Journal of Anthropological Archaeology **18,** 29–78 (1999)
Article ID jaar.1998.0332, available online at http://www.idealibrary.com on IDEAL®

Botai and the Origins of Horse Domestication

Marsha A. Levine

McDonald Institute for Archaeological Research, University of Cambridge, Downing Street, Cambridge, CB2 3ER, United Kingdom

Received April 22, 1997; revision received April 27, 1998; accepted July 28, 1998

This paper explores some issues related to the origins of horse domestication. First, it focuses on methodological problems relevant to existing work. Then, ethnoarchaeological and archaeozoological methods are used to provide an alternative approach to the subject. Ethnological, ethological, and archaeological data are used to construct a series of population structure models illustrating a range of human–horse relationships. Analysis of assemblages from the Eneolithic sites of Botai (northern Kazakhstan) and Dereivka (Ukraine) suggests that horses at these sites were obtained largely by hunting. © 1999 Academic Press

Key Words: archaeology; Eurasian steppe; horse; domestication.

1.0. INTRODUCTION

The impact on human society of the earliest domestication of the horse must have been as profound as that of the invention of the steam engine and yet we know very little about when, where, or how it came about. The increased mobility provided by the horse would have enabled people to move further and faster and to take more with them than ever before. They could exploit larger and more diverse landscapes, maintain larger families, increase the range of their trade contacts. They could move into previously uninhabitable regions. And, since a man on foot is no match for a man on horseback, the military implications of horse domestication would have been revolutionary. John Ewers has shown how profoundly the introduction of the horse into North America changed Blackfoot culture (Ewers 1955). We should expect no less of its early domestication in central Eurasia. However, until recently relatively little attention had been paid to this problem (see also Levine 1990, 1993).

Around 7000 years ago the relationship between people and horses apparently intensified. For a long time archaeologists assumed that intensification meant domestication. However, there are other explanations for this kind of change which must also be explored. It is important to be aware that human–horse relationships varied widely over time and space and that multiple relationships could be relevant at a single site. Furthermore, behavioral patterns for which we have no modern or ethnographic analogues are likely to have been important in the past. Whatever else is involved, it is clear that there was an important change in steppe ecodynamics at this time (from around 5000 to 3000 B.C.). Horses were becoming much more common in archaeological deposits. Important cultural, social, and economic changes were taking place. It was also a period of significant climatic change (Schnirelman 1992). Until we can understand the development of the human–horse relationship we cannot know how all these factors were related (Levine 1993). If we are to make sense of events during this period, we must understand the structure of the archaeozoological data.

The study of human–horse relationships has been bedeviled by both concep-

0278-4165/99 $30.00

tual and methodological weaknesses. This paper explores some of the relevant issues from two perspectives. First, it focuses on some of the problems relevant to existing work, in particular, the confusion of domestication with intensification and the use of a single criterion to classify complex human–animal relationships. Then, ethnoarchaeological and archaeozoological methods are used to provide an alternative approach. A range of behaviors, based on archaeological, ethological, and ethnographic data, are drawn on to develop a series of models describing a range of possible strategies and tactics against which the archaeological data can be tested.

1.1. The Concept of the Earliest Date

1.1.1. Biogeographic Range

C. Grigson's paper, "The Earliest Domestic Horses in the Levant? New finds from the Fourth Millennium of the Negev" (1993), illustrates what is probably the most fundamental problem associated with the study of early horse domestication—the search for the earliest date. She might well be correct, on the basis of its large size relative to the ass (*Equus asinus*) and the onager (*Equus hemionus*), that *Equus caballus* was present in the Levant earlier than had been believed. However, her conviction that this horse must have been domesticated is apparently based solely on the assumption that the geographical range of the wild horse could not have extended into the Levant: "Although the horse (Equus caballus) was a member of the Pleistocene fauna of the Levant, it died out before the end of the period" (Grigson 1993, p. 646). In fact, recent research suggests that the natural distribution of the Holocene horse might have been much wider than had been formerly believed (Azzaroli 1985; Clason 1988; Clutton-Brock 1992; Groves 1986; Uerpmann 1990). In any case, the absence of horse remains from archaeological deposits should not be taken as proof that they were extinct. Grigson would have been on firmer ground had she entitled her paper: The Earliest Horses in the Levant? New Finds from the Fourth Millennium of the Negev.

1.1.2. The Search for the Earliest Date

This kind of problem arises partly out of the tendency of archaeologists and archaeozoologists to ask certain kinds of questions, for example, when and where was the horse (or, for that matter, cow, sheep, goat, pig, etc.) first domesticated? Which came first: the invention of the wheel or the bit (Anthony and Brown 1991)? The whole issue of earliest dates is a red herring, especially in a situation such as this, in which the number of well-excavated and absolutely dated sites is very small and the criteria used to prove domestication are not very convincing. Factors completely unrelated to ancient human behavior that will significantly influence identification of the "earliest" site include the following:

natural taphonomic factors: the destruction or preservation of sites, bones, and artifacts made from organic materials;

decisions, which may be political, financial, or strategic, about where and how carefully to excavate;

decisions about whether bones should be studied or discarded;

decisions about who will study the bones, whether their primary training is as an archaeologist, zoologist, veterinarian, etc.;

the specialist's country of origin, since educational traditions influence the analytical methods used;

criteria chosen by the specialist as evidence of domestication.

Scholars looking for earliest dates commonly use only one line of evidence (e.g., biogeography, size, morphology, bitwear) from which to draw their conclusions.

This approach, simplifying human and animal behavior, as it does, is ultimately unsatisfying.

1.1.3. Size and Homogeneity

Setting the search for the "earliest date" as a primary research goal makes it rather easy to use inadequate criteria for the determination of domestication. This is because the search for a date does not require anything to be said about the actual relationship between animals and people. For instance, a decrease in size and an increase in heterogeneity are taken as proof of domestication by many scholars. Uerpmann claims that "Grössenreduktion einerseits und Zunahme der Variabilität andererseits sind klassische Domestikationsindikatoren" (Uerpmann 1990, p. 127).[1,*] Such factors as age and sex structure are rarely taken into account. However, a size change could also result from a change in the technique of exploitation. For example, a hunting method that culled primarily stallions from family groups would take larger horses than one that focused on bachelor groups, which might well be epiphyseally mature but not yet full grown, or one that focused on females, which are smaller than equal-age males. Environmental change, geographical isolation, and genetic drift are all connected with size change. Moreover, taphonomic factors can also influence size range and variability. For example, as an animal ages, even after its epiphyses are fully fused, the bones continue to increase in density. All other things being equal, the denser the bone, the better its chances of surviving in an archaeological context. Poor preservation conditions therefore tend to result in an assemblage of relatively homogeneous and large bones. At the French Upper Palaeolithic site of Solutré, both the Aurignacian and the Magdalenian horses were smaller than those from the intervening Upper Perigordian level. No one could seriously suggest that this is evidence that the former were domesticated while the latter were wild (Levine 1979, 1983).

A decrease in size accompanied by an increase in heterogeneity might be associated with domestication, but it could have other causes. It is, on its own, insufficient as an explanation. Other corroborative evidence must be obtained. Even if too few teeth were available for a full-blown population analysis, a study that compared aging data from a series of relatively small samples would surely be just as meaningful as one comparing morphometric data from a series of small samples. The latter, but not the former, are used by Uerpmann and others (e.g., Uerpmann 1990; Benecke 1993).

1.1.4. Bitwear

Another example of this commitment to an earliest date is Anthony's argument that the domesticated horse was present in the Ukraine earlier than in Kazakhstan. His evidence for this comes from bitwear studies of two samples of lower second premolars from two Eneolithic sites, Botai in northern Kazakhstan (5 from a total of 19 teeth) and Dereivka in the Ukraine (2 from a total of 6 teeth). He implies from this that horse domestication spread from west to east (Anthony 1995).

Relatively little archaeozoological research has been carried out in the former Soviet Union, including both Kazakhstan and the Ukraine, and relatively few absolute dates are available (regarding the Ukraine, see Levine and Rassamakin 1996). Botai and Dereivka do not constitute representative samples of sites within the vast regions in question. They cannot, therefore, be used to answer questions about origins and earliest dates. Moreover, serious doubts have been raised about the stratigraphic loca-

* See Notes section at end of paper for all footnotes.

tion of the “ritual” skull from Dereivka, the basis of Anthony and Brown’s theory of the origins of early horse domestication (Rassamakin 1994). These doubts seem to be confirmed by the mean calibrated radiocarbon date recently obtained for that skull, 2915 B.C., more than 1000 years later than most of the other dates for that site (Table 1) (Telegin 1986).

TABLE 1
Dereivka Radiocarbon Dates

KI 5488: 4330 ± 120 years B.P. (“ritual” skull)
Mean calibrated date: 2915 B.C.
1 σ; range 3092–2784 B.C.
3293 (0.03) 3277   3268 (0.05) 3240   3105 (0.75) 2865
2809 (0.12) 2750   2724 (0.05) 2699

2 σ; range 3347–2610 B.C.
3339 (0.78) 2838   2828 (0.02) 2650   2650 (0.02) 2619

UCLA 1671A: 4900 ± 100 years B.P. (bone)
Mean calibrated dates: 3692, 3670 B.C.
1 σ; range 3783–3548 B.C.
3892 (0.01) 3889   3796 (0.86) 2633   3577 (0.14) 3535

2 σ; range 3946–3383 B.C.
3946 (0.13) 3832   3829 (0.84) 3503   3417 (0.03) 3383

KI 2197: 5230 ± 95 years B.P. (shell)
Mean calibrated dates: 4033, 4025, 3998, B.C.
1 σ; range 4221–3959 B.C.
4221 (0.11) 4193   4154 (0.89) 3959

2 σ; range 4320–3799 B.C.
4317 (0.02) 4292   4256 (0.89) 3902   3882 (0.09) 3802

OXA 5030: 5380 ± 90 years B.P. (bone from cemetery)
Mean calibrated date: 4237 B.C.
1 σ; range 4337–4048 B.C.
4334 (0.58) 4216   4201 (0.28) 4141   4120 (0.14) 4087

2 σ; range 4435–3985 B.C.
4362 (1.00) 3988

KI 2193: 5400 ± 100 years B.P. (shell)
mean calibrated dates: 4310, 309, 4249 B.C.
1 σ; range 4346–4086 B.C.
4345 (0.63) 4216   4201 (0.25) 4141   4120 (0.12) 4087

2 σ; range 4456–3985 B.C.
4451 (0.03) 4420   4396 (0.02) 4374   4369 (0.92) 4030   4030 (0.04) 3994

UCLA 1466a: 5515 ± 90 BP (bone)
Mean calibrated date: 4350 BC
1 sigma; Range 4457–4260 BC
4458 (.83) 4317 4291 (0.17) 4256

2 sigma; Range 4527–4155 BC
4540 (.94) 4218   4198 (0.4) 4145   4115 (.01) 4093

Source. Dates from Telegin, personal communication, and conference abstract from Telegin (1995). Calibration from Stuiver and Reimer (1993).

1.2. METHODOLOGICAL PROBLEMS

1.2.1. Conventional Approaches

The theoretical framework used until recently for interpreting the archaeozoological data was seriously flawed (for a more detailed discussion see Levine 1990, 1993). For example, the criteria used by various researchers as evidence that the horses from Dereivka were domesticated included the following: (1) the absence of old horses; (2) the presence of a large proportion of male skulls; (3) the presence of objects identified as bridle cheekpieces; (4) the results of a morphological analysis comparing the Dereivka horses with other equid material; (5) their association with other domesticates—cattle, sheep, goat, pig, and dog; (6) the relatively large percentage of horse bones and teeth in the deposit (Bökönyi 1978, 1984; Bibikova 1967, 1970, 1969; Telegin 1986). However, on the basis of archaeological, ethnographic, and ethological comparisons, the absence of old individuals is much more likely to indicate hunting than herding (Levine 1982, 1990). Males would outnumber females if either bachelor groups or stallions protecting their harems were targeted in the hunt. The cheekpieces might not have been cheekpieces at all (Dietz 1992; Levine and Rassamakin 1996). The morphological study involved very small and disparate samples and produced contradictory results. The association of horses with other assumed domesticates is not evidence of horse domestication. In any case, they were also found with the remains of wild animals (Levine 1990, 1993). The only species from Dereivka to be studied in detail was the horse. Because almost all the bones and teeth from this site have unfortunately been discarded, it is impossible for them to be reassessed. However, a preliminary examination of the faunal assemblage from the new excavations at Molukhov Bugor, another Dereivka culture site,[2] has produced some interesting, but extremely tentative results. No bones that could only have come from domesticated animals and many that must have come from wild ones, for example, birds, tortoise, beaver, deer, have been identified, while the cattle and pigs were suggestively enormous. Much more work needs to be done on this assemblage, but the initial results lend support to the far more detailed analyses already carried out on the material from Dereivka (Levine 1990, 1993). On the one hand, there is little or no evidence that the Dereivka culture people were pastoralists, while on the other hand, there is a good reason to believe that they were hunter-gatherers (Levine and Rassamakin 1996).

Horses are relatively uncommon in European Mesolithic and Neolithic archaeological deposits. It has, therefore, commonly been held to be the case that they could not have been domesticated during those periods. On the other hand, relatively large quantities of horse bones and teeth have been recovered from Eneolithic sites on the central Eurasian Steppe. Characteristics of tooth morphology, population structure, taphonomy, and taxonomic distinctions based on measurements, have been credited as evidence for horse domestication. Until recently, however, the most important criterion had been that of increased relative abundance, which could be explained as well, or even better, by increased hunting rather than by domestication (Bökönyi 1978, 1984; Bibikova 1967, 1970, 1969; Petrenko 1984; Levine 1990, 1993).

1.2.2. The Identification and Significance of Bitwear

As an analytical method, bitwear analysis should make a valuable contribution to the study of horse domestication (Anthony and Brown 1991). However, it has important limitations:

1. Tamed, as well as domesticated, horses could wear bits.
2. A horse can be ridden without a bit.
3. Anthony and Brown have themselves observed that bitwear traces will wear off if a horse is not bitted regularly over a relatively long period recently before its death.
4. The question of whether the wear pattern described by Anthony and Brown could have had other causes has not been adequately addressed. Their unbitted sample of feral horses consisted of 20 individuals from two North American populations (mustangs from the mountains of Nevada and barrier island ponies from the Atlantic Coast). They have generalized from this small sample that unbitted horses could not manifest the wear pattern they describe as unique to bitwear. On the other hand, Angela von den Driesch (personal communication) has observed that similar, if not identical, wear on the lower second premolar can result from abnormal occlusion with the upper second premolar.

As far as we know, then, beveling on the anterior part of the lower P2 masticatory surface could be caused by bitwear or abnormal occlusion. Either a domesticated horse or a wild one that had been tamed could be bitted. The absence of bitwear could indicate that a horse had not been ridden recently or regularly before its death, that it was ridden unbitted, or that it never was ridden. We must conclude from this that bitwear should not be used without corroboration as proof of domestication. This is not to say that bitwear studies should not be carried out. On the contrary, their use should be much more widespread, but in conjunction with other methods of analysis.

1.2.3. Sample Size and Innovation

Archaeologists and archaeozoologists continually lament the inadequacy of their samples. The assumption being that if only large enough datasets were available, they would be able to find the answer to any practically any question. However, this might not be the case. Considering the skills needed for managing large numbers of horses and considering the small-scale nature of taming, from which, as will be argued later, domestication is most likely to have evolved, the key to the origins of horse domestication might well lie with small samples. Archaeozoologists must face up to this and develop methodologies that can cope with this reality. To regard small samples only as a problem is to miss an opportunity.

1.3. A MULTIDIMENSIONAL APPROACH

The common thread, connecting all aspects of the project, out of which this paper has evolved is the question of the origins and evolution of horse husbandry, its social and ecological implications—whether, for example, it arose out of agricultural, pastoral, or foraging communities—how the domestication of the horse altered the balance of power in ancient communities, and its impact on forest–steppe and steppe ecosystems. In the broadest sense, my goal is to evaluate the ways in which environmental, social, and economic changes are interrelated and to try to understand the role of the horse in the equation. Such a complex problem requires a multidimensional attack with ammunition provided through the development of new analytical methods. Interdisciplinary collaboration, including, for example, biomolecular analyses, stable isotope studies, paleopathology, ethnoarchaeology, ethology, and paleoenvironment research as well as more conventional archaeological methods, is crucial to this approach. The goal of this paper is to take a step in that direction by using a combination of ethnoarchaeological, ethological, and archaeological analyses to look at the archaeological and archaeozoological data. But this is only the beginning.

2. POPULATION STRUCTURE AND MODELS OF HORSE EXPLOITATION

The particular aspect of horse husbandry to be examined here is population structure. Survivorship and mortality patterns of recent horse herds are compared with various models and with assemblages from Eneolithic and Iron Age/Roman archaeological sites. The methodology used integrates taphonomy and butchery evidence with morphometrical, paleopathological, and population structure analyses. All of these are interpreted with reference to ecological, ethological, ethnoarchaeological, and contextual data (Levine 1979, 1982, 1983, 1990).

2.1. Relationships between Horses and People

People can have a wide variety of different types of relationships with horses. Horses can be wild, feral,[3] or domesticated. Wild or feral horses can be hunted for their meat and other body parts, or tamed as pets or beasts of burden. Domesticated animals can be raised for riding, traction, meat, milk, and other products. Moreover, even within one society any combination of these relationships can coexist.

Though customarily defined as the controlled breeding of plants or animals by humans, the real distinctiveness of domestication lies in the fact that it involves ownership and thus results in a completely different level of human commitment than does hunting (Levine 1979). Horse taming also involves ownership, but it seems likely from the historical and ethnographic evidence so far available that the social and economic implications of horse taming would have been, at most, relatively superficial and localized and would have disappeared with the death of the animals involved, while the repercussions of domestication would have reverberated throughout the whole society. Our goal should not, therefore, be simply to identify horse riding, traction, milking, and meat eating in the archaeological record, but, additionally, to find evidence of horse breeding and taming, which are, as such, archaeologically invisible. However, they may be approached indirectly through investigations of population structure, archaeological context, and other characteristics of the data.

Historical and ethnographic accounts, as well as new ethnoarchaeological research, are all employed here to gain access to that variability. However, it is important to observe at the very outset of this discussion that these kinds of data sources have their own particular problems. For example:

1. Inaccuracy. Particularly in the case of interviews relating to past practices, we can expect lapses of memory to distort events that took place in the past. For example, in the case of interviews dealing with the period before collectivization,[4] my informants could not recall details of herd population structure.

2. Distortions resulting from the informant's own personal agenda. It is well known among anthropologists that informants may have their own reasons for what they say. For example, they may under- or overestimate the size of their herds, if they think that there is an economic or political advantage to do so. Moreover, many people will say what is expected of them to please or simply to have a good laugh. There is no reason why the motivations of the informant should be any less complicated than those of the interviewer.

3. Which brings us to the distortions arising from the interviewer's shortcomings. For example, phrasing a question clearly, but not leadingly, can be particularly difficult. Imperfect knowledge of the informant's native language is a serious problem. The horse husbandry and butchery vocabularies of most interpreters are not ideal. Moreover, it is impossible to ask about everything. Certain limits must be placed in respect for the time and patience of the informant. Therefore, the choice of which questions to ask is critical. They need to be unambiguous and directed specifically toward solving archaeological problems.

4. Then, assuming that we have taken into account and minimized all these difficulties, we still have to deal with problems associated with the use and misuse of ethnographic analogy, by its nature highly complicated and potentially biased, to interpret the archaeological evidence—equally complex and probably even more biased, for example, by taphonomic factors.

Archaeologists have been known to throw up their arms in despair at the difficulties encountered with ethnographic analogy and, indeed, some say that it can only lead to tears. However, to interpret archaeological data we must have some understanding of how human beings actually behave. The unsatisfactory nature of the work carried out until recently regarding horse domestication has clearly demonstrated this problem (Levine 1990, 1993). Without minimizing the difficulties involved, it is therefore necessary to learn how to use ethnographic and historical data. Consequently, the objective of this ethnoarchaeological study is not the direct interpretation of archaeological data from ethnographic and historical accounts, but rather, an exploration of the range of extant possibilities, without assuming that no others could have existed in the past.

