Peter Rowley-Conwy, with a contribution by P. K. Thomas

Chapter 13
The Faunal Remains

Introduction

The study of faunal remains from archaeological sites has a long history. Methodological advances over the years have meant that zooarchaeological studies can yield a great deal of information. It has increasingly been understood that such information has been more useful to *archaeologists* than to *zoologists*. This is for two reasons. Firstly, the zoological history of more recent times is now quite well known, so zooarchaeological studies do not add much to the sum of current knowledge. Secondly, animal remains from archaeological sites are usually present because of human action. They were acquired, killed, processed, consumed and their remains discarded entirely within the cultural context of the humans who inhabited the site. This cultural context is the very thing archaeologists seek to reconstruct, and the animal remains form a valuable and powerful means to assist in this task. The following report is written entirely from this perspective.

This report discusses the faunal remains from Paithan. A grand total of 4,777 fragments of bone, tooth, scute and shell were examined, although as is usual, only a small proportion of these could be identified to species. A total of 490 items were identified as coming from the four most common domestic species: sheep (*Ovis aries*), goat (*Capra hircus*), pig (*Sus scrofa*) and cow (*Bos indicus*). Smaller numbers of items were referred to other taxa. They will be discussed grouped into the four major periods represented at Paithan (Periods 1 to 4, see Chapter 6).

An added complexity is that some layers and contexts in Period 3 are directly associated with the construction of the temples, while others are not. The Period 3 remains are therefore divided into Period 3-temple contexts and Period 3 contexts. If no subdivision of Period 3 is specified, then the overall period total comprising both 3-temple and 3 is being referred to.

Some previous bone reports are available from sites in the region which fall into this time range, and these are useful for comparative purposes. They include Nasik (George 1955), Nevasa (Eapen 1960) and Bhorkardan (Rao 1974), all the reports providing considerable detail about the bones present. Because of the nature of the site of Paithan, the present report will set itself two additional goals. First, the fact that four major periods are represented means that it is possible to examine *change through time*. Second, to achieve the first goal, *precise quantification* must be undertaken of the remains in each phase. As will be seen below, the outcome provides information of the greatest interest.

One factor which has a major effect on any sample of archaeological animal bones is the method by which they were recovered. Contrary to popular opinion, archaeologists and excavation labourers do not detect and recover all items in the deposits they are excavating: many objects are overlooked. Not surprisingly, it is the smallest objects that are most often overlooked. This has a predictable effect on zooarchaeological samples: bones of smaller animals are overlooked more frequently, and smaller animal species are therefore under-represented in the identified totals. This is true whether the excavators are fully trained archaeologists (Payne 1972, 1975) or labourers specializing in archaeological work (Rowley-Conwy 1994). The proportions of smaller bones overlooked vary greatly, depending not just on the degree of skill and diligence of the excavators, but also on factors such as soil type and moisture, amount of daylight and weather conditions and time of day. It is therefore generally recognized that it is necessary to sieve archaeological deposits in order to ensure unbiased representation of zooarchaeological remains (and indeed of all kinds of archaeological items). The Paithan excavation was conducted to fully modern standards. All deposits were sieved through 5-mm mesh, so the faunal samples may be considered unbiased by recovery.

Another factor that can have a major biasing effect on assemblages of animal bones is gnawing by dogs. If dogs have access to the bones after their discard by people, they may damage or destroy many fragments. Unfortunately, such destruction is not random: some elements within the animal skeleton are harder than others, and dogs tend to destroy the softer ele-

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ments more frequently. The bones of younger animals are also softer than those of adults, so juveniles also suffer greater losses (e.g. Brain 1981; Binford 1981; Legge 1992). Gnawing by dogs may be recognized in two ways. First, tooth marks may be present. Second, if a bone has passed through a dog's digestive system, the powerful digestive acids often leave characteristic etching on the surface of the bone (if they do not destroy it completely) (Payne and Munson 1985). At Paithan, very few bones exhibited such damage (Fig. 13.1). In Period 1, one fragment was gnawed and one digested; in Period 2, one was gnawed; in Period 3, three were digested; and in Period 4, a single fragment showed traces of both gnawing and digestion. These very small totals suggest that dogs did not have much access to the animal bones at Paithan, so the effects of this biasing factor are likely to be insignificant.

Two of the common biasing factors may thus largely be discounted. We may therefore approach the Paithan assemblage with a degree of confidence.

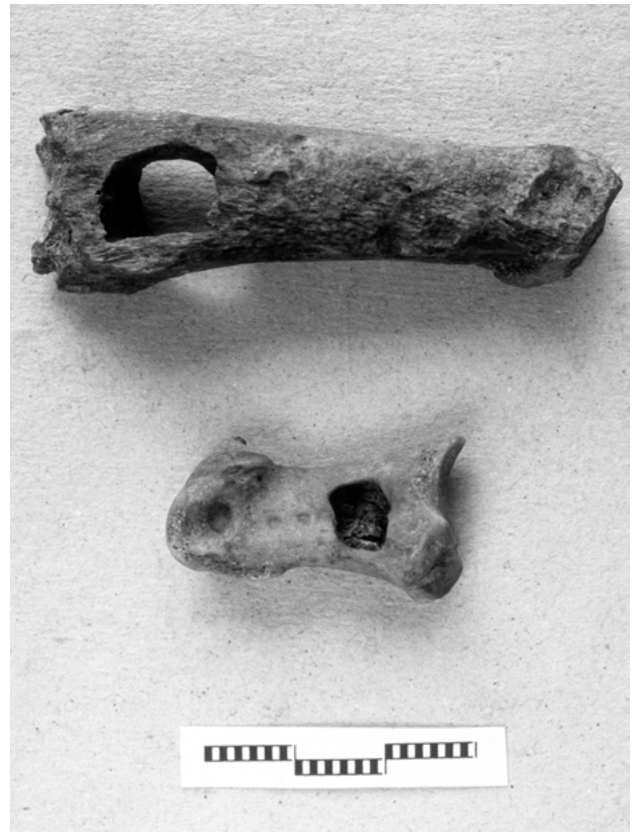

Fig. 13.1: Phalanges of blackbuck (*Antilope cervicapra*) showing the characteristic etching caused by the digestive acids of dogs (top) and holes caused by gnawing (both specimens). The specimens were identified to species by Dr P. K. Thomas.

