

OSTEO-ARCHAEOLOGY AND THE ANALYSIS OF DOMESTIC ANIMAL
REMAINS

Submitted and pledged in fully by

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Osteo-Archaeology and the Analysis of Domestic Animal Remains

The collection and investigation of animal bones are more often the concern of the paleo-archaeologist or the geologist than the archaeologist operating on an historical site. The former attempt to determine something of the climate and culture of a prehistoric age through the interpretation of floral and faunal remains which date to the period. The latter is usually preoccupied with the reconstruction of an early culture through its material equipment-- its artifacts and its buildings. Because the faunal and floral environment of an historical site is likely to be recorded in existing documents, pottery fragments and the like usually take precedence over biological remains.

It may well be that animal remains receive less attention from the historical archaeologist for purely economic reasons. The identification of animal species from teeth and fragmentary bones requires a specialized knowledge of anatomy and zoology. The application of this knowledge to the findings at a dig demands a great deal of time and effort, and even then the findings are often of limited value. Should all this time be directed to material artifacts--of which the archaeologist already has a certain knowledge--the results would probably be more informative and definitive; the archaeologist, like all scientists, must invest his efforts where the yields are greatest,

Though the archaeologist must not necessarily be his own

zoologist, a working knowledge of osteology can often be quite useful, even at historical sites, At Liberty Hall specifically, close interpretations of animal remains could conceivably reveal facts about the species and numbers of the livestock that were originally kept near the steward's house, They could also indicate the more recent farming uses of the land; whether it was used in later years as a feed lot or grazing land. These findings could, perhaps, lead to a more complete understanding of the number of students who were fed from the steward's kitchen, and their eating habits.

The following pages will focus on techniques used in the archaeological study of animal bones, particularly those of domestic animals of recent origins. Where it is appropriate, attention will be drawn to the direct implications of the methodology for the present work at Liberty Hall

There is no need, here, to make any lengthy introductory comments on the nature and history of animal domestication, or the varieties of animals that were most likely to have been found in the Liberty Hall barnyard-assuming there once was one, The animal bones which have and will be excavated from Liberty Hall probably belonged to species which are common to the farmlands of Rockbridge County today. For the most part, the animal remains on Mulberry Hill should prove to be those of a few representative domestic farm animals: sheep, pigs, goats, cows, horses, dogs, cats, turkeys, and chickens, If the steward did raise the meat for his

kitchen, the most abundant bones will probably be those of the chicken, the pig, the cow and the sheep-in that order, excluding factors of loss, disintegrating etc. The records of the Rockbridge County courthouse indicate these to be the most commonly raised farm animals at the time; the tavern rates also recorded in the c house records, show chicken, pork, mutton and beef to be the preferred meats. Then as now, chicken and pork were the most popular fare because they were the cheapest.. Regardless of whether the bones found at the site are those of locally raised animals or were merely discarded there in a refuse heap, some dietary and other information is almost sure to be gleaned from them.

AGING BONES

Four conditions must be fulfilled to establish a close estimate of the age of an animal. First, the animal must belong to a species of which the aging characteristics have been well defined. Second, the nutritional plane of the animal must be known. Third, most of the teeth and a representative selection of bones must be available. And last, the animal must have died or have been killed before reaching full adulthood.¹

It is difficult in actual practise, i.e., in an archaeological dig, to meet these basic requirements for a number of reasons. Three apply specifically to the historical archaeological sites A) Age characteristics are well documented only for modern domestic animals. Bone remains from sites dated before intensive selective

b tding began may differ considerably from homologous bones of
 •odern animals of more highly specialized breeds. B) Tooth erup-
 tion dates and epiphysial fusion dates vary significantly between
 individual breeds within a single species. C) It is difficult to
 positively identify several bones as belonging to one animal.²