2.1.1. Capturing and Taming Horses

According to Clutton-Brock, "A *tame* animal differs from a wild one in that it is dependent on man and will stay close to him of its own free will" (1987, p. 12). Aboriginal hunter-gatherers and horticulturists throughout the world are known to tame all kinds of wild animals to keep as pets (Serpell 1986, 1989).[5] There is no reason to think that this would not have been the case at least from the time of the earliest anatomically modern *Homo sapiens,* and when the need arose, taming could well have been the first step toward domestication (Galton 1883; Clutton-Brock 1987; Serpell 1989). Wild horses, particularly as foals, can be captured and tamed and, as such, ridden or harnessed and, at the end of their lives, if necessary, slaughtered and eaten.

2.1.1.1. Taming the Przewalski's horse. Historical records also show that the capture, taming, and eventual captive breeding of wild horses was dependent on the accumulation of knowledge about their behavior and on the development of techniques to exploit that behavior. Perhaps the earliest record of a horse captured by these means dates from 113 B.C.:

> A Chinese . . . near Tun-huang, on the northwest frontier, frequently saw a horse . . . drinking in the river along with a number of wild horses. He tamed the strange horse by putting at the water-side a dummy figure of a man in whose hands were bridle and halter. When the horse was used to this sight he substituted himself for the dummy, captured the horse. (Waley 1955, pp. 98–9)

In another example Mohr refers to the description by John Bell, an 18th-century Scottish doctor and traveler, of Przewalski's horse hunting from horseback: "these animals are often surprised by the Kalmucks; who ride in among them, well mounted on swift horses, and kill them with broad lances. Their flesh they esteem excellent food; and use their skins to sleep upon" (Mohr 1971, p. 27).

According to 19th-century records, there were two methods of capturing Przewalski's horse foals. One was to trap them in pits dug near waterholes. The other was for mounted men to chase and capture them with the *arkan* (a long pole with a noose fastened to one end). When the pursuer came close enough to his target, he would drop the noose over its head and neck (Mohr 1971). Grum-Grshimailo documents another method: "During the foaling season the Kalmucks take two horses into the desert. As soon as they have found a herd, they chase them until the exhausted foals fall over. These foals are picked up and placed in the domesticated herd" (Mohr 1971, p. 68). Przewalski's horses were also captured by driving, though it is not clear whether the beaters were on foot or horseback: "Even in 1750 it was said: 'The entire land around Lyau-tong is a wilderness; the emperor hunts there with three thousand beaters, who put up the game and drive it towards him, so that in one day 200 to 300 horses, amongst others may be caught'" (Mohr 1971, p. 27).

The early 20th-century collectors found that their greatest difficulty was not in catching the horses, but rather in keeping them alive in captivity. Attempts to feed unweaned foals on sheep and goat milk were not successful. The solution to this problem was to foster them with domesticated mares (Bouman and Bouman 1994). According to Frederick von Falz-Fein, one of the early collectors:

> In 1897 a number of young wild horses were captured, but they all died because the catch was not done as it should have been. I worked out the fullest details of the method and laid much stress on the importance of the animals not being chased before capture, but rather by shooting their mothers. As we could not get milking mares from the Mongolians living in the

> area, we had to buy them in Bijsk, and have them covered so that they foaled at the same time as the wild mares.. . . Since these rules were not obeyed—the catch was again unsuccessful and all the animals died. We told Assanoff again to stick to the rules and thereafter there were no more failures. (Mohr 1971, 95–96)

Przewalski's horse mares currently in captivity usually wean their young from the age of 1 year until just before the birth of their next foal, or even for several years if they do not give birth every year (Houpt and Boyd 1994). Berger observed of the Great Basin feral horses that 34 of 40 (85%) were weaned before the age of 1 year and 27 (79%) of those were not observed to suckle after their ninth month. "Because of winter-related stresses and because the last trimester of pregnancy demands the most nutritionally . . . mothers weaned their offspring during winters" (Berger 1986, p. 116). Foals can be weaned much earlier. However, there is a cost to pay: "Evidence for the importance of milk versus highly nutritious food for early growth rates is still sparse, but animal scientists have found that orphaned foals experience stunted development despite provisioning with high planes of nutrition" (Berger, 1986, p. 119). Berger mentions a mustang from the Granite Range (Nevada), orphaned at the age of 2 months. Despite access to good-quality grazing, even at the age of 3 years, he was only the size of a yearling. Similarly a captive Przewalski foal, orphaned at the age of $2\frac{1}{2}$ months, survived but lagged in growth behind his unorphaned paternal half-siblings until the age of 3 years despite supplemental feeding (Houpt and Boyd 1994).

Taming and riding Przewalski's horses captured from the wild was at one time considered to be practically impossible (Mohr 1971). However, Erna Mohr refers to a 6-month-old Przewalski horse that "had become so far tame that it was easily led and went quietly up the granite staircase to the second story of the castle, was led into a room and allowed the 7–8 year old son . . . to sit on his back" (Mohr 1971, p. 69). She also describes how an "untamable" wild stallion was tamed and ridden: "In Askania Nova however, he found his master and within a month he was being ridden by his south Russian groom and on the command would lie down like a Circassian horse" (Mohr 1971, p. 69).

This has important implications for theories concerning early horse taming. It seems likely that before the availability of domesticated mares to foster captured foals, there would have been both lower and upper limits to the ages at which taming would have been successful. Although very few data relevant to this question seem to be available, the lower limit might have been at around the age of 2 months. We can only speculate about a possible upper limit on the basis of comments in the literature referring to the difficulty or impossibility of taming adults (Mohr 1971). However, other factors, which would also have been critical, include the skills of the captor and the personality of the horse.

2.1.1.2. Taming North American feral horses. Some parallels between central Eurasian and North American aboriginal horse capture and taming techniques are particularly interesting because they suggest that certain aspects of the human–horse relationship are not culture-bound, but are rather mediated by both species' natural patterns of behavior in a much more fundamental way. For example, according to Ewers (1955), northern Plains peoples such as the Blackfoot and the Cree were not very skilled at taming mustangs, the North American feral horses. Most of the few adult feral horses captured by them died after they reached camp. However, some colts and yearlings were caught by "horse medicine men," specialist feral horse tamers, whose taming technique was described as follows:

> A man who possessed horse medicine for use in catching wild horses rubbed it on his hands, feet, and rope. Then he circled the wild horse up wind so that the odour of the medicine would be carried

> to the nostrils of the wild one. When the wild horse smelled the medicine it came to him. He roped it by the front feet and threw it down. Only horse medicine men were said to have had success in capturing wild horses. (Ewers 1955, p. 274)

According to Ewers, the southern and central Plains tribes were much more skilled than the northern tribes at capturing mustangs. The former had more and earlier experience of horses and they had bigger herds, which suggests that they were more familiar with horse behavior. However, all the Plains groups were in agreement that mustangs were difficult to catch. According to George Catlin:

> There is no other animal on the prairies so wild and so sagacious as the horse; and none other so difficult to come up with. So remarkably keen is their eye, that they will generally run "at the sight," when they are a mile distant; being, no doubt, able to distinguish the character of the enemy that is approaching when at that distance; and when in motion, will seldom stop short of three or four miles. (Catlin 1841, Vol. 1, p. 57).

The two main tools used for capturing feral horses were the lasso with a running loop and the lasso loop fixed to a long stick, very much like the Mongol *arkan* (Ewers 1955). In conjunction with an intimate knowledge of horse behavior and a fit, well-trained mount, these could be used successfully to capture and break mustangs (Catlin 1841; Ewers 1955; Grinnell 1923; James 1823; Wallace and Hoebel 1952). A number of methods of capturing horses have been described in the ethnographic literature:

1. Corralling: This method was used extensively by the Kiowa and occasionally by the Commanche[6] and Cheyenne. Wallace and Hoebel (1952) speculate that it could have evolved out of antelope and bison hunts, but the same technique was also used by the Spanish for hunting horses. On one occasion in 1852, 400 to 500 horses were driven into an enclosure by the Commanches (Wallace and Hoebel 1952). Grinnell gives a detailed description of a corral apparently used by the Cheyenne:

> [I]n the year 1836, members of Cheyenne war parties . . . in what is now Oklahoma, found a great corral which had been used for catching horses. This pen was situated in a park or opening in the black-jack timber . . . This pen was not circular in shape, but was oval, the opening being at one end. The fence . . . was a stockade formed of black-jack posts set on end in the ground and close together. On the outside of the fence brush and the limbs of trees were piled against the stockade. The wings of underbrush were heaped up high and wide, so that a horse could neither see through nor jump over them . . .
>
> . . . the Kiowas explained to the Cheyennes the purpose and the manner of use of the structure. Of the horses driven into this corral the best young ones were roped and dragged out to be used, while the older and otherwise less useful animals were butchered for their flesh and hides. The Kiowas used horse-hide for all purposes for which the skins of large animals are employed. (Grinnell 1923, p. 292)

2. The Chase: All other things being equal a man on horseback is no match for a free-running mustang. Therefore, the Indians developed variations on the chase theme that would enable them to capture strong, healthy animals.

a. Chasing animals in a weakened state: The ethnographic literature is not always clear about details of how horses were captured. However, the most widespread method seems to have involved running down the mustangs on horseback and dropping a noose over their head. This method was employed by the Mandan and the Osage (Catlin 1841), the Commanche (Wallace and Hoebel 1952), and the Cheyenne (Grinnell 1923). As observed by Wallace and Hoebel, all other things being equal, this method could be successful only for weak animals, for example, foals and pregnant or suckling mares, since a strong horse should be able to run faster than a horse and rider. However, things were not always equal. For example, using a well-fed riding horse gave the captor an advantage in the winter or early spring when most feral horses were in poor condition. On the other hand, a fit horse could be used to run down fat horses in summer or to chase "waterlogged" horses just leaving the waterhole (Wallace and Hoebel 1952; Grinnell 1923).

b. Chasing in relays: This method was expensive in terms of energy consumption, but would have resulted in the capture of the very best animals, including stallions. It was used by the Osage (James 1823) and the Commanche (Wallace and Hoebel 1952).

> In capturing the hard-to-take stallions . . . the best way was to stalk them with a team of co-operating hunters. Each herd tended to move about within a limited range of territory; when flushed, it was likely to travel in a circle, returning eventually to or near the spot where it was originally found. To accomplish this end, one or more horsemen kept the herd continuously on the move without allowing it either to eat or to drink . . . the stalkers, by remaining on the inside of the circle, travelled a much shorter distance than the herd. When their own mounts wearied, the riders were replaced by others or were supplied with fresh mounts. This procedure was continued without let-up for two or three days or until the herd became exhausted, when a number of riders on fresh mounts rode in and lassoed their pick of the wild horses." (Wallace and Hoebel 1952, p. 44)

c. The surround: On the open plains, mustangs would be surrounded by a group of riders. When a horse would try to break away, a noose was dropped over its head (Wallace and Hoebel 1952).

d. Chasing on foot: According to Catlin, the Cheyenne, who captured more mustangs than any other tribe, frequently used this method. A horseman would start out by "plunging" into a band of wild horses, forcing one animal out of the group, whereupon he would dismount from his own animal and set out on foot after the panicked individual. This is another method that exploits the horse's tendency to circle to the left when being followed:

> The Indian seeing the direction in which the horse is "leaning," knows just about the point where the animal will stop, and steers in a straight line to it, where they arrive nearly at the same instant, the horse having run a mile, while his pursuer has gone but half or three-quarters of the distance. (Catlin 1875, p. 113).

He would thus keep it on the move until it was so exhausted that he could throw a lasso over its head.

3. Capturing with decoys: Both the Cheyenne and the Commanches targeted bachelor groups by sending out a few old, gentle mares as decoys (Wallace and Hoebel 1952; Grinnell, 1923). According to Grinnell, "after a time the herd could be approached, driven together, and perhaps many of the young horses caught" (Grinnell 1923, p. 295).

2.1.1.3. Taming captured mustangs. Some of the ethnographic reports are rather self-contradictory in that they suggest, on the one hand, that taming feral horses was very difficult while, on the other hand, they describe the process as if it were very simple. For example, regarding the aboriginal inhabitants of the Great Plains, Catlin states that "Scarcely a man in these regions is to be found, who is not the owner of one or more of these horses; and in many instances of eight, ten or even twenty, which he values as his own personal property" (Catlin 1841a, p. 142). Moreover, with regard to the acquisition of a mustang by a Frenchman, raised in an Osage village, he remarks: "the whole thing, the capture, and breaking, all having been accomplished within the space of one hour, our usual and daily halt at midday" (Catlin 1841b, p. 60). This paradox is partly explained by the diverse origins of the sources referred to here, but perhaps also by the talent that experts have to make the most difficult activities appear simple. In other words, it is possible that the European observers overstated their understanding of the events taking place around them. This ignorance is well illustrated by Catlin's account of his own misbegotten attempt to capture a feral horse:

> [W]e would try the experiment of "creasing" one . . . which is done by shooting them through the gristle on the top of the neck, which stuns them so that they fall, and are secured with hobbles on the feet; after which they rise again without fatal injury. This is a practice often resorted to by expert hunters. . . . My friend Joe and I . . . having both levelled our pieces at the withers of a noble, fine-looking iron grey, we pulled trigger, and the poor creature fell. . . .We advanced speedily to him, and had the most inexpressible mortification . . . to find that one of our shots had broken the poor creature's neck, and that he was quite dead. (Catlin 1841b, p. 58)

Despite its shortcomings, it is useful to consider some of the documentation referring to the process of breaking and taming feral horses. According to Catlin, the affect of the lasso on the horse was to constrict its air passage until it fell over, whereupon its captor hobbled its forefeet together, fitted a halter with a noose that tied under its jaw, and loosened the lasso so that it could breathe. Then,

> by a great many useless struggles to rise, the horse remaining yet in its sitting posture, and the Indian approaching nearer and nearer (inch by inch) to its nose, on the shortened halter, and yelling as loud as he can, the animal's fear is increased to the highest degree. The Indian still advances nearer on the tightened halter, and at length begins patting the horse on the nose, and gradually slipping his hand over its eyes, begins breathing in its nostrils, their noses being together.
>
> After a few breaths exchanged in this manner, the relaxation of the horse's muscles and its other motions, show that its fears are at an end—that it recognises a friend instead of a foe, in its captor; and this compromise being effected, the Indian is seen stroking down its mane, and otherwise caressing it; and in fifteen or twenty minutes he is seen riding it quietly off!
>
> . . . the excess of fatigue, of fright, and actual pain, followed by soothing and kindness, seems to disarm the spirited animal, and to attach it at once, in a mysterious way, to its new master. (Catlin 1875, p. 109–110)

Interestingly this method employs the same kind of psychological approach as that recently developed by Monty Robert in which the safe space or "comfort zone," occupied by the gentle but dominant trainer, is opposed to the dangerous space away from him, in which the horse feels threatened and isolated (Bayley and Maxwell 1996). This training method takes advantage both of the horse's instinctive flight response and of its natural sociability.

One Commanche and Cheyenne method of taming involved tying the choked captive to the tail of a gentle mare (Wallace and Hoebel 1952; Grinnell 1923):

> Three or four days later . . . it was set free, and thereafter followed her about wherever she went. The mare was then used to tame another horse, and if the party was out for a long time some mares might have eight or ten captured horses following them about. These wild horses were readily broken to the saddle. While they were "tailed" to the mare, the owner would occasionally go up to the mare, pat her for a little while, and then pass on to the young horse, handling it and gentling it. In this way it became accustomed to the sight and smell of man, and no longer feared him. Sometimes after the horse had become somewhat gentle, a young man would spring on its back and at once jump off again. The wild horse soon learned that it was not to be hurt. The man who mounted would presently sit on the horse for a little while, and then the old mare might be led about by someone while the young man was sitting on the wild horse's back. Thus the work of breaking it to ride was not long. (Grinnell 1923, pp. 294–295)

Unfortunately, no survival rates are available for any of these methods. But some were, apparently, brutal enough to explain the difficulty some groups experienced in keeping captives alive. Other relevant factors could well have been the age, sex, constitution, and personality of the horse as well as the skill of the captor.

2.1.2. Modelling Horse Use

During historical times both the North American Plains tribes and the Mongols used the *arkan*, lasso, or herd drive to capture wild or feral horses to eat or to tame. Horses taming was regarded as a skill most successfully carried out by specialists, whose most important tool was their intimate knowledge of horse behavior. On this basis I would like to propose a possible scenario for the development of horse husbandry.

As a working hypothesis, I would like to suggest that horse taming probably first arose as a by-product of horse hunting for meat. Orphaned foals, captured between the ages of perhaps 2 months and 1 year, or possibly somewhat later, would sometimes have been adopted and raised as pets. Eventually, and perhaps repeatedly, the discovery was made that these pets could be put to work. This knowledge could have been acquired and lost many times from the Pleistocene onward. But it was, apparently, only during the Holocene—possibly between the Neolithic and the Early Bronze Age—that it began to influence human social developments.

Initially the difficulties involved in keeping captured wild horses alive would have set limits to their impact as work animals on human society. Furthermore, considering the problems encountered by modern collectors trying to breed Przewalski's horses, it seems likely that horsekeeping would have had to have been relatively advanced before controlled breeding, and thus domestication, would have been possible: "Failure to consider the typical social organization of the species can result in problems such as pacing, excessive rates of aggression, impotence and infanticide" (Boyd and Houpt 1994, p. 222). To breed wild horses successfully in captivity, their environmental, nutritional, and social requirements must be met:

> In zoos, juvenile male Przewalski's horses should be left in their natal bands for at least a year so that they can observe mating behaviour. They should be placed in bachelor herds when removed from the natural band, and not given harems until they are at least four or five years of age. The first mares placed with the stallion should be younger than he and the harem size should be kept small until the stallion gains age and experience. (Boyd and Houpt 1994, p. 226)

That capturing wild horses and stealing tamed or domesticated ones were regarded by the Plains tribes as preferable to breeding them supports the scenario proposed here. If it is correct, it seems likely that there would have been a relatively long period when new horses would have been recruited from wild populations. This could have been carried out by trapping, driving, and chasing, as documented for the Mongols and North American Plains tribes.

This leads me to hypothesize that horse domestication could have taken a relatively long time to develop and might well have depended on the taming of individuals predisposed to breed in captivity. Horse domestication would thus, in a sense, have been initiated by the horses themselves. Also significant is the possibility that human understanding of horse behavior had developed to such a degree that horses finally could breed in captivity. Perhaps the most likely scenario is that the human and equine parts of the equation would have evolved together. The development of horse breeding would, of course, have had particular significance outside the natural range of the wild horse.

2.2. An Ethnoarchaeological Investigation of Equine Pastoralism

Scholars from Russia and other parts of Eastern Europe have carried out immensely valuable ethnographic research on central Eurasian equine pastoralism. However, this work does not usually directly address the questions of particular relevance to the study of the origins of horse domestication. The project to be discussed below has been designed specifically to deal with issues connected with that problem. It presents some results from an ongoing ethnoarchaeological

TABLE 2
Informant's Background Information

Informant	Location	Ecosystem	Husbandry type	Economic system
Damdin	E. Mongolia	Steppe	Traditional	Nomadic
Jambalsuren	C. Mongolia	Mountains	Traditional	Settled
Mursabaev	N. Kazakhstan	Forest–steppe	Modern	Ranching
Shavardak	N. Kazakhstan	Forest–steppe	Modern	Settled
Kozakhmetov	N. Kazakhstan	Forest–steppe	Traditional	Semi-nomadic

study of equine pastoralism on the Eurasian steppe. The data have arisen principally in the course of five interviews, conducted between 1989 and 1992, with people involved with horse husbandry in Mongolia and northern Kazakhstan in the recent past or present.