Species represented

The animal bones from Paithan were transported to Goa along with the rest of the excavated material for post-excavation study and were identified there by the author in 2000. It is desirable wherever possible to identify animal bones with the help of a comparative collection. However, no such collection was available in Goa, so the specimens were identified using the author's drawings and identification notes. Most of the identified specimens were from species with which the author has long been familiar, namely sheep, goat, cow and pig, and basic classification of the fragments as sheep/goat, cow and pig was usually unproblematic. The 490 specimens identified as coming from these taxa are listed in Table 13.1; the totals are unmodified in any way, thus conforming to the 'Number of Identified Spec-

Table 13.1: Number of Identified Specimens (NISP) of the main domestic taxa at Paithan, divided by layer and expressed as percentages of the layer total.

Period	1		2		3						4	
					temple		ordinary		total			
	N	%	N	%	N	%	N	%	N	%	N	%
Sheep/goat	52	35	73	51	38	56	20	56	58	56	64	67
Cow	40	27	37	26	25	37	10	28	35	34	28	29
Pig	55	37	33	23	5	7	6	17	11	11	4	4
Total	**147**		**143**		**68**		**36**		**104**		**96**	

imens' (NISP) method of quantification (other methods of quantification will be discussed below).

The separation of sheep from goat is a considerable problem, and the NISPs of the two species are amalgamated in Table 13.1. Only a minority of skeletal elements can be reliably and consistently separated, although methodological improvements continue to be made (see Boessneck 1969 for a general review). Among the most useful elements are distal metacarpal and metatarsal (Boessneck 1969; Payne 1969; Rowley-Conwy 1998), the deciduous dentition (Payne 1985) and the distal tibia (Kratochvil 1969), and since the Paithan material was examined, a method has been published using the permanent dentition (Halstead *et al*. 2002). The small number of bones that could be definitely identified as sheep or goat using these methods is listed in Table 13.2. The sample is too small to permit precise conclusions to be drawn, but it may tentatively be suggested that (a) both species were present throughout; (b) sheep consistently outnumbered goats by between 2.75 and 8 to 1; and (c) there is no indication that the proportions changed through time. The small size of the identified sample must however be born in mind.

Apart from the major food taxa, various other items were identified (Table 13.3). Canids were the most common mammal. Dog (*Canis familiaris*) and jackal (*C. aureus*) are notoriously hard to distinguish, especially without comparative skeletons, and no attempt to do so was made in this instance. Under the circumstances, however, it is likely that most or all of the bones come from domestic dogs: they would most probably have been present and would have acted to keep jackals away from the human settlement. Single fragments of teeth from members of the horse family (Equidae) and deer family (Cervidae) were also identified, but species could not be determined. Small numbers of bones were identified as coming from birds and fish, but again, species could not be determined. Finally, 130 shells of various kinds were counted. They were referred to three main groups (see Table 13.3).

Table 13.2: Number of sheep/goat specimens definitely identified as either sheep or goat.

Period	1	2	3			4
			temple	ordinary	total	
Sheep	10	11	2	6	8	10
Goat	2	4	0	1	1	2

Table 13.3: Other specimens identified by the author, not included in Table 13.1.

Period	1	2	3			4
			temple	ordinary	total	
Dog or jackal	2	3	5	1	6	6
Equid	0	0	0	1	0	0
Deer	0	1	0	0	0	0
Bird	5	12	3	0	3	1
Fish	5	1	4	2	6	21
Frog or toad	0	0	0	1	1	0
Gastropod	15	14	3	9	12	4
Bivalve	40	13	0	1	1	3
Cowrie	0	0	0	4	4	24

Once the identifications described above had been made, there remained a number of specimens which were clearly potentially identifiable, but which came from species with which the author was not familiar. It was most fortunate that the author was able to visit Deccan College in Pune and consult Dr P. K. Thomas about these specimens. Dr Thomas kindly identified the various specimens, which are listed in Table 13.4. A fragment of crocodile mandible containing two teeth (Fig. 13.2) was identified as belonging to *Crocodilus palustris*. Twenty-one turtle scute fragments were found, all but two in Period 4; some of these could definitely be identified as *Trionyx gangeticus*, and the rest were tentatively referred to the same species. Three of the scute fragments from Period 4 were cut with a sharp knife (Fig. 13.3), suggesting that craft or manufacturing activities may be one reason for the presence of the turtle scute fragments. A few specimens of other species were present (Table 13.4), including the blackbuck phalanges illustrated in Fig. 13.1. The two monkey bones could not be identified to species. A pelvis fragment from Period 3 came from a juvenile animal, while an ulna from Period 2 came from a species visibly larger than the langur (*Presbytis entellus*).