Methodology

The most widely used method for assessing the age of an
 animal by its bones relies on the determjnation of the degree of
 bone ossification. All bones are pre-formed in cartilage. Ossi-
 fication begins at one or more centers for each bone and pro-
 ceeds until the whole bone has become rearranged structurally.³
 The process is constant for each bones and can therefore be used
 as an aging index. There are two general sources for bone age
 information• The degree of ossification and bony fusion of the
 bones of the skull, especially those of the vault; and the state
 of ossification in the various epiphyses of the long bones.⁴

Long bones are defined as all the bones of the limbs and
 extremities except for two groups of bones• the wrist (carpals)
 and ankle (tarsus). The long bone consists of a shaft (diaphysis)
 and articular ends (epiphyses). In early youth these bones
 ossify from one center for the shaft and others for the terminal
 epiphyses. The separate bony masses are not firmly united until
 the animal has reached adulthood. Once ossification has begun, the
 age of an animal can be approximated fairly closely by noting the
 regions where epiphysial fusion has occurreQ, When full adulthood

is reached, that is, after all epiphyses are fused, it becomes increasingly difficult to discern the degree of advanced aging.⁵ However, changes do occur during the adult period which enable one to distinguish between a young, middle-aged, or elderly adult.

At first, the shafts of the limb bones are relatively long and slender and the extremities are large. There are few surface marks on the bone and prominences for tendon and muscle attachments are small. In the mid-adult phase the bones become more rugged in appearance and the extremities are relatively narrower. Marks caused by blood vessels become obvious and tendon attachments may ossify to give "traction epiphyses." Smaller prominences associated with muscle attachment appear, and depressions at muscle origins are deep. The cortex of the bone is thick and the bone is heavy. In senility, calcium resorption takes place resulting in a bone with a thin cortex and large medullary cavity.

Little work has been done toward the determination of animal age by changes in the bones of the skull. In man, however, these changes have been closely studied and extensively documented. The process of aging in the human cranium, briefly outlined below is basically similar to the same process in domestic animals. In the skull, ossification begins at one or more centers and proceeds until adjacent bones meet at their sutures or seams. An incompletely ossified cranial bone has a thin, irregular "feather-edge" and a spicular or crystalline appearance caused by mineral salts which are in the process of deposition.⁷ At birth, the facial parts and skull base are very small compared to the vault or roof. Most of the bones are incompletely ossified and have not everywhere made contact with adjacent bones. At the unossified angles of the bones there are gaps closed only by cartilage, known as fontanelles. In infancy and childhood the fontanelles close and fill out as the

bones thicken along their sutures; the cranium thus develops a more rounded contour.⁸

During adolescence and youth changes in the skull are mainly matters of growth and proportion. Precise age determination during this period must rely on evidence from the teeth and the long bones.⁹ In adulthood the full skull dimensions and proportions are attained and age determination from 20 years and upwards depends almost entirely on the progressive obliteration of the cranial sutures. This is fortunately a protracted process and does not occur simultaneously in all regions.¹⁰ Chart I which is based on the obliteration of the sutures can be used to estimate within ten years, the age of a given individual between 20 and 50—hardly an exact discrimination.

In maturity and old age skull changes in all mammals are degenerative in nature. The bones become thinner and lighter, Loss of teeth may cause regressional changes in the upper and lower jaw which result in an apparent reversion to childlike morphology, The narrowing of the ascending ramus (vertical process of the lower jaw), and the filling up with bone of the alveoli of the jaws where teeth have been lost may all be useful as guides to age.¹¹

In horned domestic animals, measurements of horn-core can be useful age determinants. A horn-core from a young animal has a relatively narrow cortex and a large sinus cavity, With advancing age, the cortex thickens and the sinus cavity is reduced. In cattle, the horn itself will show annual growth rings after the first