2.2.1. *The Interviews*

Although the interviews covered all aspects of horse husbandry—from those related to riding and traction to those connected with milk, meat, and hide production—this paper concentrates on those associated with population structure. It attempts to demonstrate how certain archaeozoologically visible characteristics of horse husbandry, such as age and sex structure, fit into the overall picture of pastoral life. It also gives some indication of the variability of possible behaviors related to equine pastoralism. Although the data collected are not generally appropriate for direct translation into life tables, they can be used for the development of models and in general comparisons.

The word *traditional* is used here primarily to describe precollectivization methods of horse husbandry. Collectivization took place—or perhaps more significantly, took hold—in different places at different times. In northern Kazakhstan it is dated to the 1930s, but it was not imposed on Mongolia until 1955. Since my informants' accounts are entirely dependent on their memories, the earliest period discussed here will be that of their childhood or as far back as their parents' reminiscences. Thus, *traditional,* as defined here, extends from the end of the 19th century to the 1930s in the case of Kazakhstan and to the 1950s in the case of Mongolia.

2.2.1.1. Background information (Table 2). The first two interviews were carried out in Cambridge in 1989 and 1990. The informants, Damdin and Jambalsuren, were visiting scholars at the Mongolian and Inner Asian Studies Unit (Cambridge).

Damdin, a senior lecturer in the Department of Foreign Languages (Ulan Bator University, Mongolia), grew up on the steppe in the extreme eastern part of Mongolia, in the Jargalant district of the Dornod province during the late 1930s and 1940s. He was from a family of pastoral nomads belonging to the Khalkha clan. Since collectivization did not take place in Dornod until 1955, the way of life he describes was still rather traditional. Important characteristics of this lifestyle include the absence of permanent dwellings (they lived in felt tents, known as yurts), and year-round migrations, seasonal in character, in search of grazing for their herds of horses, sheep, goats, cattle, and camels.

Jambalsuren (Academy of Sciences, Institute of Language, Ulan Bator, Mongolia) grew up in the mountainous region of central Mongolia during the 1950s. His father was a carpenter and his family was settled. Until the age of 16 years Jambalsuren was a yak herder. Because his father was a craftsman and because of the mountainous terrain, his family did not have many horses. He, therefore, had only a limited knowledge of horse husbandry.

The next three interviews took place in 1992 in the forest–steppe zone of northern Kazakhstan, where the informants live.

Dastan Chalievich Murzabaev, president of the trade union at the Kirov sovkhoz in the Dzhambul region of North Kazakhstan, discussed contemporary horse ranching at the state farm where he worked.

Yurii Ivanovich Shavardak works for the Burlukskii sovkhoz (Volodarovskii district, North Kazakhstan). He herds all the horses from Nikolskoe, a village near the archaeological site of Botai. Most of the horses are owned privately by the Kazakh inhabitants of the village, but some belong to the sovkhoz. Shavardak grew up in Nikolskoe and, although he is Russian, he was trained to herd and butcher horses using a mixture of modern, that is, post-collectivization, and traditional Kazakh methods. Collectivization took place in this region during the 1930s.

Mamet Kozhakhmetovich Kozhakhmetov, born in 1915, is a former herdsmen, then schoolteacher, and finally, at the time of the interview, a pensioner. He was born and brought up at Botai aul[7] (Karatalskii sovkhoz, Volodarovskii district, North Kazakhstan). With the help of Eslyambey Zakir'yanovich Zakir'yanov, his relative and headmaster of the school in Nikolskoe, he described horse husbandry as it was in his childhood, before collectivization. The people from Botai aul are permanently settled now, but before collectivization they were seminomadic. They spent the cold months of the year in the permanent dwellings of the aul. In the summer, however, they moved onto the steppe. Each household had traditional rights to a particular territory and to a plot of land where they could set their yurt each year.

A relatively wide variety of ecosystems (steppe and forest–steppe) and husbandry strategies (nomadic, semi-nomadic, and settled) are represented in these interviews. The diversity of the data gives some idea of the range of possible strategies available to horse herders in the steppe and forest–steppe regions of central Eurasia. It is hypothesized that similarities and differences arising from that diversity might have some value in elucidating some of the fundamental elements of equine pastoralism. Of course, care must be taken in generalizing from such a small sample. Moreover, throughout the millennia waves of change have repeatedly swept across Eurasia, drawing people together and tearing them apart, reminding us that history is no bit player in this story.

TABLE 3
Number of Horses per Household

Informant	Minimum	Average	Maximum
Damdin	10	20–30+	100s–1000s
Jambalsuren	1/person	40	3000
Mursabaev	1	—	—
Shavardak	1	—	10
Kozhakhmetov	4–10	40	300

2.2.1.2. Number of horses per household (Table 3). Generalizations about the quantity of horses in settled households are not very useful, but it is quite interesting to compare figures obtained from Damdin and Kozhakhmetov concerning the period before collectivization. Taking care not to read too much into a sample of 2, it does seem that concepts relating to herd size were very similar for both the nomadic Mongols and semi-nomadic Kazakhs interviewed. To carry out seasonal migrations at least 10 horses were necessary. An average household had about 20 to 40 and a rich household might have kept hundreds or even thousands of horses. These figures are in line with those given by Khazanov (1984), Toktabaev (1992), and Krader (1955). Shavard-

TABLE 4
Herd Population Structure

Informant	Reproductive unit	Gelding structure	Herd sex composition			
			Stallions	Mares	Foals	Geldings
Damdin	Family group	With family group	1	15–20	15–20	15–20
Jambalsuren	Family group	Near family group	1	15	15	10
			(0)[a]	(1)	(0)	(4)
Mursabaev	Stallions + mares	In separate group	1	25	?	?
Shavardak	Family group	In separate group	1	45	45	15
Kozhakhmetov	Family group	In separate group	1	15–20	20	?

[a] Figures in parentheses refer to his own family's horses.

ak's herd comprises about 100 horses, around 15 of which belong to the state farm, while the rest are privately owned. Nearly all the Kazakh households in Nikolskoe have at least one horse, while some have as many as 10.

2.2.1.3. Population structure (Table 4). The natural reproductive unit of the horse is the family group, composed of a stallion, his mares, and their young up to the age of about 2 to 4 years. It may comprise up to 21 mares, although the average is usually much less, perhaps around 2 to 4 and usually no more than 5 or 6 (Berger 1986; Klingel 1969, 1974; Bouman and Bouman 1994, Houpt and Boyd 1994). The stallion normally starts his own family group at the age of 5 or 6 years, although he might not be successful at holding one against attacks from other males until the age of 7 (Klingel 1969; Berger 1986; Monfort et al. 1994; Houpt and Boyd 1994). The second natural type of horse social unit is the bachelor group, made up entirely of males from the age of 2 years until their departure from the group to form their own bands and, less commonly, of older males who have lost theirs to stronger stallions. The bachelor group may comprise up to 15 individuals, but the average is much lower, about 2 to 4 (Klingel 1969; Berger 1986).

The structure of the wild herd is relevant here because all the horse husbandry patterns, described by my informants, exploit to some extent the natural tendency of horses to structure themselves into family groups. That is, the pastoralist reproductive unit mimics the natural family group, composed of a stallion, his mares, and their young. However, the structure of the pastoralist herd is, in all cases, distorted by the artificially large number of mares assigned to each stallion. This is most extreme for the nontraditional herders. The ratio of 1 stallion to 15 to 20 mares is remarkably constant in the traditional context. This is particularly interesting in the light of an observation by Houpt and Boyd that "Przewalski's stallions with harems of thirteen to eighteen females have become overly aggressive toward their mares or apathetic about breeding" (Boyd and Houpt 1994, p. 226). That the domestic mare:stallion ratio is only a little greater than the Przewalski ratio, attests both to the consistency of horse behavior and to the herders' knowledge. Geldings are the domestic equivalent of equine bachelors. All males surplus to breeding requirements are castrated.

In the Mongolian cases all age and sex classes graze more or less together. In Damdin's pastoral nomadic example, the geldings graze in their natal family groups. According to Jambalsuren, geldings graze together near the family group but apart from it. The Kazakh herd structure seems generally to be more complicated. According to Murzabaev's ranching

TABLE 5
Shavardak's Herd: Population Structure

Age (years)	Frequency	Sex
0–1	40	Male:female ratio approx 1:1
1–2	30	Male:female ratio approx 1:1
2–3	2–3	Females only
3–5	8–10	Females only, have had first birth
5–10	10	Females only
10–15	10	Females only
15–20	8	Females only
>20	10	Females only
30	1	Stallion
	120.5	Excludes geldings

example, all foals are taken from their mothers at the age of about 6 or 7 months, when they are weaned. They are then kept in a separate herd, composed entirely of young horses. The family group described by Shavardak is composed of the stallion, mares, young of the year, yearlings, and a few 2- to 3-year-olds (Table 5). In Kozhakhmetov's semi-nomadic herd, foals under 1 year and yearlings were left with their mothers in the family group. All the 2- to 3-year-olds from the aul grazed together in a separate herd. The geldings would graze with the 2- to 3-year-olds unless there were too many, in which case they constituted a herd of their own.

2.2.1.4. Reproduction (Table 6). The fecundity of the horse is, at its most basic level, controlled by its biology and its ethology, so that divergence from the natural situation is of considerable interest. Horses are generally most productive between the ages of 4 and 15 years.

Przewalski's mares are capable of conceiving by 2 years of age; however, most do not breed until their fourth year. They usually remain fertile until around the age of 20 years, though one is known to have given birth at 24 years (Montfort et al. 1994). Granite Range feral mares have been known to bear their first young at the age of 2 years, which means that some became pregnant as yearlings. They can continue to produce foals at least until the age of 22 years; however, the period of greatest productivity is between the ages of 5 and 17 years:

> About 37% of the two-year-olds and 40% of the three-year-olds produced foals, while females four years and older were more successful at producing foals . . . for the most part, females between five to seventeen years of age enjoyed the greatest success in foal production . . . At least 83% of (p.79) females within this age cohort gave birth to four foals over a five year period. (Berger 1986, p. 80–81)

When he looked at some other mustang populations, Berger discovered that 2-year-olds did not produce young. The 3-year-olds did, but percentages ranged from 11 to 25%. Five-year-olds were found to be more fecund than 4-year-olds in all populations. The rates for each cohort were

TABLE 6
Reproduction

	Age begin breeding (years)		Age cease breeding (years)		
Informant	Stallions	Mares	Stallions	Mares	Foals/year/mare
Damdin	4–5	4–5	Old	14–16	Almost 1
Jambalsuren	4 (?)	4	10–15 (?)	10+ (?)	Around 1 (?)
Mursbaev	2	2	15	15	1
Shavardak	4	2–**3**[a]	30	**30**–35	Almost 1
Kozhakhmetov	4	3–4	20	**20**–30	1

[a] The most frequent age is in boldface.

TABLE 7
Riding

Informant	Which ridden? Geldings	Stallions	Mares	Age broken for riding (years)
Damdin	Y[a]	y	y	1 (2[b])–3
Jambalsuren	Y	?	y	1–3
Mursabaev	y	?	y	2
Shavardak	Y	n	n	3
Kozhakhmetov	Y (3–5[c])	n	y	2

[a] Y, most frequently ridden; y, ridden not as frequently as Y; n, not usually ridden.
[b] Age most usually broken.
[c] Number of riding horses/household.

lower than those in the Granite population, which is growing. Berger also observed that foaling rates for North American feral horses were generally higher than those of South African thoroughbreds (Berger 1986).

Wild and feral stallions usually start breeding later than mares, at around 5 years of age, but can continue longer. The oldest known successfully breeding Przewalski stallion was 36 years old. Experience with breeding captive Przewalski males suggests that "immature males (up to four years of age) may be incapable of breeding because they either are subordinate to older stallions/mares or exhibit incompetent sexual behaviour" (Montfort et al. 1994, p. 188). Apparently none of the Granite Range males under 5 years of age succeeded in producing young. Of those 5 years old or less, 71% (5 of 7) lost their first mares, while none 6 years or older did. The stallions that fathered the greatest numbers of offspring were 7 to 10 years old and the next most productive were 11 to 13 years old. The oldest stallion that succeeding in siring offspring was about 22 years of age (Berger 1986).

Domesticated Mongol and Kazakh stallions begin breeding earlier than the wild and feral ones. Moreover, while all the domesticated females begin to breed at around the same age as free-living ones, the Mongol mares start later than those of the Kazakhs. According to Berger, the causes of this kind of variability are unknown (Berger 1986). However, such factors as the availability of high-quality forage and favorable environmental conditions are probably important.

The age at which stallions cease breeding is similar in all the populations discussed here. For mares, however, it is much more variable. Kazakh mares may continue producing young until the age of 20 to 35 years. However, according to Damdin, after the age of 15 or 16 years, Mongol mares are no longer able to produce strong enough foals. They are therefore slaughtered at that age. Since most of the foals from the Kazakh populations discussed here are raised for meat rather than to ride, their quality is not as important as their quantity. It might also be significant that environmental conditions in northern Kazakhstan are generally less harsh than those in eastern Mongolia.

2.2.1.5. Riding (Table 7). Generalizing from the five interviews discussed here, it is clear that, although stallions and mares as well as geldings are ridden, the latter are most important for this purpose. Horses are usually broken at around 2–3 years of age, but are not ridden hard until they are approximately 3–4 years old. The particular arrangements described by each of the informants relate to the ways in which horse husbandry fits into their local environments and economies.

The nomadic pastoralists described by Damdin ride mainly geldings; however, mares and stallions are also broken and trained. It is the attitude of these people that all the horses in a herd must be ridden; otherwise they might as well be wild. It is only a bad herdsman who does not use all his animals. This is, no doubt, a response to the harshness of the eastern Mongolian steppe environment. Important as they are for meat and other purposes, survival depends on having enough mounts. Breaking horses here is a relatively gradual process. At the age of 1 the foal is trained to wear a halter and is broken to the saddle when it is 2 to 3 years of age. This job is carried out by boys from 10 to 16 years of age. Initially the young horses are ridden only near the yurt by children.

Settled Mongols like Jambalsuren apparently rode both male and female horses, though geldings again were most important. Jambalsuran's family did not breed horses and kept them mainly for riding. Their three mounts, one for each member of the family, were purchased from friends and neighbors.

According to Shavardak, the riding horses in Nikolskoe are almost exclusively geldings. Mares are used almost entirely for breeding, milk, and meat production, while the stallion was used only for breeding. Likewise in Kozhakhmetov's seminomadic pastoralist example, the individuals selected for riding or traction were most usually geldings. It was not considered necessary to break all horses for riding. Three to five mounts would usually be enough for a household. Mares could be broken as work animals, but it was regarded as better to save them for breeding. The difference between these Kazakhs and the Mongols, described by Damdin, is probably at least partly referable to the shorter distances traveled and less extreme climatic conditions in northern Kazakhstan by comparison with eastern Mongolia.

TABLE 8
Milk, Meat, and Fat

Informant	Milk	Meat	Fat valued?
Damdin	No	Yes	Highly
Jambalsuren	Yes	Rarely	Highly
Mursabaev	Yes	Yes	As bovidae
Shavardak	Yes	Yes	Highly
Kozhakhmetov	Yes	Yes	Highly

2.2.1.6. Milk, meat, fat, and other products (Table 8). In both northern Kazakhstan and Mongolia horses are slaughtered from late November to late December or January, while their fat content is still high. Because of the long and intensely cold winters in this region, meat can be stored outdoors without refrigeration. Except for special occasions like weddings and funerals, horses are almost never slaughtered during the rest of the year. According to Damdin, unlike beef, horsemeat cannot be dried, so that in his region it is always eaten fresh. However, in northern Kazakhstan the usual practice is to smoke any fresh meat left over at the end of the winter.

Horse milk, meat, and fat are valuable and highly valued resources for the Turkic (including Kazakh) and Mongolian inhabitants of the Asiatic steppe (Levine 1998a). Medicinal as well as nutritional properties are attributed to them. These traditional beliefs are, in fact, supported by scientific research. Horse flesh is an important source of vitamins, minerals, essential amino acids, and essential fatty acids (Gunga 1976; Rossier and Berger 1988). By comparison with that of ruminants such as cattle and sheep, equid flesh is high in protein and low in fat (particularly saturated and mono-unsaturated fat) (Gade 1976). Table 9 shows that horse meat and milk are proportionately much richer in essential fatty acids (particularly linoleic and α-linolenic

TABLE 9
Fatty Acid Composition of Some Animals

	Depot fat (% by weight)							Milk (% by weight)			
Fatty acid	Cow	Sheep	Horse	Human	Pig	Chicken	Whale	Cow	Horse	Human	Whale
Saturated											
C_{14} and below	3	3	5	6	1	1	9	25	22	15	8
Palmitic (C_{16})	29	25	26	25	30	25	15	25	16	23	17
Stearic (C_{18})	21	28	5	6	16	4	4	9	3	7	2
C_{20} and above	1	0	Trace	1	0	0	1	1	0	1	0
Mono-unsaturated											
Palmitoleic (C_{16}:1)	3	1	7	7	3	7	14	4	7	5	6
Oleic (C_{18}:1)	41[a]	37[a]	34	45	41	43	33	30[a]	19	36	18 (?)
Polyunsaturated:											
Linoleic (C_{18}:2)	2[a]	5[a]	5	8	7	18	0	4[a]	8	8	?
Linolenic (C_{18}:3)	0	0	16	0	0	0	4	0	16	0	9 (?)
Arachidonic (C_{20}:4)	Trace	1	2	2	2	1	12	Trace	5	3	26 (?)
C_{22} and above	Trace	1	2	2	2	1	8	Trace	5	3	13

[a] Mainly *trans*-isomers in linoleic acid and partly in oleic acid.
Source. Reprinted, with permission, from Sinclair (1964).

acid) than ruminant meat and milk (Sinclair 1964; Williams and Crawford 1987; Rossier and Berger 1988). Even the meat of old horses is relatively tender and, by comparison with ruminant flesh, highly digestible (Gade 1976; Rossier and Berger 1988). This difference is also reflected in the behavior of the Hadza, hunter-gatherers from Tanzania (James Woodburn, personal communication). According to Woodburn, traditionally the Hadza hunted a wide variety of herbivores of which the most important numerically were impala and zebra. Zebra was preferred, because of the nature and abundance of its fat. The Hadza, like many other traditional hunters, value fat more highly than protein (Speth 1983). They classify fat as either hard (high in saturated fat, as in the case of bovids) or soft (high in polyunsaturated fat, as in the case of equids). Because of the importance of soft fat as a weaning food, an adult male zebra is an ideal Hadza prey.

Horse flesh is regarded by both Kazakhs and Mongols as especially important in winter or when they must travel. According to Damdin, a person who eats horse flesh for breakfast can work throughout the whole day. Animal fat is considered by steppe pastoralists to be very good for human health and, of all the domesticates, that of the horse is regarded as best. Horse fat is eaten on its own or with meat, boiled or in sausages. In Kazakhstan it is thought to be good for treating tuberculosis and is of particular importance as a weaning food for babies. According to Bulat Kanafin, a Kazakh from Petropavlovsk, babies were traditionally weaned on pasta mixed with fat from one of three sources: (1) fat from the hump of a camel is used in the south, (2) ram's tail fat boiled in milk is used everywhere, (3) fat from over the horse's sternum or cervical vertebrae is also used everywhere.

