australia are an example). The South African Hottentots are only an apparent exception; they originated in the East African steppes occupied by other herding peoples. Moreover, present-day nomadic hunters do not domesticate animals; the use of animals in hunting (such as the cormorant, the hawk, the cheetah, and the mongoose) is an invention of peasant cultures, whether the animals are used as decoys, as trackers, or as agents of the kill. Primitive hunters do not even use dogs in the hunt. On the subject of the land areas occupied by peasants and nomads, see K. J. Narr, in *Historia Mundi*, F. Valjavec, Ed. (Francke, Bern, 1953), vol. 2, pp. 60–100. On Hottentot origins, see T. F. Dreyer and H. J. D. Meiring, *Soologiese Navorsing van die Nasionale Museum Bloemfontein* (1937), vol. 1, p. 81, and *Navorsing van die Nasionale Museum Bloemfontein* (1952), vol. 1, p. 19; P. V. Tobias, *African Studies* **14**, 1 (1955); J. C. Trevor, *J. Roy. Anthropol. Inst.* **77**, pt. 1, 61 (1947).
8. F. Hancar, *Das Pferd in Prähistorischer und Früher Historischer Zeit* (Herold, Vienna, 1956).
9. Eland has recently been successfully domesticated in Southern Rhodesia by J. Posselt, near Gwanda and in the Union of South Africa. I owe my introduction to domesticated eland to Paul Donnelly, provincial agriculturist, Bulawayo, Southern Rhodesia. See Onslow, *Man* **55**, 24 (1945).
10. W. Herre, *Das Ren als Haustier* (Geest and Portig, Leipzig, 1955), pp. 15–33.
11. ———, *Naturw. Rundschau* **12**, 88 (1959).
12. On African milking methods, see S. Lagercrantz, *Studia Ethnographica Upsala* (Upsala 1950), vol. 1; T. M. Bettini, *Beitr. Kulturgesch. Linguist.* **6**, 126 (1944); G. W. B. Huntingford, *The Southern Nilo-Hamites* (International African Institute, London, 1953), pt. 8, pp. 21, 29. On ancient sources, see H. Plischke, *Ethnol.* **79**, 1 (1954); J. L. Benson, in *The Aegean and the Near East*, S. S. Weinberg, Ed. (Augustin, Locust Valley, N.Y., 1956), p. 65, note 27.
13. Homer Aschman has recently described the nearly complete absorption in pastoral husbandry of a society which was formerly a sedentary society of cultivation, in *Ann. Assoc. Am. Geographers* **50**, 408 (1960). See also K. J. Narr in *Historia Mundi*, F. Valjavec, Ed. (Francke, Bern, 1953), vol. 2, pp. 77–78; J. Weisner, *Gnomon* **31**, 289 (1959).
14. R. H. Dyson, Jr., *Am. Anthropol.* **55**, 662 (1953).
15. C. A. Reed, *Science* **130**, 1629 (1959). Proponents of the nomadic-hunter domestication theory have argued that the archeological record constitutes no proof, since the transient sites of early nomads are not likely to be identified. Certainly the archeological record is haphazard for vast areas, but as Narr pointed out, such evidence as there is does point to the agricultural origin of herd animal domestication.
16. A statistical approach to determination of the presence of domestic animals has been used at least since the 1890's. See H. Krämer, *Rev. Suisse zool.* **7** (1899); J. U. Duerst, *Arch. Anthropol.* **2** (1905); A. Pira, *Zool. Jahrb. Abt. Allgem. Zool. Physiol. Tiere* **28**, suppl. 10 (1909).
17. Material currently being studied by Charles A. Reed at the Peabody Museum, Yale University, indicates that a shift from wild to domestic sheep occurred in northern Iraq as early as the 9th millennium B.C. Reed questioned recently [*Science* **130**, 1635 (1959)] the universal applicability of the statistical approach, for we find similar concentrations of submature individuals in instances where the animals never became domestic. Such finds, on the other hand, may mean that an attempt at domestication was made which was ultimately found to be impractical (see *18*).