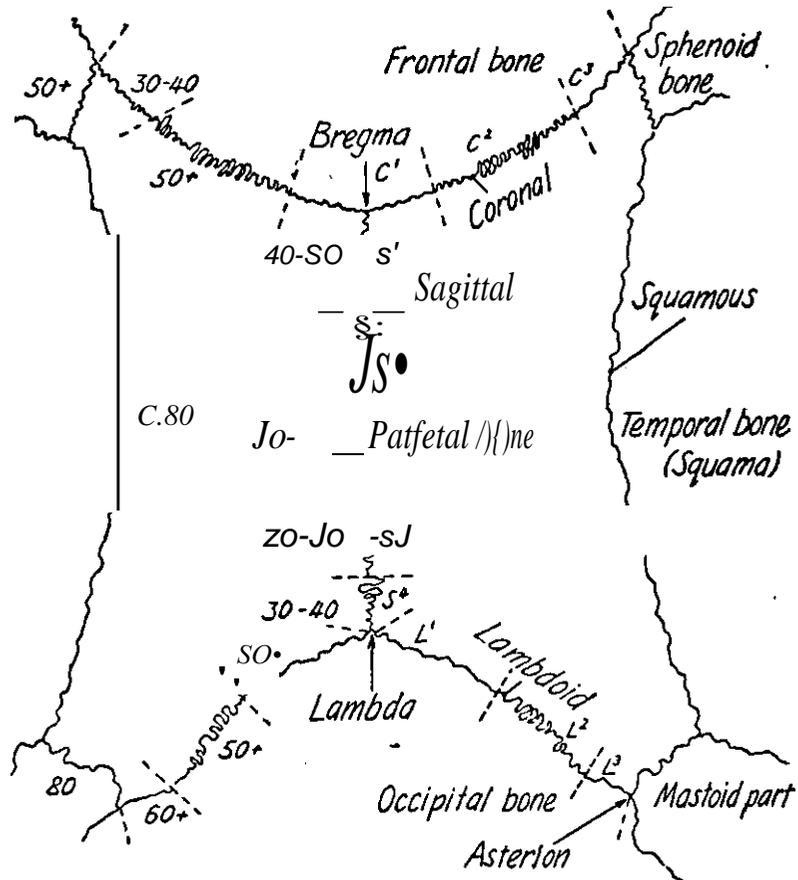


FIG 55. *Homo sapiens*, plan of vault of skull and ages at which sutures are obliterated (After H. V. Vallois). For more exact description, the sutures are sub-divided into regions. Thus C¹ means the most medial region of the coronal, S' the most posterior of the sagittal.

chart I.

two years of age,¹²

Though the fusion rates of the various cranial bones and the progressive obliteration of suture has not been as well indexed in most domestic animals as they have in man, there are more general features of aging in nearly all mammals which can be detected. The proportions of the skull change strikingly with the face usually increasing in size much faster than the cranium. In many domestic animals at early ages the bones of the forehead are convex but gradually flatten with growth and may become concave in old age. The maxillary region is also primarily convex, becoming concave with the appearance of the cheek teeth. The caudal border of the vertical ramus of the mandible (lower jaw) becomes narrow and sharp in very old animals, particularly horses and mules. The cranium behind the post-orbital bars is wider in young mammals than in adults. The various prominences, eg. the nuchal and sagittal crests and the lacrimal tubercle become more pronounced with age. And finally, the infra-orbital foramen enlarges from a slit in youth to a large, almost round hole in old age.¹³

Bird bones, such as those of the chicken or perhaps the turkey, with which we are mainly concerned, can be easily separated from those of other mammals with little experience. Their distinctive features of size and quality (brittleness, hollowness) make them relatively simple to distinguish. About the best method for identifying a bird bone, is to study the skeletons of some of

the birds now common in the area and compare these bones with those excavated. Such a detailed identification is rarely necessary; the interpretation of the general-information suggested by the presence of the bones is of greater importance.¹⁴

AGING TEETH

Of all animal remains, the tooth is the most durable and often the most informative for archaeological purposes. A single tooth may indicate the species of animal, its feeding habits, its age and even its approximate size.¹⁵ - The teeth of most mammals are composed of three substances of differing hardnesses&