Of the three, camel fat and horse fat are considered by both children and adults to be the best by far because of their superior taste and digestibility. The horse fat overlying the cervical vertebrae is regarded by all my Kazakh informants as a great delicacy to be given to honored guests. According to Damdin, in eastern Mongolia the fat skimmed off boiled horse meat can be added to the fodder of exhausted livestock or fed to dogs. It is also used as a

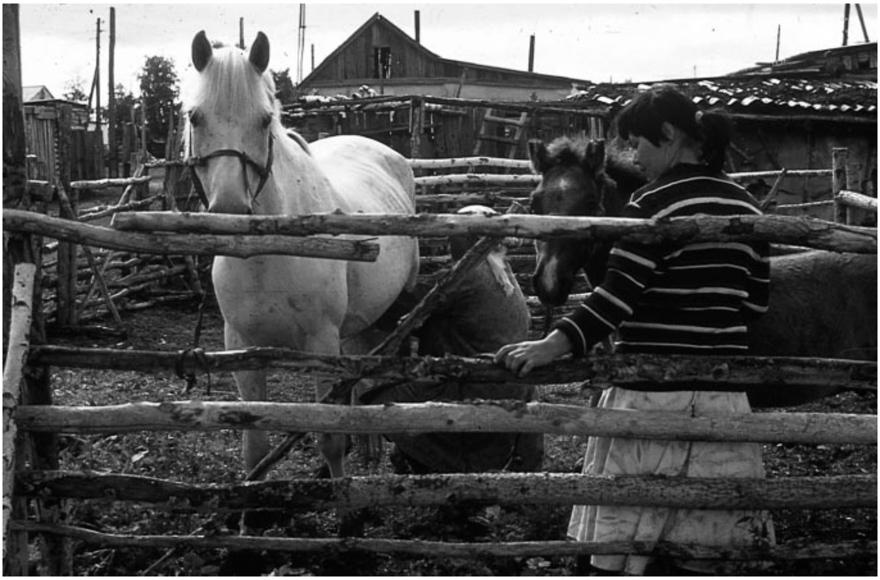

FIG. 1. Milking at Botai aul. The foal must be present for the mare to let down her milk.

face ointment to protect against the cold and wind.

Of all the people discussed here, only Jambalsuren's settled yak breeders do not value horse flesh as food. Sheep and yak are their preferred meat animals. Moreover, their whole approach to horse meat consumption is at variance with that of all the other groups discussed here. Horse meat in this non-horsebreeding region is relatively cheap. Therefore, it is eaten mainly by poor families. Moreover, while in the other regions, the ratio of males to females slaughtered for meat is either equal or favoring males, in this mountainous region it is primarily females that are slaughtered. Geldings are not eaten at all. Jambalsuran said that he himself would not eat horse meat, that the smell was terrible, and that people in this region preferred not to eat horse meat out of respect for horses. Those who did eat it, to avoid its bad smell, did so in winter when the weather was cold. This prejudice against horse meat consumption seems most likely to be referable to the need in this non-horsebreeding region to keep horses as much as possible for riding and, where this is not possible, to slaughter animals least used for riding, that is, females.

Horse milk production apparently takes place everywhere on the steppe wherever ecological conditions are favorable (Fig. 1). (Dakhshleiger 1980). Of all my informants only Damdin came from a place where very little milk was produced. He said that the milk from his region is of very poor quality: it does not ferment well, perhaps because of the climate or grazing conditions. Unfortunately he could not elaborate further on the ecological conditions necessary for horse milk production. According to Krystyna Chabros (personal communication) horse milk production is particularly important in central Mongolia. Horses are sometimes milked in the west, but not in the semi-desert regions, where there are relatively few horses. Fermented horse milk, *kumys*, "plays an extremely important role in Kazakh everyday life. It is to Kazakhs what bread is to Russian peasants. It is not only a palatable drink, but also sometimes their only food" (Toktabaev 1992, p. 11). According to a Kazakh proverb, "Kumys cures 40 dis-

TABLE 10
Usual Cause of Death

Informant	Stallions/ consecrated geldings	Mares	Geldings/male foals	Season of slaughter
Damdin	Natural causes	Slaughter	Slaughter	Late autumn to winter
Jambalsuren	Natural causes	**Natural causes**[a]/ slaughter	Natural causes	Late November to December
Mursabaev	Slaughter	Slaughter	Slaughter	Especially December
Shavardak	Slaughter	Slaughter	Slaughter	Late autumn to early winter
Kozhakhmetov	Slaughter	Slaughter	Slaughter	November to December

[a] The most probable cause is in boldface.

eases" (Toktabaev 1992, p. 12). In fact, mare's milk is much higher than that of cow in linoleic, α-linolenic, and arachidonic acid (Table 9). For this reason donkey milk, which has a similar composition, has been used in France in preference to cow's milk for feeding preterm human babies (Michael A. Crawford, personal communication).

The horse is used extensively in Kazakh folk medicine (Toktabaev 1992). Horse fat, excrement, bone, hair, liver, kidney, and stomach are used in the treatment of many ailments. Horse sweat is said to cure gastric diseases, ulcers, typhoid fever, plague, fever, and cancer of the gullet. Back problems were treated by wrapping the sufferer in a fresh horse skin.

Horse milk, fat, and meat are important foods in central Eurasia (Levine 1998a). However, they are not consumed everywhere within that region. Some curbs are clearly ecological; in Damdin's region milk cannot be produced for human consumption. Others are apparently cultural; in Jambulsuren's region horse meat is regarded as disgusting. However, this reaction might have an ecological origin. In the mountains, horses cannot be bred in large numbers; their most important use is for transport. The British taboo against eating horse meat probably combines religious, cultural, historical, and ultimately ecological factors (Gade 1976). Although this subject is of great relevance to our understanding of the dynamics of human adaptations, it has, with the notable exception of Gade (1976), as yet received little attention.

2.2.1.7. Mortality (Tables 10 and 11). According to my informants, horses not used

TABLE 11
Age at Death

	Age at death (years)[a]			
Informant	Stallions/consecrated geldings	Mares	Geldings/male foals	Maximum age
Damdin	16+	14–16	15–16 or more	27+
Jambalsuren	30+	4/**30**+	30+	33
Mursabaev	15–20 ?	1–1.5/15–20 ?	**1–1.5**/**15–20** ?	30
Shavardak	25–30	2–5/25–30	**2–5**/25–30	35–40
Kozhakhmetov	20+	1–3/20+	**1–3**/**25**+	30

[a] Age/sex classes preferred for slaughter are in boldface.

for meat are allowed to die of old age, but on the steppe this is clearly exceptional. There are two main periods of slaughter, relevant in varying degrees to both Kazakhstan and Mongolia. The first extends from the ages of around 2 to 4 years and is usually biased toward males. The second period usually takes place between the ages of 14 and 20 years and is biased toward females.

In the pastoral nomadic context described by Damdin, geldings consecrated to the spirits and all stallions die of natural causes. Other horses are slaughtered only when they are no longer productive, usually after the age of 14 to 16 years. Because the main use of mares is for producing young and (in some regions) milk, after they have been barren for 2 or 3 years running, they are slaughtered. Geldings are usually killed later than mares since they are productive longer. In the modern situation 2- to 3-year-old horses might be slaughtered because their meat is more tender than that of older animals, but that is not usually the case traditionally. In Jambulsuren's region horses are usually allowed to die of natural causes, which might be after the age of 30 years. In that context, only females, around 4 years of age, are slaughtered for meat.

All my Kazakh informants described two culling periods for horses. The first includes young animals between the ages of 1 and 4 years, surplus to breeding and work requirements, and is biased toward males. The second comprises individuals that are no longer productive, between the ages of 15 and 30 years, and is biased toward females. The relative longevity of Kazakh horses by comparison with both free-living horses and Mongol ponies might be at least partly explained by the fact that the horses in a Kazakh breeding herd are not normally exposed to the stresses of being ridden or used for traction. The less extreme environmental conditions of northern Kazakhstan, from the point of view of both human and beast, might also be a relevant factor.

According to Murzabaev, in the modern context horses are butchered either at 1 to $1\frac{1}{2}$ years, when horse meat is most tender, or at around 15 to 20 years. Young horses are usually slaughtered for family needs, while old ones are sold to the meat factory. As far as young animals are concerned, males are selected in preference to females for slaughter.

The structure of Shavardak's herd is not traditional. The horses he cares for are not his own, but rather, belong to the various Kazakh households of Nikolskoe and to the collective farm. His aim is not to increase the size of the herd, but rather to provide meat for its owners. Since the mature horses in the herd are not used for riding or traction, but only for breeding, they have a relatively long life span, although they rarely die of natural causes. Breeding animals are usually slaughtered at about 25 years of age, but some live until around the age of 30 years. Geldings are usually slaughtered when they can no longer be used for riding and traction, by 25 years of age. Most horses used for meat, both male and female, are slaughtered between the ages of 2 and 5 years. By their third year, only 2 to 3 individuals had survived out of a cohort into which approximately 40 foals had been born (Table 5). Meat from young horses is usually consumed by its owners, while that from old ones is usually sold to state farms. For example, the meat from Nikolskoe's old horses is sold to a nearby polar fox farm. However, in earlier years this meat would also have been consumed by the family.

In the traditional pastoralist context, described by Kozhakhmetov, horses did not normally die of natural causes. Sometimes, of course, they died of illness or from an injury and, very seldom, were killed by wolves. However, they were usually slaughtered either after the age of 20 years, when they were no longer useful for breeding or for work, or between the ages of 1 and 3 years, when their meat was most tender. The decision to slaughter a horse was based on a household's need for meat. Although the meat and fat from all slaughtered horses were consumed, those from young horses were preferred and were served in particular on special occasions, for example, when guests came to the house. Males were culled before females, since far fewer of them were needed for breeding and milk production.

2.2.2. Importance of the Horse in Mongol and Kazakh Life

Of all the livestock species available to steppe pastoralists, none is as well adapted to the human and natural environment as the horse and none is held in such high esteem. The horse can move rapidly and easily long distances over hard ground, providing its owners with both mobility (riding, packing, traction) and nourishment (milk, meat, fat). Other products, such as bone, hoof, hair, hide, excrement, and even sweat, are also valued, for example, as fuel, raw materials for the fabrication of tools, utensils, musical instruments, and other objects, and for medicinal purposes.

The horse occupies a position in the grazing succession that complements that of other steppe livestock: cattle, sheep, goats, camels, yaks. It can subsist on long, dry, relatively poor-quality herbage, thus encouraging the growth of the shorter, more nutritious grasses, on which bovids (cattle, sheep, goats) depend (Bell 1969). It does not need as much water as cattle. Moreover, it can find its own food under deep snow by digging to it with its hoofs, thereby making it available to the bovids, which cannot do so for themselves (Mohr 1971).

2.3. Population Structure Models

As regards relationships between people and horses, each pattern of behavior or method of exploitation is characterized by its own typical, though not necessarily unique, sex and age structure. These structures can be used as models to which the archaeological data can be compared. The development of these models—from ethnographic, ethological, and archaeological data—has been detailed in Levine (1979, 1983, 1990). Although the information obtained from the interviews described above is by no means complete, it does partly fill some gaps in the data used in the construction of the models. In conjunction with information from ethological, ethnological, archaeological, and historical sources, the ethnoarchaeological data thus facilitate interpretation of target archaeological equid assemblages in terms of human behavior.

The raw material for this method of analysis is the aged horse teeth from archaeological deposits. Determination of an individual's age at death is based on an analytical technique that employs measurements of crown height and assessments of eruption and wear. The method has been described in considerable detail elsewhere (Levine 1979, 1982, 1990). Once the teeth from a deposit have been aged, the next step is to determine what the age distribution of that whole assemblage means in terms of human behavior. The age at which an individual animal dies is in itself of limited interest. What is important is the pattern manifested by the population as a whole and how it compares with the various population structure models to be discussed below.

2.3.1. The Attritional Assemblage Model

The mortality distributions for natural attrition, scavenging, and livestock husbandry, where meat production is of secondary importance, are all similar to the attritional assemblage model (Fig. 2). Mortality is low for adults during their reproductive years, and high for juveniles and senescent individuals (Caughley 1966;

FIG. 2. Attritional assemblage model. The purpose of the broken line is to suggest how the shape of the curve might be biased by the differential destruction of immature teeth.

Dahl and Hjort 1976). This is essentially the pastoral nomad kill-off pattern revealed to me by Damdin. As explained earlier, where meat production is of secondary importance, individuals not dying of natural causes will probably not be slaughtered until after the age of 15 or 16 years.

As yet, no equid assemblage from a pastoral nomadic context has become available for analysis. However, it has been possible to study an assemblage from another kind of context in which mobility, rather than meat production, was of primary importance: Thornhill Farm, an Iron Age and early Roman settlement, from the Thames Valley (Gloucestershire) (Fig. 3). From the relatively undamaged condition of the bones, it is pretty clear that horses from this site were not eaten, but were certainly used as riding, traction, or pack animals. The assemblage is small, with only 160 ageable horse (and possibly some mule) cheek teeth and a dental minimum number of individuals (MNI) of 17 (Fig. 4). This includes 53 loose cheek teeth and 20 jaw fragments with ageable teeth. The small size of the assemblage probably accounts for the jaggedness of the distribution. An initially disconcerting feature of the assemblage is the relatively large proportion of horses dying during their apparently prime reproductive years, at least by comparison with the pattern described by my Kazakh and Mongol informants. Roman horses were broken at about the same age as Mongol and Kazakh horses, and as with the Mongols, the most important use the Romans made of them was for transport. However, it seems that the Roman horses had a much shorter expected life span than the Mongol ponies (Hyland 1990). The explanation for this might lie in the different attitude of the Romano-British agriculturalists toward their horses.

Ann Hyland, in *Equus, the Horse in the Roman World,* argues that Roman equids commonly sustained injuries that would have been caused by poor living conditions and gross overwork (Hyland 1990, p. 59). She estimates that a horse was expected to last only about 3 years in active

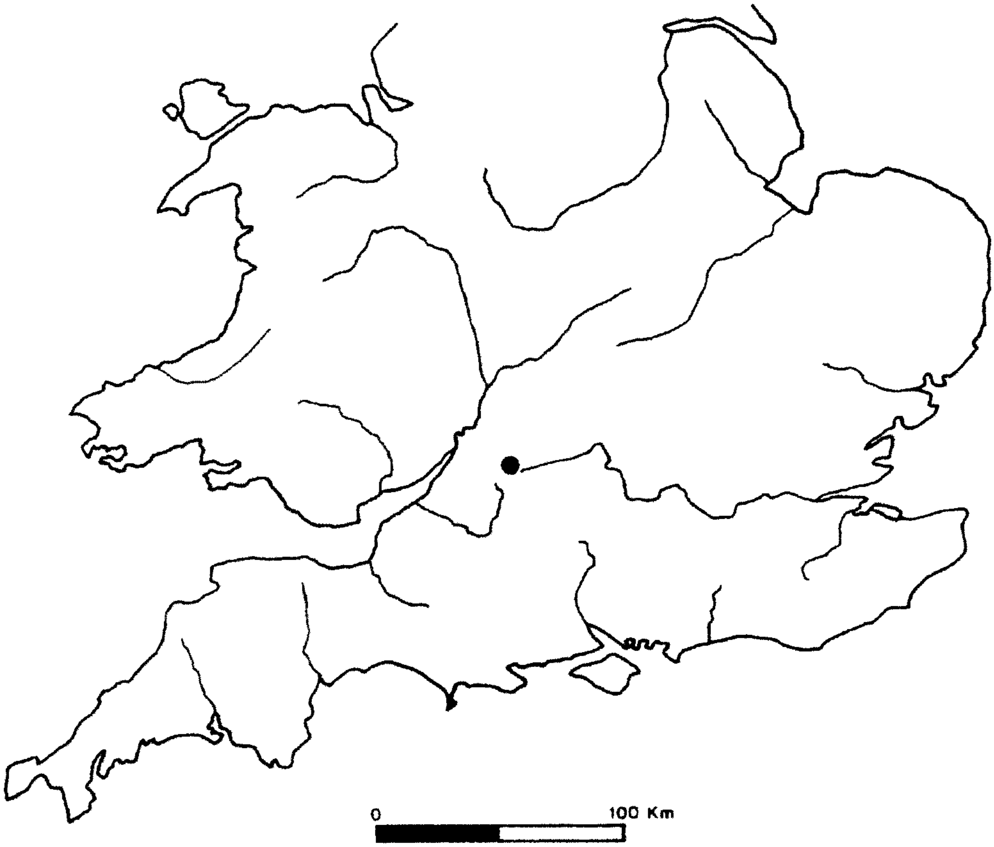

FIG. 3. Map showing location of Thornhill Farm.

military service and, on average, 4 years as a post horse (Hyland 1990, p. 86, 88). Moreover, the breeding period was also comparatively abbreviated, with mares being considered past their prime at 10 years of age, though some did breed until 15 (Hyland 1990, p. 238). The relatively high incidence of pathology, as well as the population structure, seems to confirm this pattern at Thornhill Farm. A similar, but even more extreme, distribution has been revealed for the Roman cemetery at Kesteren in The Netherlands, dated from the first to the third centuries A.D.[8] (Fig. 5) (Lauwerier and Hessing 1992).

These differences might be referable to ecology. That is, unlike the Romans, nomadic pastoralist Mongols depend on horses for their hour-to-hour survival. Horses permeate every aspect of their existence. As a result of this, they are held in high respect and treated with great care. For the Romans, horse production was largely a commercial enterprise and any loss was for the most part financial. However, the possibility that the picture described to me by Damdin might have been somewhat idealized must be recognized and awaits further investigation.

2.3.2. The Carnivorous Husbandry Model

A mortality curve resembling the carnivorous husbandry model (Fig. 6) might be generated if the slaughter of individuals at around the age of 2 to 4 years were superimposed on Damdin's pastoral nomadic attritional pattern (Levine 1990). At

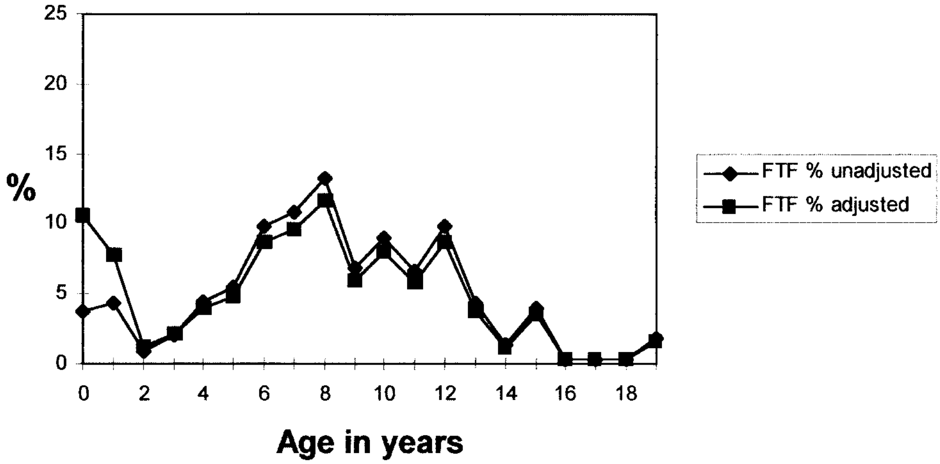

FIG. 4. Thornhill Farm age structure: adjusted and unadjusted. A hypothetical adjustment factor has been applied to compensate for the probable underrepresentation of immature animals (for details see Levine 1979, 1983). To obtain the average adjusted frequency of teeth for each age class from birth to the age of 5 years, the frequency of teeth in each age class (from 0 to 5 years) is multiplied by 1/0.23 + 0.17 (age). "Age" refers to average age; for example, 0.5 is used for 0–1 year).

that age the meat is still at its most tender (Rossier and Berger 1988). Moreover, by that time a horse's growth rate would have decreased substantially, while its energy needs would continue to increase (Fig. 7) (Willoughby 1975, pp. 40–43). It would, therefore, be most efficient to slaughter horses, surplus to a herd's breeding and work requirements, between the ages of 2 and 4 years. This was the pattern described by my informants from Kazakhstan and by Jambalsuran. Such a slaughter pattern has also been observed for modern Mongolia (Damdin, personal communication).