18. F. S. Bodenheimer, *Hachai bearzot Hamikra* (Bialik Foundation, Jerusalem, 1949), vol. 1, pp. 56–57.
19. C. W. Bishop, *Smithsonian Inst. Publs. Rept. No. 3477*, pp. 531–547.
20. V. G. Childe, *Ethnographisch-Archäologische Forsch.* **2**, 14 (1954); A. G. Haudricort, *Rev. geog. humaine et d'ethnol.* **1** (1948); P. Leser, *Enstehung und Verbreitung des Pfluges* (Anthropos, Münster, 1931).
21. V. G. Childe, *Proc. Phehistory Soc. for 1951* (1951).
22. L. C. Watelin and S. Langdon, *Excavations at Kish* (Geuthner, Paris, 1934), vol. 4, pp. 30–34; C. L. Wooley, *Ur Excavations* (Oxford Univ. Press, London, 1934), vol. 2, p. 64.
23. S. Foltiny, *Am. J. Archaeol.* **63**, 55 (1959).
24. H. Epstein, in *The Indigenous Cattle of the British Dependent Territories in Africa*, D. E. Faulkner, Ed. (Her Majesty's Stationery Office, London, 1957), p. 40; W. Herre, *Verhandl. Deut. Zool. Ges.* (1949); *Handbuch Tierzüchtung* (Parey, Berlin, 1958), vol. 1.

25. V. Lehman, *Neues Jahrb. Mineral. Geol. Palaeontol.* **B**, 90 (1949).
26. W. Herre, *Zuechtungskunde* **28**, 223 (1956).
27. M. D. W. Jeffreys, *S. African J. Sci.* **47**, 227 (1951).
28. A. Müntzing, *Proc. Am. Phil. Soc.* **103**, 208 (1959).
29. W. La Baume, *Eclogae Geol. Helv.* **40**, 308 (1947); *Forsch. Fortschr.* **26**, 43 (1950); O. von Leithner, *Ber. Intern. Ges. Erhalt. Wisent.* **2**, 1 (1927).
30. F. Zeuner, in *A History of Technology*, C. Singer *et al.*, Eds. (Oxford Univ. Press, London, 1954), vol. 1, p. 327.
31. In cattle a foreshortened and widened skull, decrease in the dimension of eye and ear openings, shortness of backbone, decrease in size—in short, overall infantilism—distinguishes domestic from wild varieties. It is remarkable that many changes are common to animals of different species that have been domesticated: curly hair instead of straight; retention of baby hair; pied coats instead of monocolored; reduction in differences between male and female; variability in size between different breed groups, leading to a pronounced contrast between giants and dwarfs; extremely one-sided development of certain characteristics, such as milk production, and sometimes pathological alterations, such as the short-leggedness of Dexter cattle, in which the responsible gene is lethal when homozygous. Some changes in the soft parts are reflected in skeletal remains. Muscular development or atrophy and changes in brain volume due to environmental modifications, such as differences in food supplied by man, or due to the specialized physiological performance required of domestic animals, mark the skeleton and lead to the development of characteristic processes, crests, or ridges. The changes are comprehensively summarized by H. Nachtsheim, *Vom Wildtier zum Haustier* (Parey, Berlin, 1949) and treated in M. Hilzheimer, *Natuerliche Rassengeschichte der Haussäugetiere* (de Gruyter, Berlin, 1926); C. Darwin, *The Variation of Animals and Plants under Domestication* (London, 1868); B. Klatt, *Entstehung der Haustier* (Borntraeger, Berlin, 1927); *Haustier und Mensch* (Hermes, Hamburg, 1948), pp. 54–59; A. Müntzing, *Proc. Am. Phil. Soc.* **103**, 207 (1959).
32. H. Bohlken, *Zool. Jahrb. Abt. Allgem. Zool. Physiol. Tiere* (1958); M. Röhrs, *Verhandl. Deut. Zool. Ges. Graz. Zool. Anz.* **21** (1957); H. Kelm, *Z. Anat. Entwicklungsgeschichte* **108** (1938).