- 1) Enamel, a very dense, hard and brittle outer casing, resistant to wear, generally forming a complete envelope to the part of the tooth exposed above the gum;
- 2) Dentine (or ivory), of which the greater part of the body and roots of a tooth consist. This is secreted by the living pulp which forms the core of the tooth. Dentine is fairly hard but tougher and more resilient than enamel.
- J) Cement is a softer, more granular, bone-like substance, covering the dentine of the roots and sometimes also more or less investing the enamel walls and crown, filling folds and valleys in it.¹⁶

The tooth itself is usually divided into three regions-a) the crown, that part covered with enamel b) a body c) the roots (both of dentine) and d) a neck, a more or less well defined separation between the body and roots.

Mammal dentition is divided into four distinct functional groups of teeth&

- 1) Incisors, for nibbling, cutting or gnawing.
- 2) Canines, long pointed teeth, especially well-developed in

in carnivores for seizing prey and tearing flesh and for use as weapons.

- J) Premolars have a transitional function between the cutting and grasping front teeth and the grinding cheek teeth. They are developed to assist in what ever function (cutting or grinding) is more important to the animal species,
- 4) Molars, or grinders are adapted primarily for crushing the food., They are of relatively little use to carnivores but are the most important group to the herbivores, especially the grass-eaters, 17

This functional differentiation in mammalian teeth is known as heterodont (several kinds of teeth) dentition. 18

Most mammals have in youth, before the eruption of the permanent teeth, a set of deciduous teeth commonly known as milk teeth. The order of eruption and stages of replacement of the milk teeth by the permanent vary widely between species and when indexed afford a useful scale for the age determination of immature animals. 19

The high crown on hypsodont teeth are the best indicators of age in an adult animal. These teeth grow out of the jaw at a fairly constant rate as they are worn away. The hypsodonts, which are characteristic of many vegetable-feeders and therefore of particular interest here, change not only in regard to length but also in respect of the crown pattern. Their enamel is deeply folded and the folds are filled with cement., As the teeth are worn, the folds undergo characteristic alterations which, when examined by the experienced eye, can serve as relatively accurate age indicators. 19

The maximum accuracy for aging by dentition can, unfortunately, be achieved only during the infantile and adolescent ages, the same

period in which bone aging is most reliable. There are, however, ways of distinguishing between young, middle-aged, and senile animals by their dentition. For example, in horses the first molar is commonly diseased (by caries) in the young to middle-aged adult, whereas caries in other cheek teeth is rare and is more often an indication of advanced age.²⁰ A comparison of the tooth size with the size of the alveolar cavity (the tooth socket)-that is, of course, if the tooth is preserved in the jaw-often serves as an indicator of the animal's age. In carnivores, for instance, if the teeth have roots which are markedly smaller than the alveoli, then it is likely that the animal suffered from paradental disease and was old.²¹

Tooth wear is a common sign of aging in animals, but caution must be taken before any conclusions can be drawn from this process alone. Many factors can influence the rate of tooth wear and it is best to supplement age observations based on it, with evidence from skeletal sources. Puppies' teeth usually show signs of heavy wearing because of their teething habits. In herbivores, diet, ie. their normal plant food, is an important factor; animals grazing on sandy soil and short grass show a higher rate of wear than animals that feed on tall, soft grass.²²

SEX DETERMINATION FROM ANIMAL BONES

It is desirable to know the sex-ratio of a group of domestic animals for many reasons. On the simplest level, this ratio can be

used to estimate the yearly probabilities of offspring production, ie, herd growth; it provides clues to the economic importance of the animal; and to an extent, it offers evidence of the total herd population.