A few of the more complete fragments listed as 'cattle' in Table 13.1 were also taken to Deccan College, with a view to attempting to establish whether they were all zebu (*Bos indicus*) or whether any water buffalo (*Bubalus bubalis*) might be present. The biological tribe Bovini constitutes the largest members of the family Bovidae, comprising principally the genera *Bos* (cattle including zebu), *Bison* (European and American), *Syncerus* (the African buffalo) and *Bubalus* (the water buffalo). Distinction between all these species is difficult. Published criteria exist for distinguishing between *Bos* and *Bison* (Olsen 1960) and between *Bos* and *Syncerus* (Peters 1986). No criteria for distinguishing between *Bos* and *Bubalus* are, however, known to the author. The two genera are quite distinct in evolutionary terms and have long been distinct species (Ritz *et al*. 2000; Hernández Fernández and Vrba 2005), so it is to be expected that reliable criteria might well exist. A complicating factor is that many breeds of water buffalo exist (Kikkawa *et al*. 1997; Kumar *et al*. 2006), and how much osteological variation there might be within *Bubalus* is not known to the author. As regards Paithan, eight specimens were compared to the *Bos* and *Bubalus* comparative skeletons at Deccan College. Six of these appeared to align with *Bos*. These were fragments of a distal metacarpal and a distal metacarpal from Period 1, a distal tibia and a distal metatarsal from Period 2 and an astragalus and proximal radius from Period 3. The other two appeared to align with *Bubalus*. These were a distal humerus from Period 1 and an astragalus from Period 3. These very tentative identifications can do no more than suggest the possible presence of *Bubalus*, not unexpected in view of its presence at both Bhokardan (Rao 1974) and Nasik (George 1955) – although it was apparently not present at Nevasa (Eapen 1960). A comparative osteological study of *Bos* and *Bubalus*, and a survey of archaeological material containing these species, would be of great benefit to South Asian zooarchaeology.

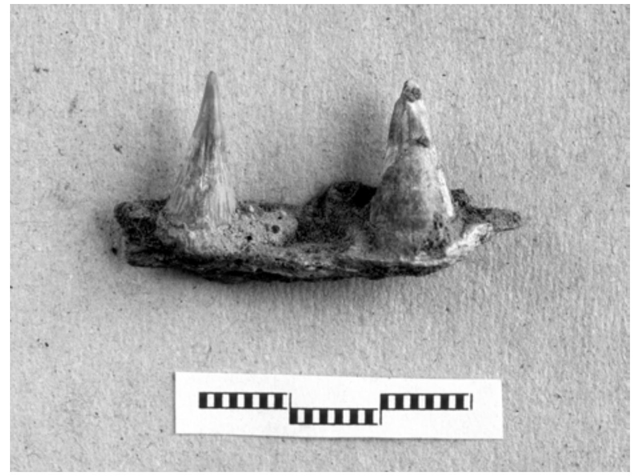

Fig. 13.2: Fragment of mandible of *Crocodilus palustris*, identified by Dr P. K. Thomas.

Once all the various items discussed above had been identified, there remained the majority of bone fragments which could not be identified. In many cases, it was possible to determine that the animals from which the fragments had come were relatively small (sheep/goat and pig size), while others came from larger animals (cow size). Given that the overwhelming majority of *identified* bones come from sheep/goat, pig and cow, it is highly probable that the overwhelming majority of *unidentified* fragments also do so, even though this cannot be demonstrated. Table 13.5 presents the totals for the two size categories, divided into

Table 13.4: Dr P. K. Thomas' identifications of bones and scute fragments from Paithan.

Period	1	2	3			4
			temple	ordinary	total	
crocodile *Crocodilus palustris*	0	0	1	0	1	0
turtle *Trionyx gangeticus*	2	0	0	0	0	19
hare *Lepus nigricollis*	0	2	0	1	1	3
bandicoot *Bandicota indica*	0	0	0	1	1	0
blackbuck *Antilope cervicapra*	0	1	1	2	3	1
monkey Cercopithecoidea	0	1	0	1	1	0
swamp cat *Felis chaus*	0	0	0	1	1	0

the anatomical region of the skeleton, for each of the phases. Finally, there were numerous fragments that could not be classified at all, and these are also listed at the bottom of Table 13.5.

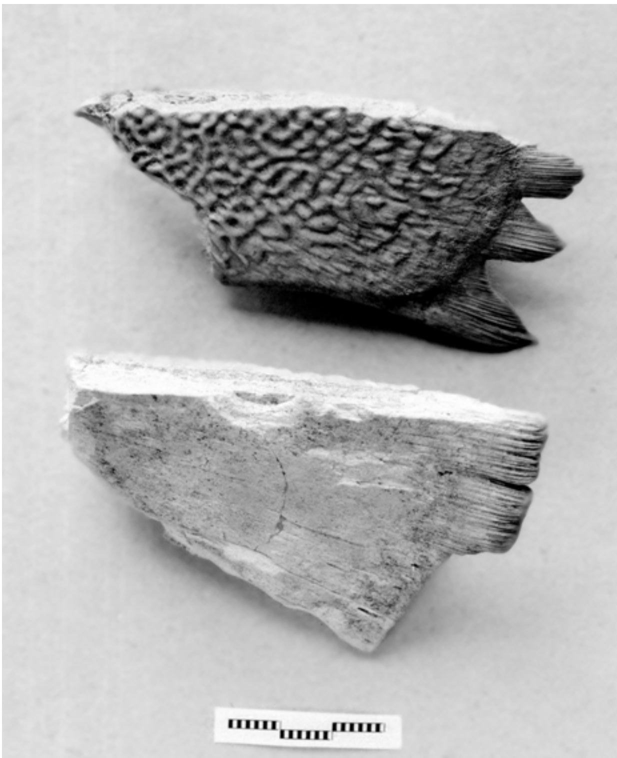

Fig. 13.3: Fragments of scute of turtle (*Trionyx gangeticus*) cut with a knife.