33. H. Epstein, *Z. Tierzücht. Züchtungsbiol.* **71**, 59 (1958).
34. B. Klatt, *Haustier und Mensch* (Hermes, Hamburg, 1948), p. 32.
35. Job 3: 9–10.
36. It is interesting to note that B. Klatt suggests (in *Haustier und Mensch*, p. 34) that the arni buffalo (*Bubalus bubalis*) was the first bovine to be domesticated in Mesopotamia, and that the reason for this was the near-perfect crescent shape of its horns, which made it a suitable epiphany of the lunar deity. The urus, according to Klatt, was probably domesticated as a substitute for the arni, which disappeared from Mesopotamia in early historic times. One might suggest that capture and subsequent sacrifice contributed to the disappearance of the arni, while the urus survived ritual domestication. It was J. U. Duerst, in *Die Rinder von Babylonien, Assyrien und Agypten und Ihr Zusammenhang mit den Rindern der Alten Welt* (Reimer, Berlin, 1899) who first pointed out that there was a relative abundance of representations of arni buffalo and a scarcity of representations of urus in early Mesopotamian art, and that subsequently representations of urus increased, whereas the arni vanished as a subject. The topic is also treated by M. Hilzheimer, *Die Wildrinder im alten Mesopotamien* (Pfeiffer, Leipzig, 1926).
37. J. F. Downs, in "Domestication: An Examination of the Changing Social Relationships between Man and Animal," *Kroeber Anthropol. Soc. Publ. No. 22* (1960), pp. 18–67, restated the enclosure-for-food concept. Hahn and subsequent authors were dubious about this view, at least in so far as it concerns cattle, partly because of the rejection of meat and animal products by many of the great cattle-keeping cultures on religious grounds.
38. The mummified cat interments of Egypt (at Bubastis near Zagazig and at the Alexandrinian Serapeum) are probably the best example of domestication for religious reasons. A complete record of mummified cats (the cat was the epiphany of the goddess Bast) exists, showing a sequence of development from the ancestral Libyan wild cat (*Felis catus* Libya) to the domestic cat. Domestic forms appear first in the course of the XIIth and XIIIth dynasties. Nowhere outside of Egypt were wild cats domesticated. It has been argued that the Libyan wild cat entered into some kind of symbiotic relationship with ancient grain-storing Egyptians [see K. Z. Lorenz, *Man Meets Dog* (Pan, London, 1959), pp. 22–24]. The argument is not convincing, since even today there is a symbiotic relationship between the wild cat and man in southern Nubia, but despite the long history of this relationship no development toward domesticity has taken place. The rodent killer of ancient Egypt, as of the Mediterranean basin and most of Europe, was the housesnake, and the cat did not succeed in displacing it in many areas until the post-Christian era. The cat does not seem to appear in the Bible, but I think it is significant that the post-Biblical Hebrew term for cat is "the swaddled," undoubtedly referring to the tradition of mummification. Moreover, it is likely that our word *cat* ultimately derives from the old Semitic word for cotton, the material in which the mummy was swaddled. (On the cat in Egypt, see *18*, p. 1962.) On the spread of the cat, see E. Werth, *Grabstock, Hacke, Pflug* (Ulmer, Ludwigsburg, 1954), p. 324. The cat is found in the Germanic culture area as sacred to Freya and has survived in folklore as the familiar of the witch.
39. H. Spurway, *New Biol.* **13**, 11 (1952).
40. O. Antonius, *Grundzüge einer Stammesgeschichte der Haustiere* (Fischer, Jena, 1922), p. 184.
41. W. Herre, *Hammaburg* **4**, **7** (1950); *Zool. Garten* **17**, 103 (1950).
42. J. Boessneck, *Veröffentl. zool. Staatssammlg. München* **3** (1953).
43. Fundamental studies on horn and skull conformation were made by J. U. Duerst, *Das Horn der Cavicornia* (Fretz, Zürich, 1926). Duerst's later views, especially those on the parietal angle, are quoted by H. Epstein in *Z. Tierzücht. Züchtungsbiol.* **71**, 61 (1958).