As in man, sex differences are mainly manifested by degree rather than by kind. However, there are animals whose qualitative sexual dimorphism is striking- such as antlers in the male deer, Other differences are not so blatant but are still obvious; bulls usually have stouter horns than cows, and boars longer tusks than sows. Nevertheless, without a large sample and a careful statistical treatment of the bones, it is difficult to discover the line between sexes in an animal population, Furthermore, well-documented sex-differences in one species of domestic animal are not equally valid for other species,

In any case, sex differences in animals are not nearly as well defined as they are in man, The best method for animals continues to be the quantitative method whereby measurements are defined, indices are made based on these measurements, and adequately sized statistical study is used to correlate these variables.²³

DETERMINATION OF SPECIES FROM BONES

Few people with any knowledge of animals would experience real difficulty in assigning an entire skeleton to the class mammalia. However, it is rare that an entire skeleton is ever preserved in tact at an archaeological site, The necessity thus arises for a technique

for determining an animal's species on the evidence of a complete or nearly complete, single bone.

An excellent system for making such determinations, is that of Cornwall.²⁴ His identification scheme is based on a systematic process of elimination. He begins by assessing what part of the mammalian skeleton the bone represents. By first doing this, such errors as mistaking a finger bone of a larger species for one of the main bones of a smaller species can be avoided. He then notes the articulation characteristics of the bone-how many points of articulation there are, whether they are flat, concave, or convex etc, Cornwall's detailed outline describing the general, characteristic features of each bone will not be repeated here. Suffice it to say, that given this outline, even an amateur can determine the function of a mammalian bone.

Once the function of the bone is determined, the next step is settling on the species from which it came. The first elimination in this process is by size. If a bone, for instance a femur, is of moderate length, one can immediately eliminate the possibility that it came from a small mammal (Insectivora, Chiroptera, Rodentia, Carnivore, and Primates, save man) or that it came from a very large mammal (elephants, rhinoceroses, hippopotamuses, etc.). The important exercise, here, is to refrain from telling oneself this is not a horse bone; instead *one* must be able to explain why it is not a horse bone.²⁵

Returning to our moderately sized femur, let us say that we have

been able to narrow the species possibilities by size alone to the following animals-man, a large carnivore (bear or lion), horse, pig, large deer or a larger cow. Based on the bone's dimensions, some further eliminations are possible. One can reason that an adult man, cow, or horse could not have a femur this small.. The fusion of the epiphyses is studied and it indicates that the bone is decidedly that of an adult. Logically, **if** the femur does not belong to an adult man, cow, or horse, then the choices are limited to the smaller animals in our group-and all young animals are eliminated.26

The second elimination involves deciding on the order of mammal to which the bone belongs. Withh, here, the species must be named, These steps involve the most intensive zoological and anatomical study, These differentiations are based on detailed facts concerning characteristics of the bones' shaft, its head, and general data such as whether or not the bone *is* too short or too stocky to belong to a carnivore etc, In assessing species specific characteristics, further anatomical analyses are made, but these alone are seldom exact enough to be conclusive. By far, the most discriminating species eliminations must be made, not on the basis of the physical characteristics of the bone, but through its relationship to other finds in the dig of known origin and date, and the location of the site,

.The **first** step, once this somewhat rigorous preliminary assessment of species has been made, **it** to compare the bone with known

material. If a whole series of comparative specimens is available, then this task can be completed with little discrepancy. However, when incomplete species comparisons only are possible, as is more often the case, one must necessarily employ some educated guesswork, making allowances for differences in sex, age, heredity, and environment.

Despite the exactitude of this method, some species differentiations will still be impossible. In sheep and goats, for example, most of the bones are so similar (excluding the horn cores and metapodials) that the species are often included together in archaeological literature as "sheep/goat" or "caprovid"²⁷.