Change through time

The examination of changing species frequency through time is a main goal of this contribution. To be able to examine this, precise quantification of the bone assemblage is required (see above). One step towards precise quantification has been taken, with the summing of fragments presented in Table 13.1. There has, however, been considerable discussion about whether the NISP total presented there is the best method of quantification to use in such studies. For the following discussion, see Fig. 13.5 for the location of the various bones mentioned; 'distal' refers to the end of the bone away from the vertebral column, 'proximal' to the end nearer the vertebral column.

Various factors may lead to the basic NISP total being an imperfect method of quantification. One is the simple fact that different species have different numbers of bones in their bodies. Pigs, for example, have four metacarpals in each forefoot and four metatarsals in each hindfoot, while cattle, sheep and goats have only one in each case. This problem is increased when considering animals such as fish, which have a completely different bodily conformation; and clearly, no meaningful comparison can be made between (say) the number of sheep bones and the number of cowrie shells found on a site. Another factor may be differential fragmentation. A distal humerus of a cow might be broken into (say) five fragments, all of which might be identifiable, while a sheep distal humerus might be

Table 13.5: The unidentified bone fragments from Paithan, divided into size class and anatomical region where possible.

Period	1	2	3			4
			temple	ordinary	total	
Sheep/goat or pig sized animal						
limb splinter	129	182	72	128	200	144
vertebral fragment	43	39	16	15	31	10
skull fragment	21	12	7	20	27	11
rib fragment	122	170	82	82	164	86
total	315	403	177	245	422	251
Cow-sized animal						
limb splinter	61	52	31	41	72	47
vertebral fragment	19	15	1	5	6	0
skull fragment	21	6	0	19	19	2
rib fragment	65	69	11	17	28	23
total	166	142	43	82	125	72
Unclassified fragments	421	421	493	443	936	372

found in a complete state. If a simple NISP count was applied in such an instance, cattle would incorrectly appear to be five times more common than sheep (for general discussions, see Casteel 1977; Watson 1979; Gautier 1984; Grayson 1984; Davis 1987).

One method of quantification that seeks to get round these problems is the calculation of the Minimum Number of Individuals (MNI) total. This seeks to establish the minimum number of individual animals that it took to generate the bone assemblage. At its simplest, a total of (say) five left and three right distal humeri of cattle must derive from a minimum of five cattle – because the right-side elements might come from the same animals that produced the left side elements. There are, however, problems with the MNI method. The MNI for each species is usually a rather small number, a particular problem in small assemblages like that from Paithan, and the frequency of species represented by a single bone is exaggerated. It is also based on an unrealistic assumption. Using the hypothetical example of five left and three right distal humeri in the context of an archaeological site occupied for two centuries, it is clear that the MNI is in any literal sense meaningless: many more than five cattle would have been killed and consumed in two centuries. We cannot know how many; but even if only one animal was killed each year, making 200 cattle in all, it is evidently highly unlikely that *any* left and right elements in the archaeological assemblage actually come from the same animal.

No method of quantification is perfect. Perhaps the safest option is one that lies between NISP and MNI. This is one that sums the so-called Minimum Animal Units (MAU) for each taxon. The MAU is intended to bring all elements into line with the basic artiodactyl (e.g. cow, sheep/goat) skeleton, in the following two steps (Binford 1984). (1) Differential fragmentation is, to some extent, overcome by recording which part of (say) the distal humerus is present. Thus, the Paithan records show whether any distal humerus fragment is complete (i.e. the entire articulation is present) or whether just the medial or just the lateral portion of the articulation is present. This allows determination of the Minimum Number of Elements (MNE) to be calculated: it is the sum of complete articulations, plus *either* the medial *or* the lateral portions, whichever is the most common. In an ideal world, the analyst would attempt to refit medial and lateral fragments or determine whether they could come from the same bone. In practice, the time constraint usually means that this is impossible, especially when the analyst does not know the site phasing at the time the recording is carried out. Shaft fragments that do not have articular ends are discounted. For mandibles and maxilla, the same principle is used: complete mandibles are counted, and loose teeth or partial mandibles then grouped into a theoretical minimum number that is added to the complete ones. (2) The resulting MNE totals are brought into line with the artiodactyl skeleton. Each such skeleton has two distal humeri. Each such skeleton has two distal humeri but only one atlas vertebra (see Fig. 13.5), so the MNE for atlas is doubled. Each artiodactyl skeleton has two distal metacarpals, so the MNE of these bones is left unchanged; each pig skeleton, however, has four distal metacarpals, so the two easily recognizable lateral metacarpals are discounted, and the MNE for the central pair is halved. Phalanges (toes) cannot be divided between fore and hind foot. There are eight first phalanges in each artiodactyl skeleton (two in each foot), so the total is divided by 4; and the same procedure is used for second and third phalanges.