44. On the stunted growth of cattle on mountain pastures, see V. Vezzani and E. Carbone, *Report of the 4th International Grassland Congress*, R. O. Whyte, Ed. (Aberystwyth, Wales, 1937).
45. A. Schmid, *Rassenkunde des Rindes* (Benteli, Bern, 1942), vol. 1. Names of breeds and breed groups are given according to I. L. Mason, "A World Dictionary of Breed Types and Varieties of Livestock," *Commonwealth Bur. Animal Breeding Genet. (Gt. Brit.) Tech. Commun. No. 7* (1951).
46. H. Heck. *Oryx* (1951); Heck's popular claims have been severely criticized by O. Koehler [*Z. Tierpsychol.* **9** (1952)] and by W. Herre.
47. A. Müntzing, *Proc. Am. Phil. Soc.* **103**, 205 (1959).
48. W. Herre, *Züchtungskunde* **28**, 223 (1956).
49. *Verhandel. Deut. Zool. Kiel* **1948**, 312 (1949).
50. G. Nobis, *Petermanns Geogr. Mitt.* **99**, 2 (1955).
51. E. A. Nobbs, *S. African J. Sci.* **24**, 331 (1927).
52. I am greatly indebted to D. A. Robinson, director of the Department of Native Agriculture, Southern Rhodesia, and to the scientific personnel of that department's animal husbandry research centers. I also wish to express my gratitude to the many individuals who were associated with Institut National pour l'Etude Agronomique du Congo Belge (INEAC) and Institut pour la Recherche Scientifique en Afrique Centrale (IRSAC) centers at Luiro, Bukavu, and Nioka in the Belgian Congo, and with breeding centers at Entebbe in Uganda; at Sangalo, Maseno, Kibigori, Kisii, and Kabinga in Kenya; and at West Kilimanjaro and Arusha in Tanganyika. I wish to express my special thanks to the department of agriculture, University College of Rhodesia and Nyasaland, for its hospitality, especially to its chairman, Prof. C. Davis, and to Dr. John Oliver, senior lecturer in animal husbandry.
53. H. Curson and R. W. Thornton, *Onderstepoort J. Vet. Sci.* **1936**, 618 (1936); J. H. R. Bisschop, *S. African J. Sci.* **33**, 852 (1937); H. H. Curson and H. Epstein, *Onderstepoort J. Vet. Sci.* **1934**, 3 (1934); H. Epstein, *J. Heredity* **24**, 449 (1933); ———, *J. S. African Vet. Med. Assoc.* **5**, 1 (1934); ———, *E. African Agr. J.* **21**, 83 (1955); D. E. Faulkner and H. Epstein, *The Indigenous Cattle of the British Dependent Territories in Africa* (H. M. Stationery Office, London, 1957).
54. H. Epstein, *E. African Agr. J.* **22**, 149 (1957); *Z. Tierzücht. Züchtungsbiol.* **71**, 65 (1958).
55. Dwarfed Sanga, *Tumombe mapako*, are by now probably extinct in Southern Rhodesia. In 1946 E. A. B. McLeod, a Rhodesian rancher, tried to obtain government assistance in collecting a remnant of the dwarfed animals, but failed.
56. Bechuana cattle from the Lake Ngami area stood nearly 6 feet high at the withers. The Africana Museum, Johannesburg, possesses a skull whose horns measure 8 feet 8 inches from tip to tip. The total length along the contour of the horns and across the forehead is 13 feet 7 inches.
57. These ancestors were *Bos planifrons* Rütim. and *B. acutifrons* Lydekker. Descriptions of them appear in L. Rütimeyer, *Abhandl. schweiz. Palaeontol. Ges.* **4**, 4 (1877).
58. A. D. Bangham, *Nature* **179**, 467 (1957).
59. E. J. Boston, in *Jersey Cattle*, E. J. Boston, Ed. (Faber, London, 1954), pp. 19–42.