DETERMINATION OF ANIMAL POPULATIONS

Certainly, one question the archaeologist must ask himself when studying animal remains is, from how many individuals has the bone material come? This is always difficult to discover. Dead animal carcasses are often thrown onto garbage heaps; carnivores (wild or tame) may have removed bones from the area; burrowing rodents may have removed some of the bones sooner or later after their deposition; the site may have been partly altered by natural forces (erosion etc,) or by modern activities, such as farming; and, of course, broken, crushed or otherwise highly deteriorated bones will further distort the true numbers of the original animal population.;⁸

Until recently, the most commonly used method for estimating

animal populations was the "minimum number approach," It simply takes account of the most frequently found bone (in paired bones, either the left or right) and calls this the number of individuals. If, for example, 10 left calf metacarpals are found, then there were at least 10 calves, maybe more, but not less.²⁹

This method is not satisfactory for the very reasons cited above—bone loss in one way or another. S. Bokonyi has developed a method which offers much more precise analysis than this simplistic approach. Bokonyi begins by dividing the bones of all species into four groups according to age: a) juvenile b) sub-adult c) adult d) mature and senile. Each age is then further divided into small, medium, and large individuals, leaving 12 groups in each species. The minimum number of individuals for each group is determined and the sum of all 12 groups is found. Number of individuals = sum of minimum number of individuals in all groups. In practice this gives a higher number of individuals than the "minimum number" technique. Here is Bokonyi's illustration.

At a given site the most frequently found cattle bone is the left metacarpal. 10 pieces all from adult animals. But there are also 5 juvenile right metacarpals, 8 sub-adult radii, and 2 senile mandibles. With my method the number of individuals increases from 10 to 45. And if one determines that all 10 left metacarpals are from medium sized animals, but in addition there are 8 adult right metacarpals from large and 7 from small individuals, we then have the bone not of 45 but of 60 individuals.

This is no doubt not the actual number but it is more accurate than the former "minimum number."

A second method, that of Krantz, is based on the examination

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of mandibular halves and works best on medium sized herbivores. The mandible of most mammals is composed of 2 bones which should separate in butchering as well as any two bones. Krantz has selected it here because it is very hard bone with a high survival rate and because it is one of the best diagnostic bones for the identification of species. Furthermore, it is about the easiest of all paired bones to match according to individuals.

His procedure is to segregate jawbones into rights and left and to determine which can be paired off, It disregards small fragments which cannot be confidently assigned. If all jaws were recovered, then every right and left mandible could be matched,, If half of the original bones were recovered then agiven left mandible would have a 50/50 chance of having its mate on the right. If half the recovered lefts can be matched with rights, then the sample of recovered mandibles is one-half what was originally deposited, Krantz summarizes his method with this equationa 31

N=number animals in original population

R= total of right mandibles found

L= total of left " "

P= number of established pairs

$$N = \frac{R^2 + L^2}{2P}$$
 (Sampling error is increasingly significant as the number of bones decreased)

Ag in, Krantz's sophisticated, if somewhat limited, technique like Bokonyi's is not perfectly accurate; both do, however, show imagination and are decided improvements over the old methods.

INTERPRETATION OF FRAGMENTARY BONES

As mentioned earlier, most bones found in an archaeological site are for one reason or another, in fragmentary form. Often the fragments are too small or too altered to offer any useful information. Some, however, which at first glance appear worthless, may with a little effort and a lot of luck provide a surprising amount of information. From the outset there are two points that the archaeologist must keep in mind when dealing with fragments: What kinds of fragments are determinable? and What fragments are worth determining?²

Size is never a measure of importance. Remember, a single tooth can tell us the animal's species, age, and size, while a huge femur fragment may tell us no more than that the animal was large. Unless a bone's function can be identified, the species to which it belongs cannot be determined. Since bones are recognized largely by the characteristics of their articulations, it is important to recover articular surfaces, including loose epiphyses of immature bones. Shaft fragments also may retain identifying evidence. For example, a single inch of the shaft of a human femur, with its characteristic raised linea aspera, is enough to conclude that it came from a man. These shaft-fragments should be carefully examined for clues which might point to their function or might enable a match with comparative material.^{JJ}