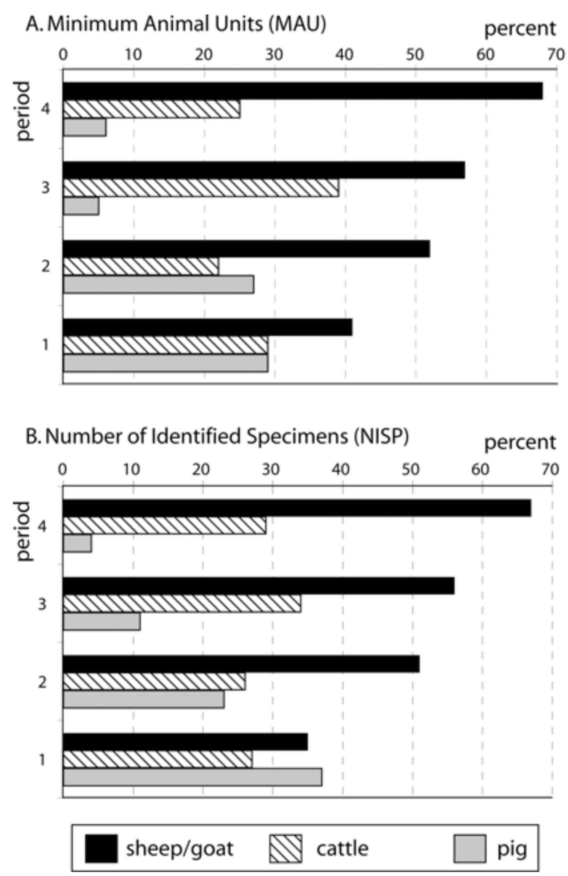

Fig. 13.4: Minimum Animal Units (MAU) of the main domestic taxa at Paithan, divided by layer and expressed as percentages of the layer total (see text for the method of deriving the MAU).

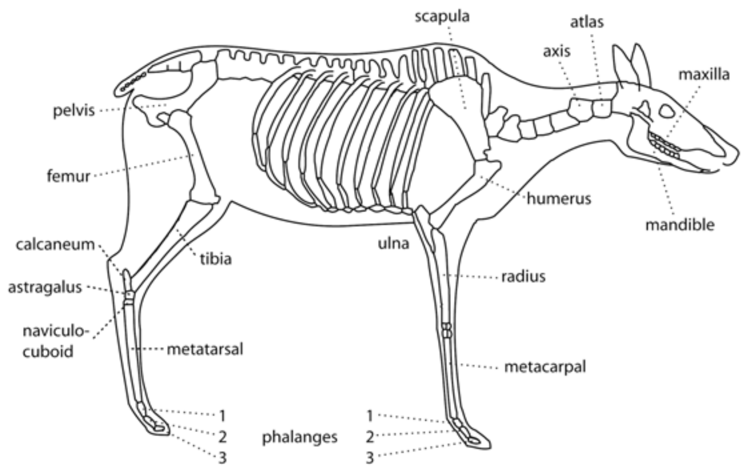

Fig. 13.5: Diagram of the skeleton of an artiodactyl, showing the various bones.

The resulting MAUs for each element are listed in Appendix 13.1. The sum of MAUs for each species in each period should, in theory, give the most secure basis for the relative quantification of species frequency, and thus for considering change through time. These MAU totals are listed and calculated as percentages in Table 13.6.

Using the MAU totals, we are in a position to examine change through time at Paithan. Fig. 13.4 plots the percentages of the three main taxa, based on MAU (top), with the NISP percentages from Table 13.1 also presented for comparative purposes (bottom). It is immediately apparent that there is substantial change through time. In both charts, sheep/goat increase substantially through the four periods represented at the site; the pattern is broadly similar using both methods of quantification, except that in Period 1, the NISP percentage is lower, which accentuates the visible increase. Cattle do not vary directionally through time, although they appear to peak in Period 3; this peak is more prominent in the MAU chart. Finally, and perhaps most interestingly, pig decreases through time in both charts. The outline is rather different depending on method of quantification, however: in the NISP chart, the decrease is fairly even, while in the MAU chart, it appears as a more abrupt step between Periods 2 and 3.

There is no independent way to determine which method of quantification gives the result which is closest to reality, although for the reasons discussed above, this author prefers the MAU method. Quite apart from anything else, the Paithan sample is relatively small, and stochastic variations may therefore appear more marked. But the most important conclusion is that change through time is clearly visible, and it is consistent across the four periods: sheep and goat increase in frequency, while pigs decrease, throughout the time of occupation of Paithan. This will be further discussed in the conclusions.

Table 13.6: Minimum Animal Units (MAU) of the main domestic taxa at Paithan, divided by layer and expressed as percentages of the layer total (see text for the method of deriving the MAU).

Period	**1**		**2**		**3**						**4**	
					temple		**ordinary**		**total**			
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Sheep/goat	42	**41**	53.25	**52**	22.5	58	12.25	57	34.75	**57**	42.75	**68**
Cow	29.75	**29**	22.25	**22**	13.5	35	10.25	44	23.75	**39**	16	**25**
Pig	30	**29**	27.25	**27**	2.5	6	1	4	3.5	**5**	4	**6**
Total	**101.75**		**102.75**		**38.5**		**23.5**		**62**		**62.75**	

The changing frequencies of sheep/goat and pig are clearly the most important change occurring through time at Paithan, but a couple of more minor points may also be made in this section. Neither birds nor fish are ever very common, but bird bones reach a minor peak in Period 2, while fish do so in Period 4. Among the shells, bivalves decrease through time; if their presence reflects their use as a food source, their dietary importance was apparently reducing. Gastropods may also show a decrease, but the trend is less clear. Cowries, in contrast, appear to *increase* through time. Since cowries are marine species, all such shells must have been imported from coastal regions, and it may be that the increase in Period 4 signals an increase in trade or other connections at this time. None of the other taxa listed in the tables appear to show any trend through time.

The nature of the samples, and the temple deposits

One interesting aspect of any animal bone assemblage is the question of whether the assemblage is dominated by butchery waste, food waste or a mixture of the two. The starting point for any analysis is the MAU total, described above and listed by period for each species in Appendix 13.1. Each table in Appendix 13.1 starts with the head and neck (mandible through to axis – see Fig. 13.5), then runs down the forelimb (scapula to metacarpal), then down the hindlimb (pelvis to metatarsal) and ends with the phalanges. The outline of the soft tissues in Fig. 13.5 shows the decreasing amount of meat towards the feet of the animal. The lower limbs are therefore generally classified as butchery waste, discarded at an early stage in the butchery process. The upper limbs and trunk carry most of the edible meat.