A very similar age distribution was produced from information provided by Yuri Shavardak, the semi-traditional horse herder from northern Kazakhstan (Table 5). Unfortunately, the data on which the

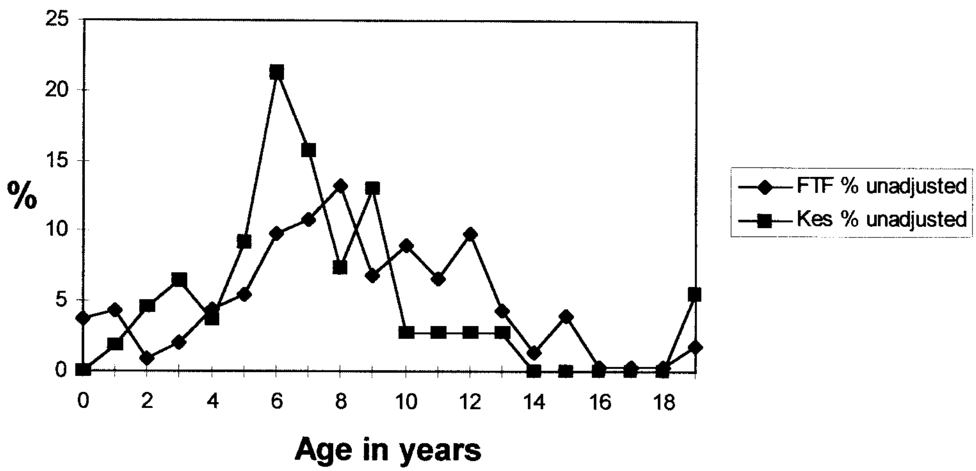

FIG. 5. Thornhill Farm and Kesteren age structure.

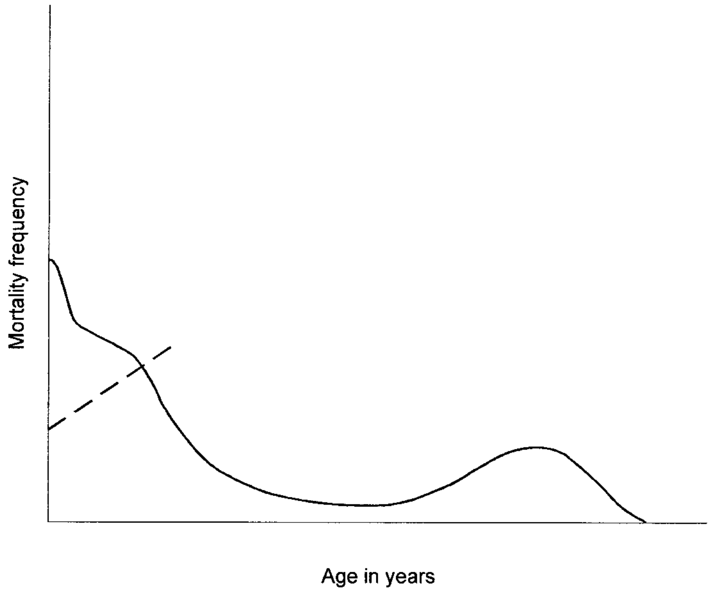

FIG. 6. Carnivorous husbandry model.

distribution is based are incomplete. There is almost no information about infant mortality. The ages given are approximate and the eight geldings, associated with the herd, are excluded from the distribution. Moreover, it is not clear either

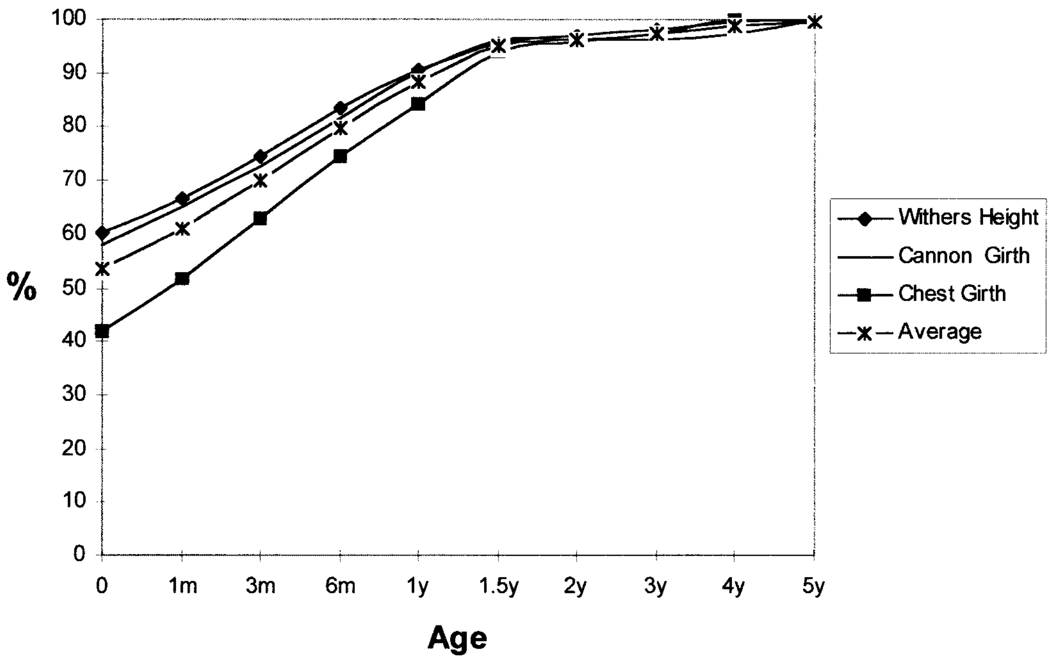

FIG. 7. Horse growth rate.

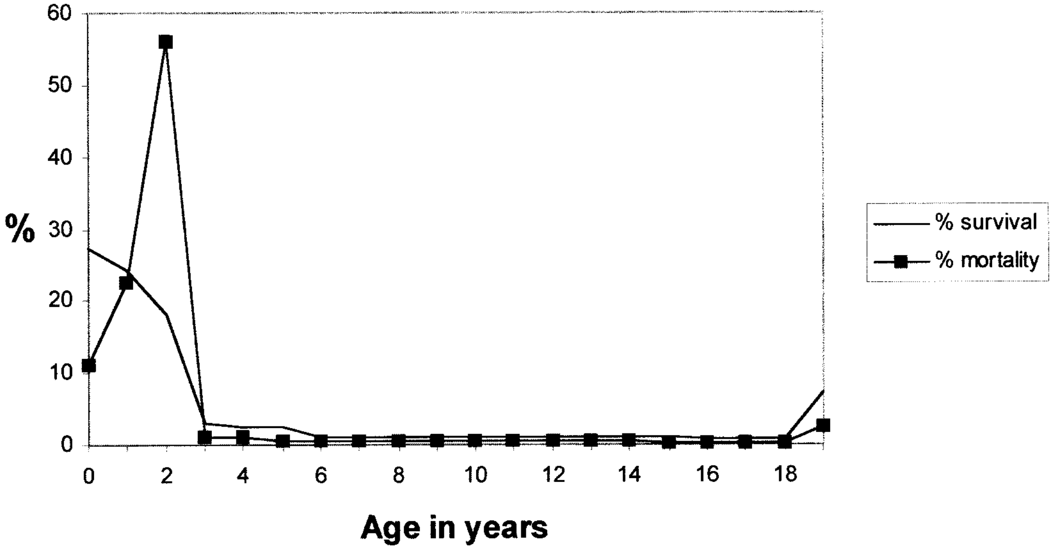

FIG. 8. Age structure of Shavardak's herd.

that the population was stable or the age structure static. On the other hand, its similarity to the carnivorous husbandry model is noteworthy, as is its difference from the life assemblage model (Fig. 8).

2.3.3. The Life Assemblage or Catastrophe Model

The life assemblage model (Fig. 9) is representative either of a living population, a catastrophe assemblage, or an as-

FIG. 9. Life assemblage model.

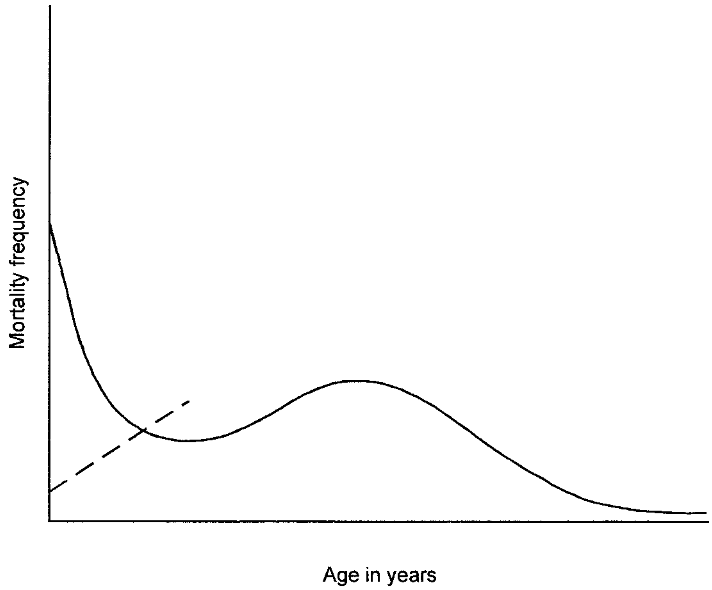

FIG. 10. Family group model.

semblage in which all age classes are represented as they would be in the living population because of completely random sampling (Caughley 1966; Dahl and Hjort 1976). This would also be the age structure of a living Khalkha Mongol herd. Herd driving or any hunting technique that would randomly sample a wild-living horse population would probably produce this mortality pattern or that of the family group variant.

2.3.4. Social Group Models (Variants of the Life Assemblage Model)

2.3.4.1. The family group model. The main difference between the life assemblage model and the family group model (Fig. 10) is the relatively small proportion in the latter of individuals 3 to 6 years of age, marking the absence of bachelor males (Levine 1979, 1983).

This is the kind of pattern produced by the western European, Upper Pleistocene material previously studied, particularly when an adjustment factor has been applied to compensate for the probable under-representation of immature animals (Levine 1979, 1983). Figure 11 shows the population structure of the horse teeth from Jaurens, a natural deposit, formed when a catastrophic event or series of events, probably floods, overcame and swept its victims into a cave. Figure 12 shows the age distribution of the pooled assemblages from 10 Paleolithic sites. Some of the deposits included, for example, those at Solutré, were formed by herd drives, and others, probably by the hunting of single family groups or random individuals.

2.3.4.2. The bachelor group model. The most important characteristic of the horse bachelor group, the absence of females, may be difficult to detect in the archeaological record, since few anatomical elements show much sexual dimorphism (Levine 1979, 1983). The most archaeologically visible feature of the bachelor group model might, therefore, be the absence of individuals less than about 2 years of age (Fig. 13). From the age of about 5 or 6 years, some leave the bachelor group to build up their

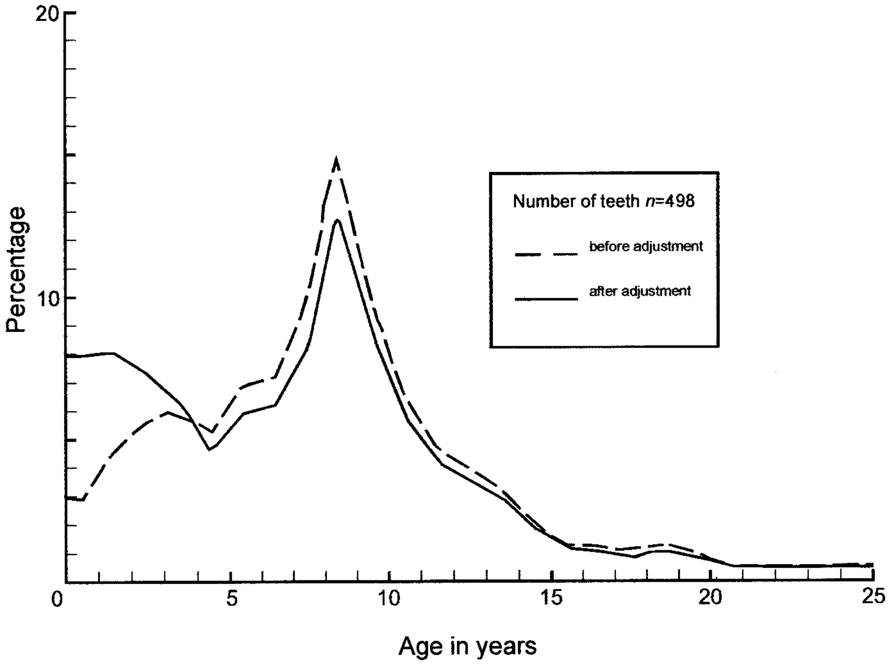

FIG. 11. Jaurens age distribution.

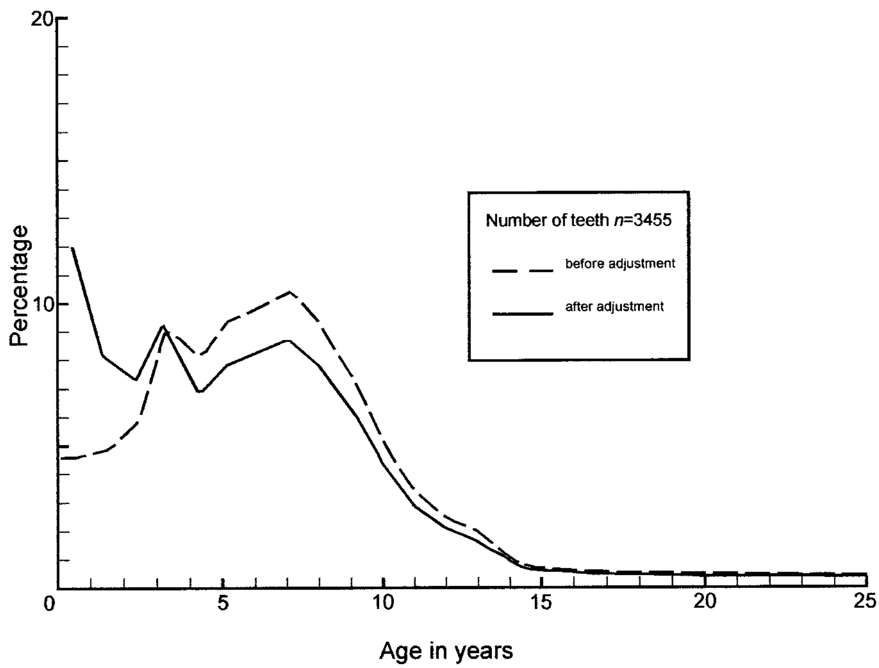

FIG. 12. Pooled Paleolithic sites age distribution.

FIG. 13. Bachelor group model.

own family groups (Berger 1986). Stallions that have lost their harems will either rejoin a bachelor group or remain solitary. Bachelor group hunting might, in the archaeological context, be indistinguishable from the stalking of prime adults.

2.3.5. The Stalking Model

Stalking (Fig. 14) is a selective hunting technique in which the prey is approached by stealth and killed (Levine 1983). Chasing individual prey from horseback would also

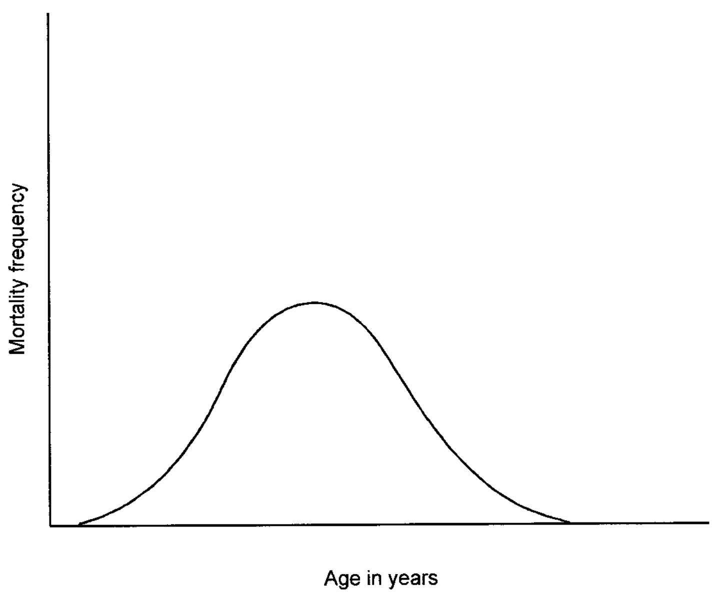

FIG. 14. Stalking model.

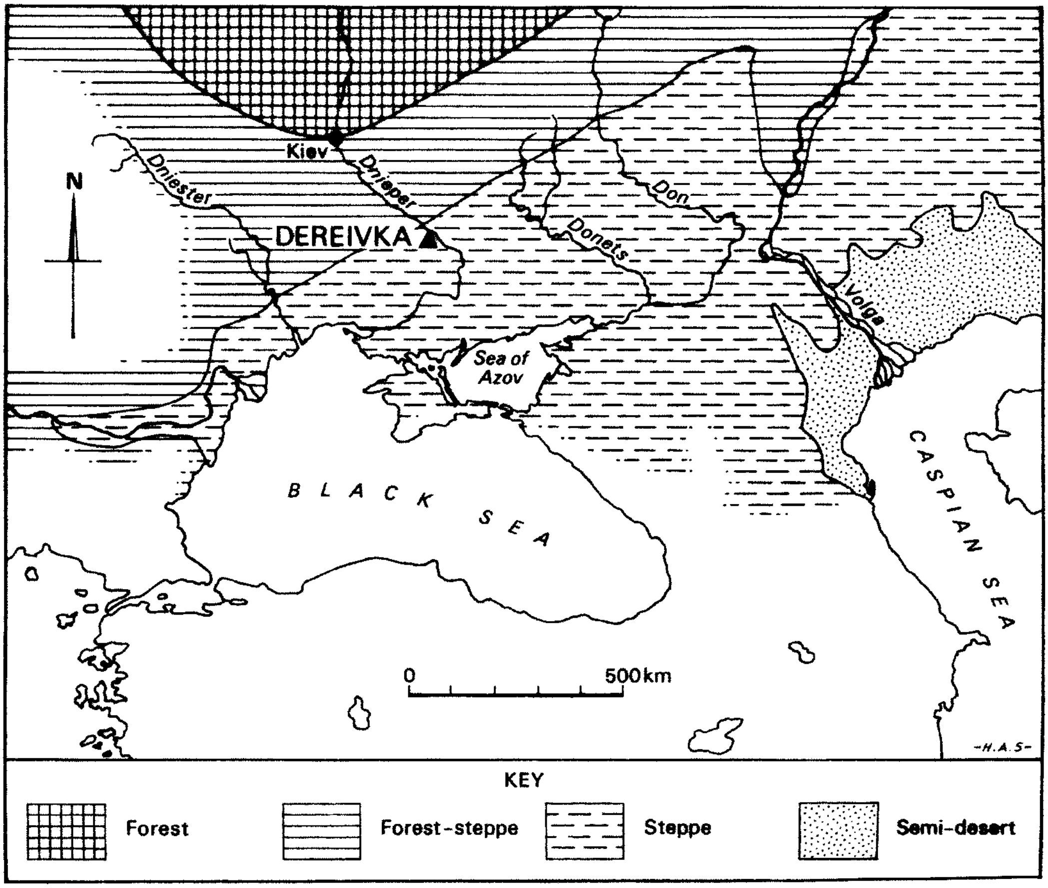

FIG. 15. Map of the Ukraine.

be included in this category, since the initial approach would be by stealth and the selection based on the preferred rather than the most vulnerable individual. Hunting mainly prime adults should produce a distribution approximating a bell-shaped curve. This is the kind of pattern that would result from the Hadza decision to select large fat male zebra as their preferred prey (see Section 2.2.1.6).

The population structure of the horses from the Ukrainian settlement site, Dereivka, best fits the stalking model (Fig. 15)(Levine 1990, 1993). The relevant deposits are Eneolithic (Sredni Stog IIa),[9] with calibrated radiocarbon dates ranging from around 3095 to 4570 BC, of which the majority fit within the second half of the fifth millennium BC (Table 1) (Telegin 1986). The mortality distribution of the horses from Dereivka is characterized by very small percentages of individuals less than 4 years old and more than 8 or 10 years old (Fig. 16). More than half died between the ages of 5 and 8 years (50.1%, unadjusted), when they would have been most useful, both reproductively and as work animals, had they been domesticated. It is most unlikely that herders would have slaughtered their horses at that age.