The following is a partial list of fragments that should never be discarded:

be

- 1) Teeth-even a piece of enamel showing any possible characteristic sculpture
- 2) Toes-loose phalanges may not always enable exact determination between species of similar size, but still may provide information
- J) Multi-faceted carpals and tarsals-the astragali and calcanea .especially since different animal groups have different arrangements at wrist and ankle
- 4) Horn-cores, hoof cores, and antler fragments-horn-cores may be the only way to distinguish between sheep and goats
- 5) Any bones found in their correct articulated positions
- 6) Several fragments found together-joints may be preserved which will enable the rebuilding of something significant
- 7) The alveoli in maxilla or mandible J4

These cases are by no means exclusive. The important principles to follow are always to excavate carefully, noting possibly significant spatial relationships between bones, carefully lifting those which appear worthy of preservation and study, and collecting all fragments which might be associated with a single specimen. Splinters, fragments of long-bone shafts which bear no characteristic features, broken vertebrae and ribs, and small skull, mandible, and pelvis fragments which are unrelated to any portion worth re-assembling, may all be discarded, J5

Conclusion

The archaeologist must exercise his own discretion in picking and choosing between the fragmentary bones which he feels will offer valuable information and those which will not. Obviously, at a site of permanent human settlement the number of bones and fragments will be quite large, In such cases, it is unnecessary to analyze all the bones if the costs in time, effort, and money would be prohibitive

anyway. He must carefully choose the remains which are sufficiently-complete to give an unequivocal answer to their origin quickly. This, of course, does not suggest that he disregard all fragments which he cannot identify at first glance. As Cornwall writes a

•••it is the occasional wild mammal, fish or bird which holds considerable interest, as supplementing the basic menu of beef, mutton and pork, which the bulk of the collection usually represents. Only those doubtful fragments which could most readily belong to the list of common species at the site should be jettisoned forthwith•• The remainder is worthy if a second review, in case the original element of doubt should have resided in their being unusual rather than altogether inscrutable,,J6

This statement is, and is not, applicable to the Liberty Hall dig. It is applicable, in that , as mentioned previously, the common diet of the people who inhabited the region is well described in recorded history, it is, therefore, the less common supplements to this diet which will provide a more complete picture of life and times. It is not applicable in the sense that Cornwall is speaking of digs where animal remains are found in an over-abundance, So far, this is not true of Liberty Hall-though bones have been found, their numbers have not been bewilderingly large, The value of the smaller and less easily determined fragments is consequently increased. These fragments will become progressively informative and meaningful as they are matched to complete bones belonging to the same species. When this is done, even minute features of each fragment-small details of surface relief, shallow muscle impressions and unnoticed small foramina for nutrient vessels-will all add to the reconstruction of the kinds and importance of the **domestic** animals that were once raised (or-consumed) on Mulberry Hill.Jq

FOOTNOTES

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2. Ibid.
3. Ibid.
4. Cornwall, *Bones for the Archaeologist*, (The Macmillan Co., 1956), p. 219
5. Ibid.
6. Silver, p. 284.
7. Cornwall p. 219.
8. Ibid. 221
9. Ibid. 223
10. Ibid.
11. Ibid. p. 222.
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15. Silver p. 290
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17. Huidekoper, Rush S. *All of the Domestic Animals; Description of the Horse, Sheep, Pig and Dog* (Philadelphia: F. A. Davis Pub., 1891). p. 8.
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21. Ibid.
22. Ibid.
23. Cornwall p. 234.
24. Cornwall p. 185.
25. Ibid. 191.
26. Ibid. 192.
27. Charles A. Reed. "Animal Domestication in the Prehistoric Near East" in *Science*, vol. 130, 1959, p. 1634.
28. Grover S. Krantz, "Population Estimations Based on Mandibles" in *American Journal of Archaeology* vol. 72, 1968 pp. 286-288.

29. S. Bokonyi, "New Method for the Determination of the Number of Individuals in Animal Bone Materral" in American Journal of Arch eology vol. 74, 1970, 291.
30. Ibid.
31. Krantz p. 287.
32. Cornwall p. 196.
33. Ibid. p. 198
34. Ibid.
35. Ibid.
36. Ibid. 199.