The samples from Paithan are mostly too small for significant conclusions to be drawn, but a few suggestions may be offered. Considering sheep/goat first, the feet are rather rare, while meat-bearing bones such as the pelvis are relatively common, particularly in Periods 1 and 2. This is unusual, since the pelvis is not a very hard bone and often does not survive in large numbers. This might suggest that the Paithan sheep/goat bones derive predominantly from food waste rather than butchery waste, although the pattern is less clear in Periods 3 and 4, and the small size of the sample must be born in mind. Distal metacarpals and metatarsals are remarkably rare (and since they are among the most diagnostic elements for separating sheep from goat, their rarity contributes to the small number of definitely identifiable bones of these species: see Table 13.2). In the forelimb, proximal metacarpal is more common than distal metacarpal; it may be that this bone was chopped through during butchery so that the distal end and the phalanges could be discarded. Fig. 13.6 shows a metacarpal exhibiting marks resulting from two chops that have not cut through the bone. In the hindlimb, metatarsals are rare, while astragalus and calcaneum are more common; possibly the leg was cut through between the astragalus and the naviculo-cuboid, and the foot subsequently discarded. The samples of cattle and pig bones are even smaller, so conclusions are even more tentative. Among the cattle bones, feet are generally rare, as are heads except for the five maxillas (upper jaws) in Period 3-temple. Among the pigs, feet are also rare, but heads are substantially more common in Periods 1 and 2.

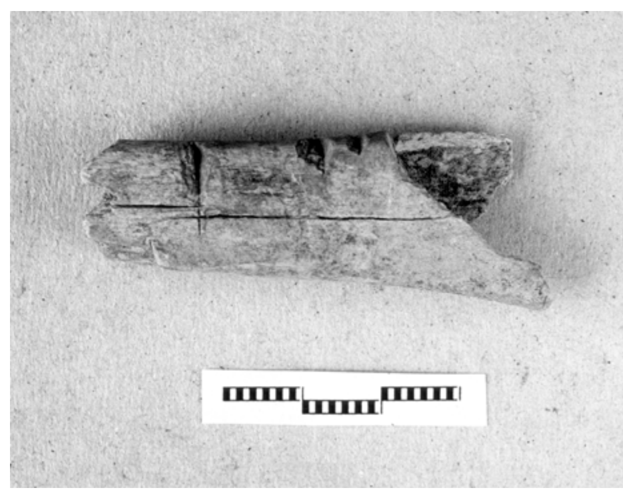

Fig. 13.6: Metacarpal shaft fragment of sheep or goat, showing two heavy chop marks.

The Paithan samples thus appear to represent rather ordinary waste material, with the exception that the feet and in some cases the heads may have been detached and dumped elsewhere. From this perspective, we can approach the nature of the temple deposits. The tables of bones in Appendix 13.1 do not suggest that the contents of the Period 3-temple and Period 3 deposits differ materially from each other, or from the other periods, with the possible exception of the presence of the cattle maxillas in Period 3-temple already noted. The small size of the samples must again be stressed, however, and the presence of the cattle maxillas is plausibly due simply to chance. The unidentified bones recovered from Period 3-temple and listed in Table 13.5 similarly resemble those from the other deposits. Little or nothing in the animal bones in fact marks Period 3-temple out in any way. The only possible exception to this is the fragment of crocodile mandible containing two teeth, identified by Dr P. K. Thomas as *Crocodilus palustris* (Table 13.4). This fragment was recovered from Period 3-temple deposits. Whether its presence there has any significance that does not emerge from the straightforward study of the bones carried out here must be a subject for future discussion.

Age at death and metrical analysis

Age at death is an informative tool in zooarchaeology. Best results are obtained from large statistically reliable assemblages. The Paithan assemblage is too small to produce such results, but the available mandibular data are tabulated in Appendix 13.2. Ageing is based on the replacement and wear of the mandibular teeth, the most useful being the rear milk premolar (dp4), or the rear adult molar (P4) if it has replaced dp4, and the three permanent molars (M1, M2 and M3). During identification, the state of eruption and wear of the teeth in the mandibles were recorded, and for the more complete fragments, this permits an approximate age at death to be established (see Appendix 13.2 for details).

In large assemblages, age at death may enable us to understand something of the herding practices employed in the past. For example, in sheep, goats and cattle, maximum meat weight is usually reached somewhere around 2–4 years of age, and this is a good time to slaughter animals for meat. Animals of this age will not put on much more meat, and their removal allows more lambs, kids or calves to be reared. However, if dairy products are what is desired, it is necessary to kill some animals at a much younger age, usually in the first month or two of life. A female will only lactate after producing offspring, and if these offspring are kept alive, they will consume at least some of the milk (see e.g. Payne 1973; Legge 1981, 1992; Halstead 1987, 1998).

The small number of sheep/goat mandibles from Paithan do not include any animals in the first 2 months of life. Such jaws are smaller and softer than those of adults and are thus more prone to loss due to dog gnawing in ancient times or poor recovery during excavation. As mentioned above, however, dog gnawing is rare at Paithan, and recovery was excellent, so these factors may be discounted. The small sample therefore appears to suggest that dairy products were not a major goal at Paithan, although this does not exclude the possibility of some less specialized use.