It therefore seems reasonable to conclude that the vast majority, if not the totality, of the horses from Dereivka were wild and, because of the relatively large proportion dying during their most pro-

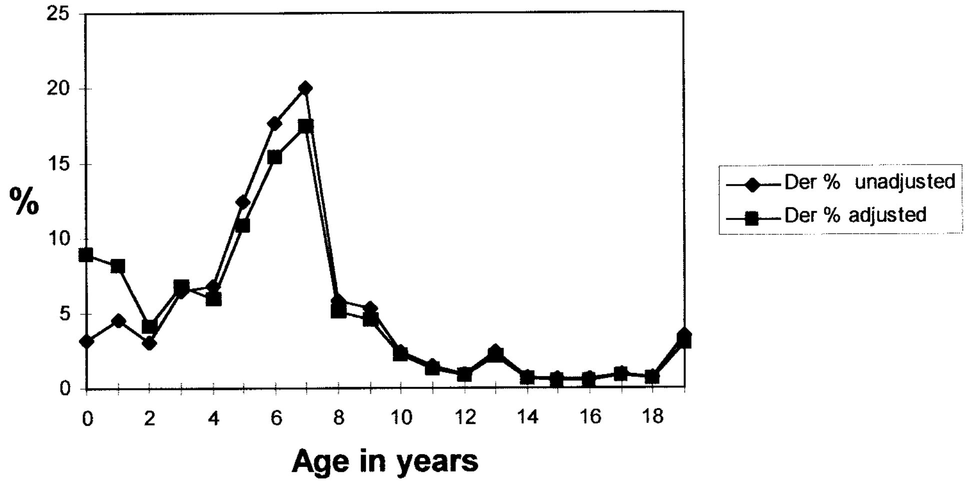

FIG. 16. Dereivka age structure.

ductive years, the mortality distribution that they best fit is the stalking model or a mixture of the stalking and random individual or family group models. The fact that 9 of 10 sexable tooth rows came from males might indicate that bachelor groups were hunted or that somewhat inexperienced stallions with family groups were relatively easy to kill. Studies of equid behavior have shown that when a family group is attacked, the stallion will turn and fight to protect his mares and young (Damdin, personal communication; Mohr 1971; Kruuk 1972).

According to G. and M. Grshimailo (in Mohr 1971, p. 67),

> a wild stallion when he scented danger, he informed his herd by snorting and at once they were off in single file, a young colt in the lead and the foals in the middle between the mares. As long as the herd was on the move and the hunters were to the side, so the stallion stayed to that side and kept his herd going in the direction he had chosen . . . As soon as the horses had broken through the chain of hunters who now hunted them from behind, so the stallion changed his position and was now on guard in the van and in the way of those following him.

Clemenz (1903) observed (as reported by Mohr 1971, p. 68) that

> the stallion remains behind and watches his pursuers. . . . The nearer the hunters approach the more uneasy is the stallion and he keeps between the herd and those pursuing it . . . But when the terrible enemy horses with their two-legged riders press the herd, then the stallion turns to attack his pursuers and is the first to fall to a bullet.

Hunters from Dereivka might well have taken advantage of the tendency of stallions to defend their bands. It is also possible that the inhabitants of the settlement already had domesticated or tamed horses and that they were used for hunting wild ones, as has been recorded for the Central Asian Kalmucks and some of the North American, central, and southern Plains tribes (Mohr 1971; Ewers 1955). This possibility seemed to have been supported by Anthony and Brown's (1991) apparent discovery of bitwear on the teeth of the so-called ritual skull from Dereivka. However, it is worth reaffirming that there is considerable doubt now about the dating and stratigraphic position of that skull (Rassamakin 1994; Telegin, personal communication).

That being said, it must be emphasized that interpretation of population structure should not be made with reference to mortality data alone. For example, according to Fig. 17, the age distribution of the horses from the Roman site of Kesteren is

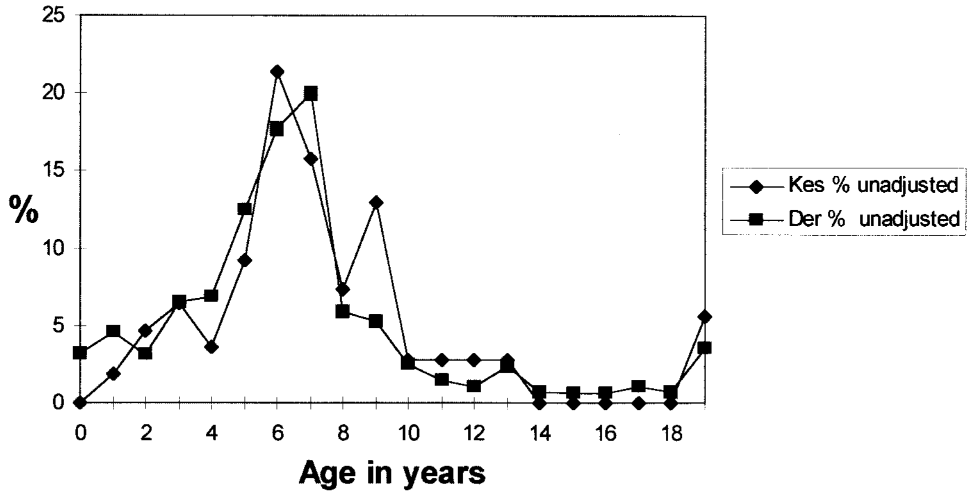

FIG. 17. Kesteren and Dereivka age structure.

rather similar to that at Dereivka. The proportions of horses dying between the ages of 5 and 8 years are particularly close, 50.1% at Dereivka and 46.3% at Kesteren, whereas at Thornhill Farm it is only 26.2%. However, a much larger proportion at both Kesteren (31.5%) and Thornhill Farm (49.9%) die between the ages of 8 and 14 years than at Dereivka (18.6%). The average life expectancy is lower at Dereivka (7.7 years) than at either Thornhill Farm (9.3 years) or Kesteren (8.3 years). Moreover, contextual data leave little doubt that the horses from Kesteren were domesticated and suggest that they might well have been used for military purposes (Lauwerier and Hessing 1992). Although Dereivka's context is less straightforward, it nevertheless seems to support the proposition that horses from that site were predominantly, if not entirely, wild (Levine 1990, 1993 and below).

3. BOTAI

Botai is an Eneolithic settlement site located in Kokchetau Oblast in the forest–steppe region of northern Kazakhstan[10] (Fig. 18) (Zaibert 1993; Kislenko 1993). The site covers approximately 15 hectares, around 10,000 m^2 of which have been excavated, on the high, right bank of the Iman-Burluk, a tributary of the river Ishim (Fig. 18). Although some remains of Pleistocene mammals have been discovered eroding out of the river bank, the prehistoric human occupation of Botai apparently extended only from the Mesolithic to the Eneolithic. Substantial Neolithic remains are probably present, but excavation has so far been confined largely to the Eneolithic occupation, dated to around 3500 B.C. (Table 12) Levine and Kislenko 1997).

Botai comprises around 300 polygonal "dwellings," which show up on the surface of the ground as rows of shallow depressions. They are packed close together in a kind of honeycomb pattern, and are oriented in parallel rows on either side of "streets," 4 to 8 m wide. More than 140 of these structures, each ranging in area from 30 to 70 m^2, have been excavated so far (Kislenko 1993). More than 40 first phalanges, mainly of horse, polished and covered with geometric designs, have been found in various dwellings, as has a carved human figurine. Although no cemetery has been discovered at Botai, some

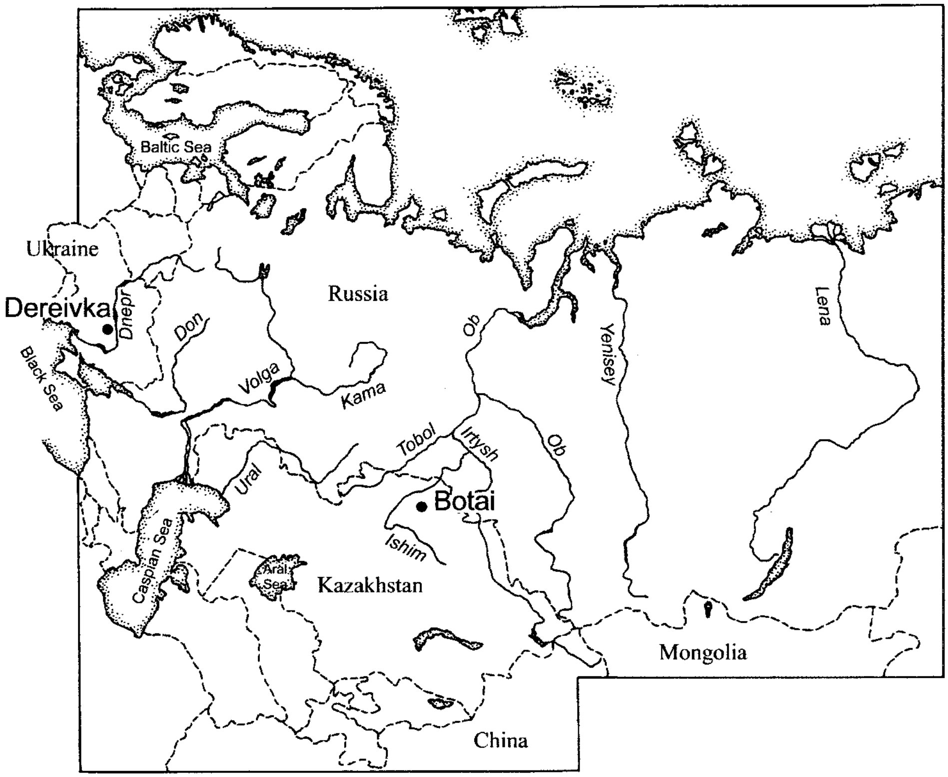

FIG. 18. Map showing location of Botai.

human remains have been recovered from the settlement, including a trepanned human skull covered with ochre, found in a niche in a wall; a sawn piece of occipital bone; and a skeleton in a pit surrounded by horse skulls. It has been estimated that, during the 15 years of Botai's excavation, more than 300,000 artifacts and 10 tons of bones (99.9% of which belonged to horse) have been uncovered (V. F. Zaibert, personal communication). Two short papers have been published about the bones, one by Kuz'mina (1993) and the other by Ermolova (1993). The former concludes from a morphometrical analysis of 428 bones and teeth that the horses from Botai were domesticated, while the latter maintains in her very short, though broadly based, study of more than 300,000 anatomical elements, that they were wild.

3.1. Site 31

During July and August 1992, the North Kazakhstan Archaeological Expedition, under the overall direction of V. F. Zaibert (A. Kh. Margulana Institute of Archaeology, Petropavlovsk), excavated Botai, Site 31 (Fig. 19). A. M. Kislenko (A. Kh. Margulana Institute of Archaeology) and N. S. Tataryntseva (North Kazakhstan Regional History and Ethnography Museum) directed the excavation.[11] Its aim was to provide me with a faunal assemblage to which my analytical methods could be applied.

Site 31 is situated in the southwestern part of Botai, adjacent to the present river bank. This locality was chosen because of its very high density of cultural remains by comparison with other parts of the settlement, resulting from its longer period of use. It includes two structures, the hex-

TABLE 12
Botai Radiocarbon Dates

Oxford Accelerator Laboratory

OxA-4315 Botai: 4630 ± 75 years B.P. (bone)

1 σ

3611 B.C. (0.02) 3602 B.C. 3512 B.C. (0.56) 3397 B.C. 3391 B.C. (0.28) 3332 B.C.
3221 B.C. (0.07) 3193 B.C. 3156 B.C. (0.06) 3134 B.C.

2 σ

3625 B.C. (0.07) 3572 B.C. 3538 B.C. (0.71) 3262 B.C. 3242 B.C. (0.22) 3101 B.C.

OxA-4316 Botai: 4620 ± 80 years B.P. (bone)

1 σ

3508 BC (0.46) 3403 B.C. 3386 B.C. (0.27) 3327 B.C. 3321 B.C. (0.03) 3309 B.C.
3228 BC (0.13) 3186 B.C. 3159 (0.11) 3125 B.C.

2 σ

3625 BC (0.06) 3572 B.C. 3538 B.C. (0.94) 3095 B.C.

OxA-4317 Botai: 4630 ± 80 years B.P. (bone)

1 σ

3613 B.C. (0.03) 3601 B.C. 3513 B.C. (0.54) 3396 B.C. 3392 B.C. (0.27) 3331 B.C.
3224 B.C. (0.09) 3190 B.C. 3157 B.C. (0.07) 3133 B.C.

2 σ

3628 B.C. (0.08) 3566 B.C. 3540 B.C. (0.69) 3258 B.C. 3245 B.C. (0.23) 3099 B.C.

Other Dates[a]

IGAN-432	4340 ± 120 years B.P. (bone)
IGAN-449	3530 ± 160 years B.P. (charcoal)
IGAN-4234	4900 ± 50 years B.P. (bone)
IGAN-4235	4160 ± 40 years B.P. (bone)
IGAN-4236	4540 ± 60 years B.P. (bone)
IGAN-4237	4430 ± 60 years B.P. (bone)

[a] From Zaibert and Kislenko (personal communication).

agonal Dwellings 26 and 29 (the latter partially dug in 1981); a possible earlier, rectangular structure, Dwelling 29a; and various ditches and pits, both inside and outside of the structures (Fig. 20). The 1992 excavation covered 96 m^2, of which about 18 m^2 had been eroded away by a gully. The site was divided into 2 × 2-m squares, which were further subdivided into meter squares. These were dug in arbitrary 10-cm spits and all finds, including bones and teeth, were located within these units. All osteological material, including vertebrae and unidentifiable bone fragments, was collected.

Large concentrations of bones were found within Dwellings 26, 29, and 29a: on their floors and in the post-occupational fill, and between the dwellings and within pits and trenches both inside and outside of them. Around 40,000 anatomical elements and almost 5000 artifacts—including ceramics, bone, and stone tools, and an engraved horse first phalange—were recovered from Site 31 (Figs. 21 and 22). More than 99% of the bones and teeth recovered were from horse. A cursory glance at the rest of the fauna suggests that the other bones were largely if not wholly from wild taxa. Herbivores, carnivores, and birds were present. Several fragments of human bone were also recovered, including a piece of sawn cranium.

Such dense bone concentrations are characteristic in particular of the dwellings located near the river bank. Various

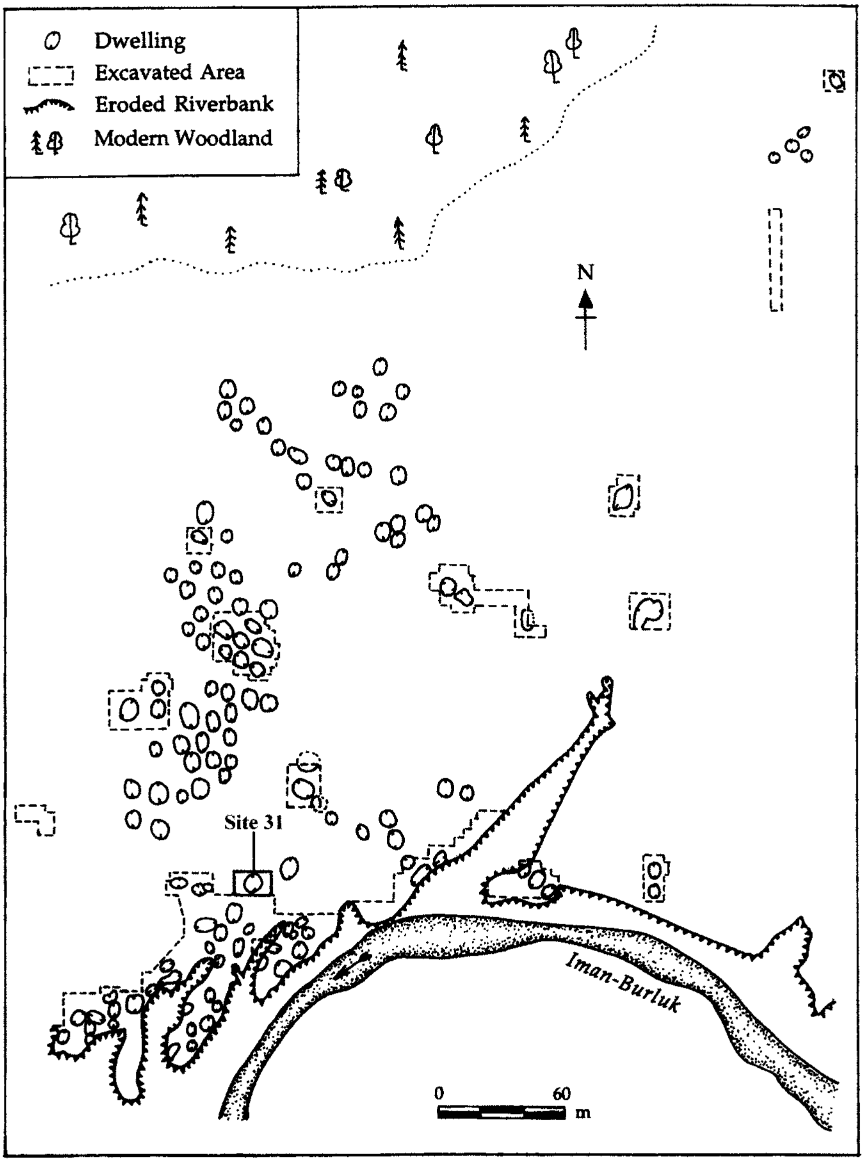

FIG. 19. Plan of Botai, showing location of Site 31.

theories have been proposed to explain the formation processes involved. For the moment, I believe that the best explanation is that, as a "dwelling" fell into decay and was abandoned, it was converted into a dump for the bones and carcass parts of horses butchered for consumption. This would explain why the bone concentrations were found at various levels above the floor, mixed with the clay of which walls were apparently constructed. It is hoped that new light will be thrown on this problem by a micromorphological analysis of the deposits being carried out by C. A. I. French (Department of Archaeology, Cambridge).

3.2. Botai Age Structure

The analysis of the osteological material from Site 31 has so far been concerned mainly with the population structure of the assemblage, based on tooth eruption and wear. Because a detailed stratigraphic study of the site has not yet been completed, for the purposes of this paper, all osteological data have been pooled. The remains studied to date come almost entirely from F, X, CH 35-37, and T 38, that is, from Dwellings 26, 29, 29a, pit 4, and the deposits between the dwellings (Fig. 20). 5556 bones and teeth (excluding ribs and unidentifiable bones) have been examined and constitute all the equid material recovered from those units.

The age structure of the material examine from Botai so far is based on the study of 526 cheek teeth,[12] some loose, some in jaws, with an MNI of 29, based on upper D2s and P2s. Table 13 shows that the teeth from Botai, Thornhill Farm, and Dereivka are all very similar in size to those used in the design of the aging system employed here. The age distributions produced by this means should, therefore, be comparable (for details of aging method see Levine 1979, 1982, 1983, 1990).

As in the case of Jaurens and the pooled Palaeolithic data previously described, the mortality distribution of the teeth from Botai is comparable with the life assemblage or catastrophe model, particularly when it is adjusted to compensate for the under-representation of immature individuals (Figs. 11, 12, 23). That is, all age classes are represented approximately as they would have been in the living population.

A comparison of the data from Botai with those from Dereivka and Thornhill Farm (Fig. 24) shows that the horses from Thornhill Farm, despite the probable ill treatment as manifested by high incidences of bone pathology, had a longer average life expectancy (9.3 years) than those from Dereivka (7.7 years) and Botai (6.5 years).[13] Only about 33% of the horses at Thornhill Farm died between the ages of 3 and 8 years, while the figure for Dereivka was 63% and that for Botai was 55%. Approximately 55% of the horses from Thornhill Farm died between the ages of 8 and 16 years, as against 20% for Dereivka and 24% for Botai.