In pigs, the focus is usually different: pigs produce half a dozen or more offspring (as opposed to the one or two in the other major species), and meat is the only significant product. The high breeding turnover of pigs means that most animals are typically killed in their first 2 years of life, and the jaws listed in Appendix 13.2 suggest that Paithan was not an exception to this.

Metrical analysis is also an important zooarchaeological tool. Sometimes, measurements may complement analysis of age at death. For example, in cattle and goats (but not in sheep), elements such as distal metacarpal allow males and females to be distinguished, males forming a separate scatter larger than the females. Distal metacarpals fuse only when the animals approach adult size, however. Under a herding policy focussed on dairy products, it is likely to be the males that are killed when very young, because of the herdsmen's desire to keep the females alive and in due course join the milking herd. In the archaeological record, this policy will lead to a predominance of females among the measurable adults. If, on the other hand, the males are kept alive for longer and are killed for meat, the sex ratio visible in the distal metacarpals will be more equal (see e.g. Legge 1981; Halstead 1998; Rowley-Conwy 2000).

As mentioned above, butchery practices at Paithan unfortunately mean that distal metacarpals and metatarsals are virtually absent, and none could be measured. The Paithan measurements do not therefore play a primary part in the analysis presented here, but are listed in Appendix 13.3 in the hope that they may be of use to other researchers in the future.

Conclusions

The relatively small zooarchaeological assemblage from Paithan has proved to be of the greatest interest, and due to the excellent method of recovery has generated a considerable amount of information.

The major conclusion is that there was a consistent *increase* in the importance of sheep and goat, and a concomitant *decrease* in the importance of pigs, through the period of occupation of the site. This is a conclusion of considerable interest, and it would be of the greatest importance to know whether this is mirrored at other sites in India and indeed in South Asia in general. The rise of Islam probably meant that pig keeping declined in much of central and western Asia. The reasons for a parallel decline, although not disappearance, in the pig in the non-Muslim context of Paithan raises wider issues concerning the changing importance of this species: was the Islamic prohibition superimposed on a more general decline taking place for other reasons?

This is a question for future research. In the meantime, it is hoped that the present report has achieved the aims set out in the introduction and also that it shows something of the kinds of information that can be extracted from animal bones, and which makes them so worthwhile an object of study.

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Appendix 13.1 Minimum Animal Units (MAU) Tables

Note: P indicates the Proximal, D the Distal, articulation of each longbone

A. Sheep/goat: Minimum Animal Units

Period	1	2	3			4
			temple	ordinary	total	
Mandible	1	2	2	4	6	4
Maxilla	1	2	2	2	4	3
Atlas	2	2	0	0	0	0
Axis	2	4	0	2	2	4
Scapula	6	2	0	0	0	0
Humerus P	1	0	0	0	0	0
Humerus D	1	4	1	2	3	2
Radius P	0	1	0	3	3	0
Ulna	3	5	1	1	2	1
Radius D	0	3	0	1	1	2
Metacarpal P	2	3	1	1	2	4
Metacarpal D	0	1	0	0	0	1
Pelvis	4	6	1	2	3	2
Femur P	1	1	0	0	0	2
Femur D	2	2	0	2	2	2
Tibia P	3	2	1	1	2	1
Tibia D	3	6	0	0	0	2
Astragalus	5	3	2	0	2	1
Calcaneum	2	2	1	1	2	6
Naviculo-cuboid	1	0	0	0	0	0
Metatarsal P	0	1	0	0	0	2
Metatarsal D	1	0	0	0	0	2
Phalanx 1	0.75	1	0	0.5	0.5	1.75
Phalanx 2	0	0.25	0	0	0	0
Phalanx 3	0.25	0	0.25	0	0.25	0

B. Pig: Minimum Animal Units

Period	1	2	3			4
			temple	ordinary	total	
Mandible	3	3	0	0	0	0
Maxilla	7	5	0	0	0	0
Atlas	0	0	0	0	0	0
Axis	0	0	0	0	0	0
Scapula	5	2	1	0	1	1
Humerus P	0	1	0	0	0	0
Humerus D	2	2	0	0	0	0
Radius P	1	0	0	0	0	0
Ulna	0	2	0	0	0	0
Radius D	0	0	0	0	0	0
Metacarpal P	2	1	0	0	0	0
Metacarpal D	0	1	0	0	0	0
Pelvis	1	0	0	1	1	1
Femur P	0	0	0	0	0	0
Femur D	2	1	0	0	0	0
Tibia P	0	0	0	1	1	0
Tibia D	2	4	0	0	0	0
Astragalus	1	1	0	0	0	0
Calcaneum	1	1	0	0	0	0
Naviculo-cuboid	0	0	0	0	0	0
Metatarsal P	1	1	0	0	0	1
Metatarsal D	0	2	0	0	0	1
Phalanx 1	1.25	0	0	0.25	0.25	0
Phalanx 2	0.5	0	0	0	0	0
Phalanx 3	0.25	0.25	0	0.25	0.25	0

C. Cattle: Minimum Animal Units (MAU)

Period	1	2	3			4
			temple	ordinary	total	
Mandible	1	1	0	0	0	2
Maxilla	1	1	5	0	5	3
Atlas	0	0	0	2	2	0
Axis	0	0	0	0	0	0
Scapula	2	0	0	1	1	1
Humerus P	3	1	0	0	0	0
Humerus D	2	0	0	2	2	1
Radius P	1	3	0	1	1	1
Ulna	0	0	0	0	0	0
Radius D	0	1	1	0	1	1
Metacarpal P	2	0	0	1	1	1
Metacarpal D	2	0	1	1	2	2
Pelvis	3	0	1	1	2	0
Femur P	5	0	0	0	0	0
Femur D	2	2	0	0	0	1
Tibia P	0	0	1	0	1	0
Tibia D	1	2	0	0	0	0
Astragalus	0	1	1	2	3	0
Calcaneum	2	1	0	1	1	1
Naviculo-cuboid	0	3	0	1	1	1
Metatarsal P	0	5	0	0	0	0
Metatarsal D	1	1	0	0	0	0
Phalanx 1	1	0	0.25	0.5	0.75	0.25
Phalanx 2	0.25	0.25	0	0	0	0.75
Phalanx 3	0.5	0	0	0	0	0

Appendix 13.2
Ageable jaw fragments of the three main species at Paithan

Ages are approximate only for sheep/goat, and they are taken from Payne (1973); for pigs, they are taken from Higham (1967).

For all taxa, (P) means tooth present but wear stage not ascertainable; E = top of tooth erupted to level of the jawbone; H = tooth half erupted; U = erupted to full height but unworn; J = tooth just in wear; nye = not yet erupted.

For sheep/goat, the numbered wear stages are those distinguished by Payne (1973), the first stage with no wear being numbered 1. For pig, the lettered wear stages are those distinguished by Grant (1982).

Period	dp4	P4	M1	M2	M3	Age
A. Sheep/goat						
2		(P)	(P)	6	H	18–24 months
2		U	8	5	U	18–24 months
3(o)		5	(P)	8	6	3–4 years
3(o)		6	(P)	6	(P)	?18–24 months
3(o)*	8					?
3(t)			10	8	3	2–3 years
4*	7		H	nye		2–6 months
4		9	14	14	10	6–8 years
4	(P)		E			?2–6 months
* = identified as sheep						
B. Cattle						
3			(P)	U		
4					J	
C. Pigs						
1			J	H	nye	10–11 months
1		U	(P)	a		15–16 months
1		a	g	b		16–18 months
2	d		a	U		11–12 months
2	e		d	E		9–10 months
2				a	H	19–21 months

Appendix 13.3
Measurements of animal bones from Paithan

All measurements are in millimetres. Only fully fused adult bones are included. All the cattle bones measured are tentatively identified as *Bos*, not *Bubalus* (see text). Bracketed measurements are uncertain.

All measurements are as defined and illustrated by von den Driesch (1976), except as follows: distal humerus HT and HTC, and distal metatarsal Dd, from Legge and Rowley-Conwy (1988); pig tooth measurements from Payne and Bull (1988).

A. Sheep/goat

Sheep/goat distal humerus

Period	Sheep or goat	Trochlea breadth (BT)	Thickness of trochlea (HT)	Trochlea at constriction (HTC)
2	Goat?	29.0	19.0	13.7
3(o)	Sheep	-	20.8	15.3
3(t)	?	-	-	15.9

Sheep/goat radius

Period	Sheep or goat	Proximal breadth (Bp)	Distal breadth (Bd)
2	Goat		28.3
2	Sheep		28.8
3(o)	Sheep?	33.9	
3(o)	Sheep		30.1
3(o)	Sheep	38.2	

Sheep/goat tibia

Period	Sheep or goat	Distal breadth (Bd)
1	Sheep	25.3
1	Goat	28.8
2	Goat	27.5
2	Sheep	28.1
2	Sheep	27.9
4	Sheep	23.8

Sheep/goat astragalus

Period	Sheep or goat	Greatest length (GLl)	Distal breadth (Bd)	depth (Dl)
1	Sheep	30.5	17.9	16.9
1	Sheep	30.4	-	16.9
1	Sheep	34.3	19.7	18.3
1	Sheep?	31.4	20.2	16.4
2	Sheep	33.0	19.9	18.0
2	Goat?	-	22.8	-
2	?	-	19.0	-
3(t)	Sheep	33.8	21.0	18.7
3(t)	Sheep	31.5	19.4	18.0

B. Cattle

Cattle radius

Period	Proximal breadth (Bp)
3	86.8

Cattle tibia

Period	Distal breadth (Bd)
2	75.2

Cattle astragalus

Period	Greatest length (GLl)	Distal breadth (Bd)	Depth (Dl)
3(o)	(69.0)	(45.1)	36.9

Cattle metatarsal

Period	Distal breadth (Bd)	Distal thickness (Dd)
2	(61.2)	34.8

C. Pig

Pig scapula

Period	Length of glenoid (GLP)	Breadth of glenoid (BG)	Smallest length of collum (SLC)
1	(27.2)	(20.0)	17.5
1	33.4	21.6	-
1	-	-	20.2
1	(28.5)	20.2	18.2

Pig astragalus

Period	Greatest length (GLl)
2	44.9

In the following table, each jaw fragment is given one line; thus, if measurements for more than one tooth appear in the same line, they were found in the same jaw fragment.

Pig mandibular teeth

Period	dp4		M1			M2			M3	
	L	WP	L	WA	WP	L	WA	WP	L	WA
1			15.5	9.9	10.5					
1						20.7	13.5	14.1		
1			15.2	9.4	9.8	19.1	12.4	13.4		
2	17.5	7.8	16.1	–	10.0					
2	17.4	7.9	14.3	8.4	9.7					

Pig maxillary teeth

Period	dp4		M1			M2			M3	
	L	WP	L	WA	WP	L	WA	WP	L	WA
1	14.8	11.3	16.7	12.7	13.7					
1									33.2	19.6
1	16.3	13.5	21.4	16.6	–					
1									29.8	19.5
1						21.7	17.8	17.6		
2			15.7	–	13.8	23.0	17.2	17.8	29.1	17.6
2			17.7	12.3	12.1	–	15.7	–		