The age distributions for both Botai and Dereivka fit hunting models, but the differences between them strongly suggest that different hunting techniques were used (Fig. 24). For example, although the mortality rates for both Botai and Dereivka are very similar from the age of 8 years and onward, the rates for younger horses are distinctly divergent. At Dereivka mortality is concentrated between the ages of 5 and 8 years, while at Botai it extends back at least to 3 years. The difference is even greater when the distribution is adjusted. While the horses from Dereivka were probably stalked, it seems that those from Botai were killed in herd drives.

3.3. Other Supporting Data

This interpretation is supported by other characteristics of the assemblages. For example, the sex ratios at the two sites are very different. At Dereivka the ratio of males to females is 9:1 (on the basis of jaw bones), which is compatible with stalking; while at Botai the ratio is almost 1:1 (7:6 for jaw bones and 17:20 for pelves), which is best explained by a non-selective technique, such as herd driving. The small proportions of pathological bones at Dereivka and Botai by comparison with Thornhill Farm also support the theory that the horses at the former two sites were wild (Levine, in preparation).

Herd driving is a better paradigm for what was happening at Botai than other non-selective hunting techniques for various reasons. Herd drives necessitate large-scale human cooperation and at

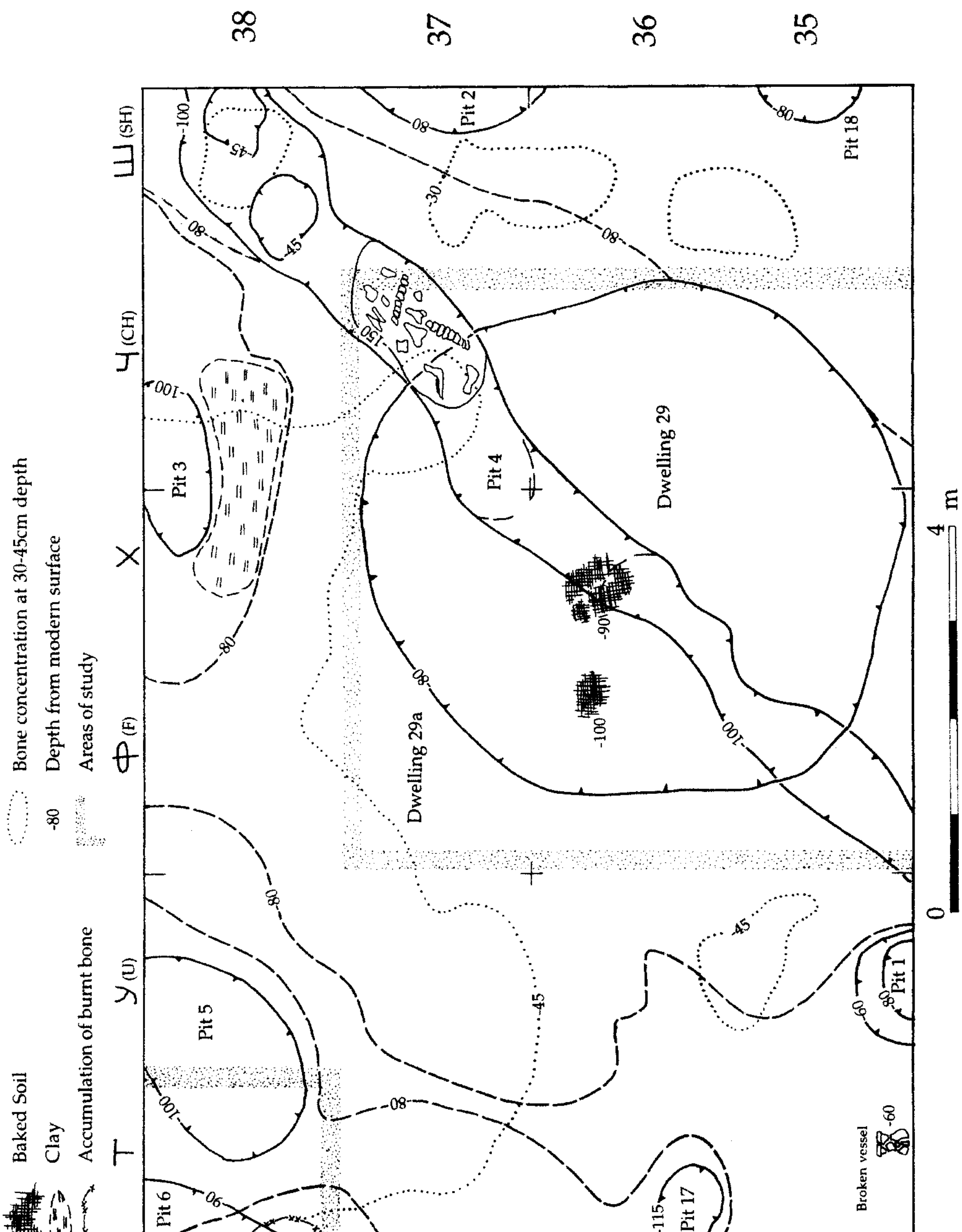

FIG. 20. Plan of excavation, F-X-Ch-T. Redrawn from Kislenko and Tataryntseva (unpublished).

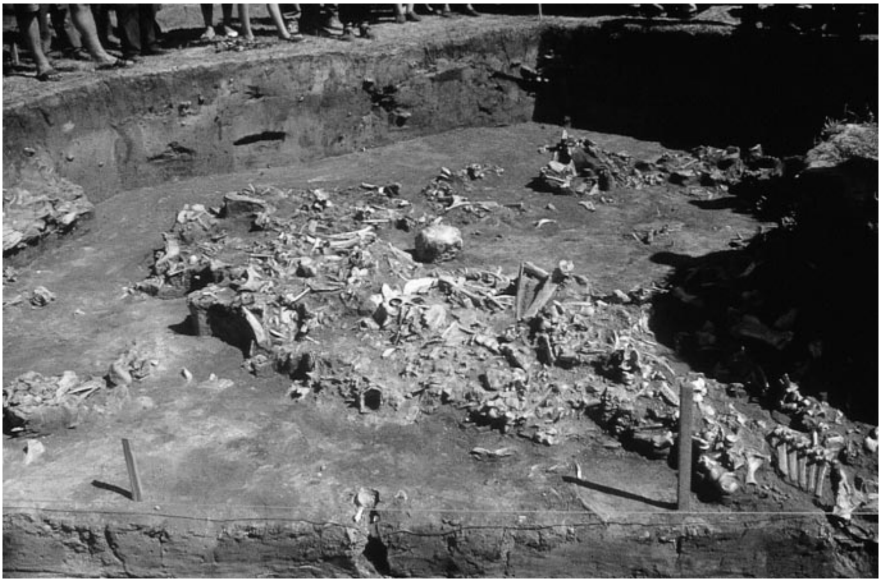

FIG. 21. Botai bone concentration.

least seasonal aggregation. Although the size of the population at Botai at any one time is not known, available evidence suggests that it probably was relatively large. Herd drives usually result in the deaths of large numbers of animals. The quantity of horses killed at Botai was immense. Additionally, such a large-scale slaughter, according to ethnographic and archaeological evidence, often results in very wasteful under-utilization of carcasses. The relatively high incidences of articulated limb bones and vertebrae at Botai, the large concentrations of bones apparently discarded together, the undamaged state of many anatomical elements, and the relatively small proportion of unidentifiable fragments suggest that large numbers of animals were killed more or less simultaneously and that flesh was plentiful enough to be wasted.

Dereivka was, by comparison, a small settlement, comprising probably three dwellings at most. Fewer than 5000 bones and teeth of all taxa were recovered, about 60% of which were from horse. Its population, almost certainly never consisting of more than a few families, would not have been sufficient for the huge kills sustained at Botai. The relatively small size of the settlement and faunal assemblage at Dereivka, as well as its age and sex structure, is compatible with the stalking model.

4. DISCUSSION

4.1. Speculating about the Social Implications of Horse Hunting Methods

There is, according to Anthony (1995), evidence of bitwear on some of the teeth from Botai. Leaving methodological questions aside, in view of the important archaeological and osteological differences between the two sites, it is interesting to speculate about the social implications of stalking and chasing from horseback versus herd driving at Botai and Dereivka. Care must, of course, be taken when invoking ethnographic parallels to interpret archaeological data. Nevertheless, even taking into account the behavioral differences between horses and bison, an examination of Ewer's study of the Blackfoot can take us down some interesting and

FIG. 22. Engraved phalange from Botai 31.

unexpected paths into Eneolithic central Eurasia (Ewers 1955).

According to Ewers, there were basically two methods of bison hunting from horseback, the surround and the chase:

> The surround method employed a considerable number of horsemen to encircle a herd of buffalo, start them milling in a circle, and shoot down the frightened and confused animals as they rode around them.
>
> The chase was a straightaway rush by mounted men, each hunter singling out an animal from the herd, riding alongside it and killing it at close quarters, then moving on to another animal and killing it in like manner. The Blackfoot seem to have virtually abandoned the surround in favor of the chase around the middle of the 19th century. During the last two decades of buffalo hunting the chase alone was employed as a method of killing buffalo from horseback. (Ewers 1955, p. 154)

Ewers hypothesized that the surround method had evolved out of the pre-horse communal herd drive. This hunting technique was dependent both on the seasonal aggregation of usually small scattered bands into large camps and on the bison's high population density, particularly in early winter. The whole community would have cooperated in driving the bison herd down V-shaped approaches into corrals or pounds or over cliffs. When successful, it could produce huge surpluses, permitting inefficient exploitation of the carcasses. However, "buffalo hunting on foot in the Pedestrian Culture Period must have been exceedingly dangerous, arduous, time consuming, and sometimes unsuccessful" (Ewers 1955, p. 304).

According to Ewers, the acquisition of the horse eventually transformed the communal herd drive into the surround: "In the mounted surround the Indians simply took advantage of the horse's greater mobility to expedite the kill. Horsemen also replaced footmen in driving and luring buffalo into pounds or over cliffs" (Ewers 1955, p. 304).

The chase represented a further step in the development of bison hunting. It was more flexible, efficient, and less hazardous than the surround; any number of hunters could participate; it was less time consuming; and it facilitated the slaughter

TABLE 13
Tooth Size Comparison

Tooth	Jaw	Height (+mm)	Mean M-D Pal.(X)	SD Pal.	No. Pal.	M-D Der (x)	z Der	M-D Bot (x)	z Bot	M-D FTF (x)	z FTF
P2	U	250–300	377	11.9	5					323	−0.45
		350–400	374	26.7	14			406	1.20	362	−0.04
										361	−0.05
		550–600	389	23.3	17			368	−0.90	347	−0.18
								383	−0.26	354	−0.15
								37	−0.52		
	L	250–300	339	18.2	16			333	−0.33		
								347	0.44		
		300–350	340	18.6	23	293	−2.53	344	0.22	343	−0.02
		450–500	335	18.7	25	307	−1.50	340	0.27	328	−0.04
						344	0.48	335	0.00	290	−0.24
		500–550	325	16.6	11			331	0.36	303	0.06
P3	U	350–400	299	14	9			309	0.71		
								307	0.57		
								277	−1.57		
		450–500	302	12.8	17			301	−0.08		
								312	0.78		
		650–700	314	13.5	10			295	−1.41		
		700–750	314	15	8			297	−1.13	282	−0.21
								324	0.67	281	−0.22
P4	U	450–500	287	11.4	12			294	0.61	258	−0.25
								266	−1.84	259	−0.25
		750–800	298	15.7	10			287	−0.70		
	L	350–400	273	13.4	4			267	−0.45		
		400–450	293	3.6	3					242	−1.42
										247	−1.28
M1	U	350–400	258	11.7	7			264	0.51		
		400–450	257	21.8	16					229	−0.13
										231	−0.12
		650–700	274	10.8	16			259	−1.39		
								266	−0.74		
		700–750	283	25.3	5			268	−0.59	275	−0.04
										274	−0.04
M2	U	700–750	270	12.4	9			258	−0.97		
								259	−0.89		
		750–800	280	18	16			273	−0.39	268	−0.07
										267	−0.07
	L	400–450	279	20.3	4					232	−0.23
										241	−0.19
		750–800	288	6.3	4			284	−0.63		
M3	U	400–450	300	25.8	9					295	−0.02
										286	−0.05
	L	350–400	322	21.7	32			332	0.46	301	−0.1
								317	−0.23	325	−0.01
								309	−0.60		

[a] Measurements to 0.1 mm. Der, Dereivka; FTF, Thornhill Farm; Bot, Botai. No. Pal., number of specimens in Paleolithic sample; SD Pal., standard deviation of Paleolithic sample; height = tooth height from division of the root; M-D, mesio-distal diameter of tooth; X, sample mean of the Paleolithic teeth; x, the sample (individual teeth from Bot, FTF or Der) mesio-distal diameter to be compared with the Paleolithic mean; z, number of standard deviations x is from the sample mean ($z = x - X/\mathrm{SD}$) (±1.0 SD indicates that x is not significantly different in size from X, ±2.0 SD indicates that they might belong to two separate populations, ±3.0 SD indicates that they are significantly different). None of the z scores from Der, FTF, or Bot are more than 3 SD from the mean of the Paleolithic material and only one is more than 2SD, which means that, for the purposes of aging, they can be treated as if they belonged to one population.

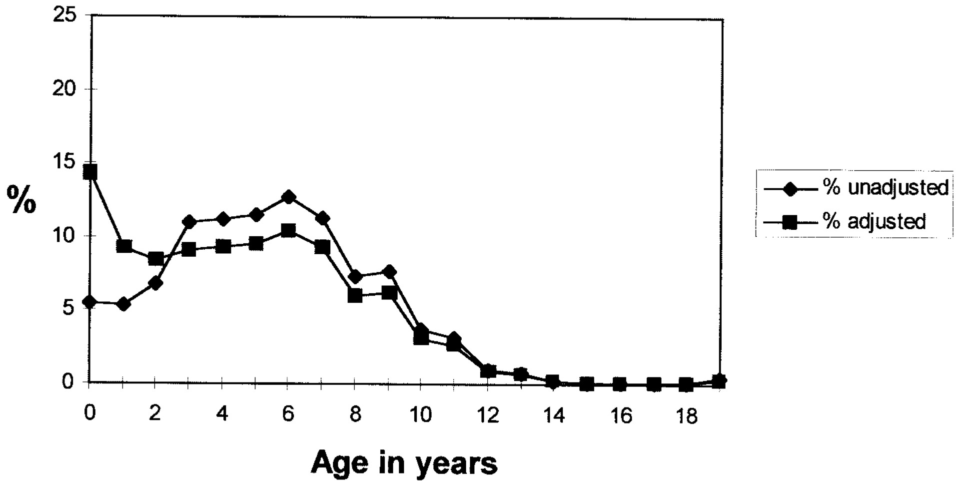

FIG. 23. Botai age structure: adjusted and unadjusted.

of selected individuals. According to Ewer's informants, in the course of a single chase, no more than four or five bison cows would have been killed. Less skilled hunters or those with inferior horses would capture no more than one or two (Ewers 1955, p. 159).

4.2. Botai and Dereivka

Although Ewers was talking about the bison hunt, we know (Section 2.1.1.2) that feral horses can be captured by driving, surrounding, chasing, or stalking. There are obvious parallels between Botai and the herd drive or surround and between Dereivka and the chase or the stalk. This interpretation is supported not only by the population structures of the two sites, but also by other features, such as the settlement and assemblage size and the sex structure. However, it would be foolhardy to try to draw too many conclusions from a sample of only two sites, particularly in view of the fact that Botai is roughly 2400 km away from and, apparently, 1000 years

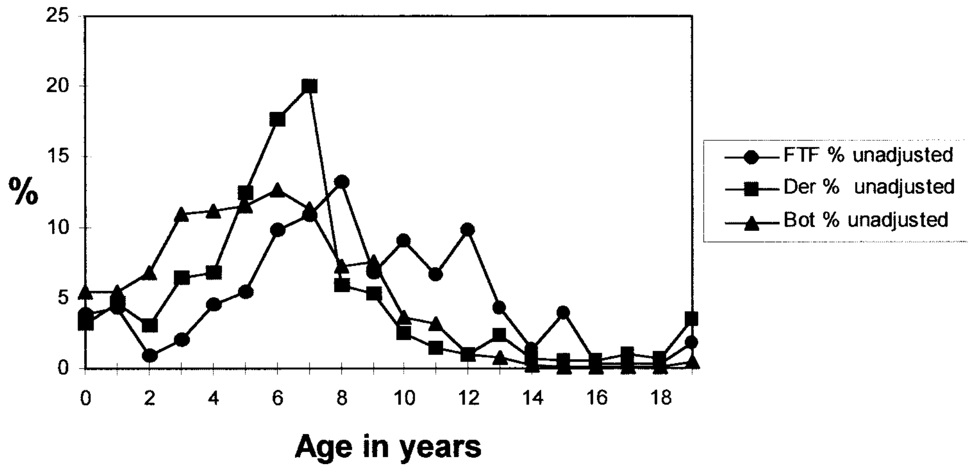

FIG. 24. Botai, Dereivka, and Thornhill Farm age structure.

later than Dereivka. However, new research suggests that the Eneolithic level at Dereivka, in fact, extends from Tripolye B-II/C-I to C-II and therefore should be dated to 3700–3150 B.C., not 4000–4500 B.C. as suggested by Telegin (Rassamain 1994; personal communication). If this is true, then Botai (at around 3500 B.C.) could be contemporary with or even earlier than Dereivka. The archaeology of these two regions is still open to revision so that it would be a unwise to take any of this too seriously. Nevertheless, it is worth considering for a moment why one hunting method rather than another might have been selected.

Perhaps Ewers was wrong in concluding that the herd drive was more dangerous, time consuming, and generally inefficient than the chase. Maybe these were not the prime considerations determining which method of hunting should be employed. Possibly the horses at Dereivka were stalked on foot rather than chased from horseback. Factors quite different—ecological, social, economic, or cultural—than those inspiring the Blackfoot could have been crucial to the decision about which method to use. For example, the herd drive could have been the magnet used to draw together the large numbers of people needed for other activities. The advantages thus obtained might well have outweighed those derived from the more individualistic chase. Social or environmental instability might well have favored such a scenario. Tradition could have acted as a brake to progress, maintaining technologically obsolete, but culturally useful practices. In other words, it seems most likely that horse hunting did not so much evolve as adapt.

5. CONCLUSION

The results of the analyses carried out on the data from Dereivka and Botai suggest that the vast majority of the horses from those sites were killed in the hunt. Different hunting techniques were employed at each of them: stalking or chasing at Dereivka and driving or surrounding at Botai. The possibility that some of the horses might have been tamed or domesticated, as suggested by Anthony and Brown's bitwear studies, is certainly not excluded. However, the possibility that the wear pattern they define as bitwear could have other causes has not been disproved.

Although the study of population structure is a crucial step in the analysis of almost any faunal assemblage, it should not be the only step. If, as is often the case, an assemblage were composed of a palimpsest of exploitation methods, it might not be possible by means of the population structure alone to disentangle the whole range of component patterns. If, for example, a relatively small number of horses at Botai or Dereivka were ridden, their age distribution would be swamped by that of the much larger number of hunted animals. Complementary analytical methods must, in that case, be selected that will identify, out of the whole assemblage, poorly represented but important activities.

Some such methods are quite simple, just requiring application of known techniques. For example, the presence of shed deciduous teeth within, and contemporary with, enclosures might suggest that young animals were being raised and possibly that controlled breeding had been taking place. But unless careful sieving were carried out, it is unlikely that these elements would be recovered. Various scientific methods, currently being developed, could also be applicable to the study of horse exploitation. For instance, the current hope is that it will be possible to use ancient DNA to distinguish populations and to identify genetic variability and change. One application of this method would be to determine whether specimens with "bitwear" belonged to the same population as those without it. Lipid, stable isotope, and trace element analyses could be used to look at another aspect of population variability—diet.[14] It has been hypothesized that a homogeneous horse population would have had a homogeneous diet. Different methods of exploitation could affect the natural pattern either, for example, by mixing together individuals from various populations or by controlling access to food so that domesticated or tamed animals would have a different isotopic signature than wild ones (Henry Schwarcz, personal communication). Micromorphological analyses of site formation processes can also contribute to our understanding of human–horse relationships. Since wild and feral horses are notoriously shy of human begins, the identification of ancient horse dung heaps within a settlement could indicate that tamed or domesticated horses had been living at the site or nearby. The dung, a by-product of intimacy between people and horses, could have been collected as a building material, for fuel, or for fertilizer (C. A. I. French, personal communication[15]). Another approach is the study of horse paleopathology. On the one hand, the incidence of pathology among wild horses is likely to be lower than that among domesticates. On the other hand, the kinds of pathologies found in horses ridden or used for traction should also be indicative of the kind of work to which they were put. Preliminary work on the osteological material from Botai, Dereivka, Thornhill Farm, and a sample of modern and Scythian comparative material supports these hypotheses[16] (Levine 1998b).

As new analytical techniques become available, we must consider how we can exploit them to suit the purposes of our research. The potential for the study of the beginnings of horse domestication and pastoral nomadism to yield new and exciting results is almost unlimited, if approached with an open mind and a sense of adventure.

ACKNOWLEDGMENTS

I could not possibly name all the people, particularly from the former Soviet Union, whose support and hospitality contributed to the production of this paper. Those to whom I am most indebted include A. M. Kislenko, N. S. Tataryntseva, V. F., Zaibert, A. Bayov, and V. Rutter for their help in Kazakhstan; and D. Y. Telegin, Y. Y. Rassamakin, and the late N. G. Belan for their help in Kiev. I also acknowledge the kindness and patience of my informants: Damdin, Jambalsuran, D. Ch. Murzabaev, Y. I. Shavardak, M. K. Kozhakhmetov, E. Z. Zakir'yanov, and B. Kanafin. From my small army of interpreters and translators I, in particular, thank N. Musina, N. Zhabrovets, G. Zerova, G. L. Barnes, K. Chabros, and H. Lewis. I am particularly grateful to M. K. Jones for his unfailing support of this project and for reading and commenting on this paper. I also thank, for their support, A. C. Renfrew, P. A. Jewell, A. G., Sherratt, G. N. Bailey, L. B. Jeffcott, J. Clutton-Brock, M. Leggatt, and J. Rippengal. I am grateful to the Oxford Accelerator Laboratory for providing me with radiocarbon dates. I thank G. Owen and A. Baker (Haddon Library, Cambridge) for their help with the photography. I also thank John O'Shea and my reviewers, particularly R. W. Redding, for their valuable comments and suggestions. I gratefully acknowledge the following organizations for funding this research: the McDonald Institute for Archaeological Research, the Wenner–Gren Foundation, the British Academy, the Leakey Foundation, the Oxford Archaeological Unit, and the Natural Environmental Research Council.

REFERENCES CITES

Anthony, D. W.
1995 Horse, wagon and chariot: Indo-European languages and archaeology. *Antiquity* **69**(264): 554–565.

Anthony, D. W., and D. R. Brown
1991 The origins of horseback riding. *Antiquity,* **65**(246):22–38.

Azzaroli, A.
1985 *An Early History of Horsemanship.* E. J. Brill, Leiden.

Bayley, L., and R. Maxwell
1996 *Understanding Your Horse.* David and Charles, Newton Abbot.

Bell, R. H. V.
1969 *The Use of the Herb Layer by Grazing Ungulates in the Serengeti National Park, Tanzania.* Ph.D. thesis, University of Manchester.

Benecke, N.
1993 Tierdomestikationen in Europa in vor- und frühgeschichtlicher Zeit - Neue Daten zu einem alten Thema, aus Bericht der *Römisch-Germanischen Kommission* 74, 1993 [Vortrag zur Jahressitzung 1993 Römisch-Germanischen Kommission], pp. 5–47. Verlag Phillipp von Zabern, Mainz am Rhein.

Berger, J.
1986 *Wild Horses of the Great Basin, Social Competition and Population Size.* Univ. of Chicago Press, Chicago.

Bibikova, V. I.
1967/1970 A study of the earliest domestic horses of Eastern Europe, parts 1 and 2. Reprinted in *Dereivka, a Settlement and Cemetery of Copper Age Horse Keepers on the Middle Dnieper,* by D. Y. Telegin. BAR International Series 287, pp. 135–162.
1969 On the history of horse domestication in south-east Europe. Reprinted in *Dereivka, a Settlement and Cemetery of Copper Age Horse Keepers on the Middle Dnieper,* by D. Y. Telegin. BAR International Series 287, pp. 163–182.

Bökönyi, S.
1978 The earliest waves of domestic horses in East Europe, *Journal of Indo-European Studies,* **6**: 17–73.
1984 Horse. In *Evolution of Domesticated Animals,* edited by I. L. Mason, pp. 162–173. Longman, London.

Bouman, I., and J. Bouman
1994 The history of Przewalski's horse. In *Przewalski's Horse, the History and Biology of an Endangered Species,* edited by L. Boyd and K. A. Houpt, pp. 5–38. State Univ. of New York Press, Albany.

Boyd, L., and K. A. Houpt
1994 Activity patterns. In *Przewalski's Horse, the History and Biology of an Endangered Species,* edited by L. Boyd and K. A. Houpt, pp. 195–228. State Univ. of New York Press, Albany.

Catlin, G.
1841 *Letters and Notes on the Manners, Customs, and Conditions of the North American Indians, Written during Eight Years' Travel (1832–1839) amongst the Wildest Tribes of Indians in North America,* reprinted in 1973, Vols. 1 and 2. Dover, New York.
1875 *Life Among the Indians,* reprinted in 1996. Bracken Books, London.
1875 *Illustrations of the Manners, Customs and Conditions of the North American Indians,* Vols. I and II. Chatto and Windus, London.

Caughley, G.
1966 Mortality patterns in mammals. *Ecology* **47**: 906–918.
1977 *Analysis of Vertebrate Populations.* Wiley, Chichester.

Clason, A. T.
1988 The equids of Gomolava. In *Gomolava, Cronologie und Stratigraphie der Vorgeschichtlichen und Antiken Kulturen der Donauniderung und Südosteruopas,* edited by N. Tasic and J. Petrovic. Novi Sad.

Clutton-Brock, J.
1987 *A Natural History of Domesticated Mammals.* British Museum of Natural History, London.
1992 *Horse Power: a History of the Horse and the Donkey in Human Societies.* Harvard Univ. Press, Boston, MA.

Dahl, G., and A. Hjort
1976 *Having Herds, Pastoral Herd Growth and Household Economy,* Stockholm Studies in Social Anthropology, 2.

Dakhshleiger, G. F.
1980 *The Household Economy of the Kazakhs on the Boundary of the 19th–20th centuries [Khoziaistvo Kazakhov na Rubezhe XIX-XX Vekov].* 'Nauka' Kazakhskoi SSR, Alma-Ata.

Dietz, U. L.
1992 Zur Frage vorbronzezeitlicher Trensenbelege in Europa. *Germania* **70**:17–36.

Ermolova, N. M.
1993 Mammal remains from the site of Botai (from the 1982 excavation) [Ostatki mlekopitayushchikh iz poselenya Botai (po raskopkam 1982 g.]. In *Problems in the Reconstruction of Economy and Technology from Archaeological Data* [Problemi Rekonstruktsii Khozyaistba i Tekhnologii po Dannim Arkheologii], edited by V. F. Zaibert, H. A. Aleksashenko, and O. V. Myaksheva, p. 87–89. Petropavlovsk.

Ewers, J. C.
1955 *The Horse in Blackfoot Culture.* Bureau of American Ethnology Bulletin 159, Smithsonian Institution, Washington, DC.

Gade, D. W.
1976 Horsemeat as human food in France. *Ecology of Food and Nutrition* **5**:1–11.

Galton, F.
1883 *Inquiries into Human Faculty and Its Development.* Macmillan, New York.

Grigson, C.
1993 The earliest domestic horses in the Levant? New finds from the fourth millennium of the Negev. *Journal of Archaeological Science* **20**:645–655.

Grinnell, G. B.
1923 *The Cheyenne Indians, Their History and Ways of Life*, Vol. 1. Yale Univ. Press, New Haven, CT.

Groves, C. P.
1986 The taxonomy, distribution and adaptations of recent equids. In *Equids in the Ancient World,* edited by R. H. Meadows and H.-P. Uerpmann, pp. 11–65. Dr. Ludwig Reichert Verlag, Wiesbaden.

Gunga, Zh.
1976 In what is the value of horse-flesh [V chem tsennost' Koniny?]. *Mongoliia* **31**(Pt.2):206.

Houpt, K. A., and L. Boyd
1994 Social behavior. In *Przewalski's Horse, the History and Biology of an Endangered Species,* edited by L. Boyd and K. A. Houpt, pp. 229–254. State Univ. of New York Press, Albany.

Hyland, A.
1990 *Equus, the Horse in the Roman World.* Batsford, London.

James, Edwin, Ed.
1823 *Account of an Expedition from Pittsburgh to the Rocky Mountains Performed in the Years 1819, 1820,* vol. 3, pp. 107–108. London.

Khazanov, A. M.
1984 *Nomads and the Outside World.* Cambridge Univ. Press, Cambridge.

Kislenko, A. M.
1993 An experimental reconstruction of an Eneolithic dwelling [Opit rekonstruktsii eneoliticheskovo zhilishcha]. In *Problems in the Reconstruction of Economy and Technology from Archaeological Data [Problemi Rekonstruktsii i Tekhnologii po Dannim Arkheologii],* edited by V. F. Zaibert, H. A. Aleksashenko, and O. V. Myaksheva, pp. 117–137. Petropavlovsk.

Klingel, H.
1969 The social organisation and population ecology of the Plains Zebra (*Equus quagga*). *Zoologica Africana* **4**(2):249–263.
1974 A comparison of the social behaviour of the Equidae. In *The Behaviour of Ungulates and Its Relation to Management,* edited by V. Geist and F. Walther, 2 vols., pp. 124–132. IUCN Publications, N.S., 24, Morges, Switzerland.

Krader, L.
1955 Ecology of Central Asian pastoralism. *Southwestern Journal of Anthropology* **11**(4):301–326.

Kruuk, H.
1972 *The Spotted Hyena.* Univ. of Chicago Press, Chicago.

Kuz'mina, I. E.
1993 The horse of Botai [Loshadi Botaya]. In *Problems in the Reconstruction of Economy and Technology from Archaeological Data [Problemi Rekonstruktsii Khozyaistba i Tekhnologii po Dannim Arkheologii],* edited by V. F. Zaibert, H. A. Aleksashenko, and O. V. Myaksheva, pp. 178–188. Petropavlovsk.

Lauwerier, R. C. G. M., and W. A. M. Hessing
1992 Men, horses and the Miss Blanche effect: Roman horse burials in a cemetery at Kesteren, the Netherlands. *Helinium* **32**(1/2):78–109.

Levine, M. A.
1979 *Archaeozoological Analysis of Some Upper Pleistocene Horse Bone Assemblages in Western Europe.* Ph.D. dissertation, Cambridge, 1979.
1982 The use of crown height measurements and eruption-wear sequences to age horse teeth. In *Ageing and Sexing Animal Bones from Archaeological Sites,* edited by B. Wilson, C. Grigson, and S. Payne, (B.A.R.) British Series 109, pp. 223–250.
1983 Mortality models and the interpretation of horse population structure. In *Hunter–Gatherer Economy in Prehistory,* edited by G. N. Bailey, pp. 23–46. Cambridge Univ. Press, Cambridge.
1990 Dereivka and the problem of horse domestication. *Antiquity* **64:**727–740.
1993 Social evolution and horse domestication. In *Trade and Exchange in Prehistoric Europe,* edited by C. Scarre and F. Healy, pp. 135–141. Oxbow, Oxford.
1996 Domestication of the horse. In *The Oxford Companion to Archaeology,* edited by B. M. Fagan, C. Beck, G. Michaels, C. Scarre, and N. A. Silberman, pp. 315–317. Oxford Univ. Press, New York.
1998a Eating horses: The evolutionary significance of hippophagy. *Antiquity* **72**(275):90–100.
1998b A preliminary examination of early Iron Age horse palaeopathology at Ak-Alakha 5, Kurgan 3. In *The Phenomenon of the Altai Mummies,* edited by V. I. Molodin and N. V. Polos'mak. Novosibirsk.

Levine, M. A., and A. M. Kislenko
1997 New Eneolithic and Early Bronze Age radiocarbon dates for North Kazakhstan and South Siberia. *Cambridge Archaeological Journal* **7**(2):297–300.

Levine, M. A., and T. Y. Rassamakin
1996 Problems related to archaeozoological research on Ukrainian Neolithic to Bronze Age sites [O probleme arkheozoologicheskikh issledovanii pamiatnikov Neolita-Bronzy Ukrainy]. In *The Don-Donets Region in the Bronze Age System of the East European Steppe and Forest Steppe [Dono-Donetskii Region v Sisteme Drevnoctei Epokhi Bronzy Vostochnoevropeiskoi Stepi i Lesostepi].*

Russian-Ukrainian Conference and Ukrainian-Russian Field Seminar, Vol. 2, Voronezh.

Mohr, E.
1971 *The Asiatic Wild Horse.* J. A. Allen, London.

Montfort, S. L., N. P. Arthur, and D. E. Wildt
1994 Reproduction in the Przewalski's Horse. In *Przewalski's Horse, the History and Biology of an Endangered Species,* edited by L. Boyd and K. A. Houpt, pp. 173–194. State Univ. of New York Press, Albany.

Petrenko, A. G.
1984 *Ancient and Medieval Animal Husbandry in the Volga and Ural regions, [Drevnee i Srednevekovoe Zhivotnovodstvo Srednevo Povolzh'ia i Predural'ia].* Academy of Sciences Moscow.

Rassamakin, Y. Y.
1994 The main directions of the development of early pastoral societies of the northern Pontic zone: 4500–2450 BC (Pre-Yamnaya cultures and Yamnaya culture). In *Nomadism and Pastoralism in the Circle of Baltic–Pontic Early Agrarian Cultures: 5000–1650 BC,* edited by A. Kosko, Baltic-Pontic Studies, Vol. 2, pp. 29–70.

Rossier, E., and C. Berger
1988 La viande de cheval: Des qualités indiscutables et pourtant méconnes. *Cahiers de Nutrition et de Diétologie* **23**(1):35–40.

Schnirelman, V. A.
1992 The emergence of a food-producing economy in the steppe and forest–steppe zones of Eastern Europe. *Journal of Indo-European Studies* **20:**123–143.

Serpell, J. A.
1986 *In the Company of Animals.* Basil Blackwell, Oxford.
1989 Pet-keeping and animal domestication: A reappraisal. In *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation,* edited by J. Clutton-Brock, pp. 10–21, Unwin Hyman, London.

Sinclair, H. M.
1964 Carbohydrates and fats. In *Nutrition, a Comprehensive Treatise,* Vol. I: *Macronutrients and Nutrient Elements,* edited by G. H. Beaton, and E. W. McHenry, pp. 59–114. Academic Press, New York.

Speth, J. D.
1983 *Bison kills and bone counts.* Univ. of Chicago Press, Chicago.

Stuiver, M., and P. J. Reimer
1993 Extended ^{14}C database and revised CALIB radiocarbon calibration program. *Radiocarbon* **35:**215–230.

Telegin, D. Y.
1986 *Dereivka, a Settlement and Cemetery of Copper Age Horse Keepers on the Middle Dnieper.* BAR International Series 287.
1995 *The absolute date of Dereivka settlement and cemetery on the middle Dnieper.* Abstract for conference: Early horse keepers of the Eurasian steppes, Petropavlovsk, June 18–24.

Toktabaev, A.
1992 *Kazakh Horse-Breeding in the XIX c. to the Beginning of the XX c., Historical and Ethnographic Research [Konevodstvo Kazakhov v XIX–Nachalye XX vv. (istoriko-etnograficheskoye issledovaniye)].* Unpublished dissertation summary, Almati.

Uerpmann, H.-P.
1990 Die Domestikation des Pferdes im Chalkolithikum West-und Mitteleuropas. *Madrider Mitteilungen* **31:**110–153.

Waley, A.
1955 The heavenly horses of Ferghana, a new view. *History Today* **5:**95–103.

Wallace, E., and E. A. Hoebel
1952 *The Comanches, Lords of the South Plains.* Univ. of Oklahoma Press, Norman.

Williams, G., and M. A. Crawford
1987 Comparison of the fatty acid component in structural lipids from dolphins, zebra and giraffe: Possible evolutionary implications *Journal of Zoology, London* **213:**673–684.

Willoughby, D. P.
1975 *Growth and Nutrition in the Horse.* A. S. Barnes, South Brunswick.

Zaibert, V. F.
1993 *The Eneolithic of the Ural-Irtish Interfluve [Eneolit Uralo-Irtishskovo Mezhdurech'ya].* Academy of Sciences, Republic of Kazakhstan, Petropavlovsk.

Zaleski, E.
1984 The collectivization drive and agricultural planning in the Soviet Union. In *The Soviet Rural Economy,* edited by R. C. Stuart, pp. 79–106. Rowman and Allanheld, Totowa.

NOTES

[1] "Reduction in size on the one hand and increase in variability on the other are classic indicators of domestication" (Uerpmann 1990, p. 127).

[2] Excavated in 1994 and 1995 by Tatiana Nerudenko, Scientific Director of the Chigirin State Historical Park, Ukraine.

[3] Clutton-Brock (1992, p. 19) defines feral animals "as those that live in a self-sustained population after a history of domestication."

[4] Collectivization refers to the socialisation of ag-

riculture, by which food production was transferred from private farms to collective and state farms (respectively, kolkhozes and sovkhozes). This process began in Russia in 1927 (Zaleski 1984).

[5] Following Serpell, "The Oxford English Dictionary (OED) defines a pet as "Any animal that is domesticated or tamed and kept as a favourite, or treated with indulgence and fondness." In practice, however, the word tends to be used more loosely as a blanket description for animals that are kept for no obvious practical or economic purpose" (Serpell 1989, p. 10). Since the former definition may be impossible to apply to archaeological and ethnographic contexts, the latter is be used here.

[6] Also written as "Comanche."

[7] An *aul* is a Kazakh village.

[8] Age determinations from Lauwerier and Hessing (1992).

[9] According to a new typology, it belongs to the Dereivka culture within the Sredni Stog region (Rassamakin 1994).

[10] Botai is located at 53°10′ north latitude, 67°40′ east longitude. The central part of the settlement is 238 m above sea level.

[11] All the site information presented here is from the excavation notes of A. M Kislenko and N. S. Tataryntseva.

[12] Teeth less than half complete are excluded from the population structure analysis.

[13] Although increased age is associated with increased incidences of certain types of pathologies, the age difference between the horse populations at these two sites is unlikely to be great enough to account for the observed pathological differences. This is the subject of ongoing research by M. A. Levine, G. N. Bailey, and L. B. Jeffcott.

[14] I am collaborating with R. P. Evershed and S. Vaughan (Organic Geochemistry Unit, School of Chemistry, Bristol) on an analysis of lipids in pot residues and bone from Botai and from bones and flesh from Ak-Alakha 3; and with T. O'Connell and R. E. M. Hedges (Research Laboratory for Archaeology and the History of Art, Oxford) on a stable isotope study of material from Ak-Alakha 3, Botai, Molukov Bugor, and other Ukrainian sites.

[15] C. A. I. French (Department of Archaeology, Cambridge) is carrying out a micromorphological analysis of sediments from Botai.

[16] In collaboration with G. N. Bailey (Department of Archaeology, Newcastle) and L. B. Jeffcott (Department of Clinical Veterinary Medicine, Cambridge), I am working on a NERC funded project concerned with horse palaeopathology.