A Study of the Animal Bone Recovered from Pits 9 and 10 at the Site of Nagsabaran in Northern Luzon, Philippines

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Abstract

Excavations in 2004 at the site of Nagsabaran in northern Luzon produced a small but important animal bone assemblage dating to the Neolithic and Metal Age periods of the region. Detailed zooarchaeological analysis of the bone fragments has demonstrated that during the Neolithic period human subsistence strategies focussed on the hunting of wild pigs and deer, supplemented by the rearing of domestic pigs and fishing. In the Metal Age, the immense shell middens attest to the importance of aquatic invertebrates in the diet, but human populations continue to hunt wild pigs and deer and raise domestic pigs as they did in the Neolithic period. The domestic dog is evident within the archaeological record from about 1,500 years ago.

Introduction

The archaeological site of Nagsabaran in northern Luzon (Figures 1a and 1b) consists of a large shell midden located on the south bank of the Zabaran Creek (or Nagsabaran Creek), close to where it joins the Cagayan River from the west. It is about 22 kilometres from the mouth of the Cagayan River located in the Barangay Alaguia, Lal-lo (N18° 09′31″, E121° 38′22″). Bordered on the north by the Zabaran Creek and wet rice

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paddies to the south, the Nagsabaran shell midden is an isolated, island like formation in the alluvial plain, about 600 metres long and 3 metres deep (Figure 2a).

Figure 1. The location of Nagsabaran in the north of northern Luzon, Philippines (After Piper *et al*., in press).

The earliest investigations in the area by a Filipino-Japanese team in the 1990s reported the site as "Alaguia" shell midden (Ogawa, 2002). It was subsequently renamed Nagsabaran in 1996. A single date on a shell recovered during the 1996 excavations returned a ^{14}C date of 2950±90 uncalibrated BP (see Hung 2008 and Tsang 1998). Eight test pits dug in 2000 and 2001 produced large numbers of artefacts including pottery, stone flakes, clay penannular earrings, other ornaments of bone, tooth and shell, and glass and stone beads. Based on the stratigraphic sequence uncovered at Nagsabaran, the site could be divided into two depositional sequences - an upper horizon of deep shell midden, overlying alluvial silt deposits. The results of the 2000 – 2001 investigations seemed to indicate a cultural chronological sequence of red-slipped pottery and associated artefacts in the alluvial silts supplanted by later materials characterised by blackish and reddish-brown ceramics and glass beads and bracelets (Hung 2008).

In order to better understand the cultural sequences of the last 4,000 years in the Cagayan Valley a 3rd collaborative season of archaeological investigation was conducted at Nagsabaran, between Hsiao-chun Hung and Prof. Peter Bellwood of the Australian National University and the National Museum of the Philippines during November - December 2004.

The excavations consisted of one 4 x 4 metre square (Pit 9) and one 2 x 4 metre (Pit 10) square dug through the archaeological horizons to a depth of 2.5 metres (Figures 2a and 2b). The stratigraphy is very similar to other shell midden sites in the Cagayan Valley with a ~1 metre thick layer of shell midden overlying three distinctive alluvial layers that are collectively about 1 metre in depth. The results of the investigation confirmed earlier studies and identified marked differences in the occurrences of different types of cultural material from the shell midden and underlying silts. For example, the shell midden contained a high proportion of blackish and reddish brown pottery in association with glass beads and bracelets, iron tools, jar burials and inhumations. Intriguingly, the four flexed burials were complete, including mandible but excluding the skull, and the jar burials consisted exclusively of skulls and loose teeth. It is conceivable that the skulls within the jars were those removed from the inhumations and all represent part of a single burial tradition (Hung 2008). The underlying alluvial silts contained red-slipped pottery, coarse buff or beige pottery, spindle whorls, fired clay penannular earrings and pendants and stone flakes and adzes. The transition between the shell midden and underlying silts occurred between spits eight and eleven (80 centimetres and 110 centimetres below modern ground level: bmg). The few artefacts recovered from these spits would seem to indicate site abandonment between the two phases of activity at Nagsabaran . Below Layer 3 was a forth silty horizon almost devoid of archaeological materials.

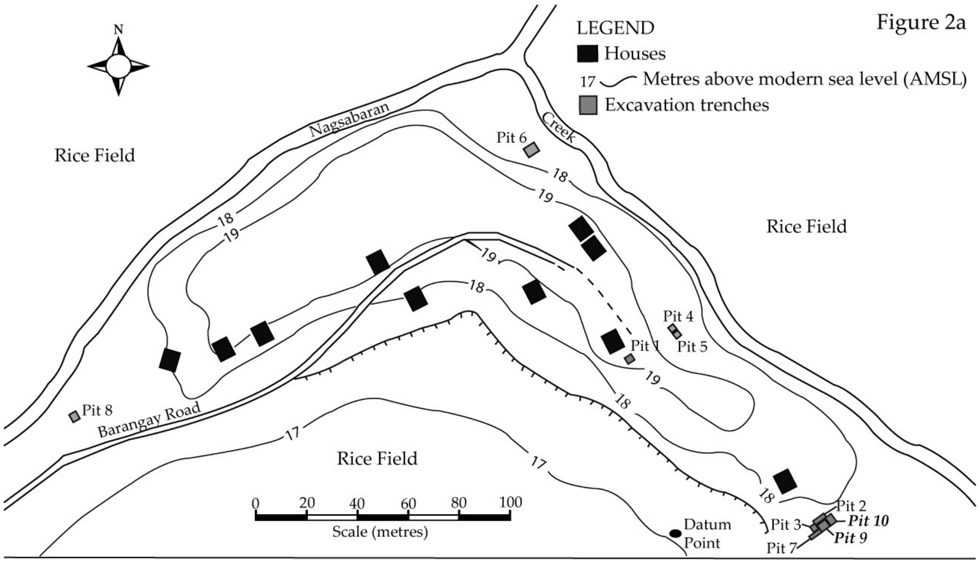

Figure 2a

Figure 2b

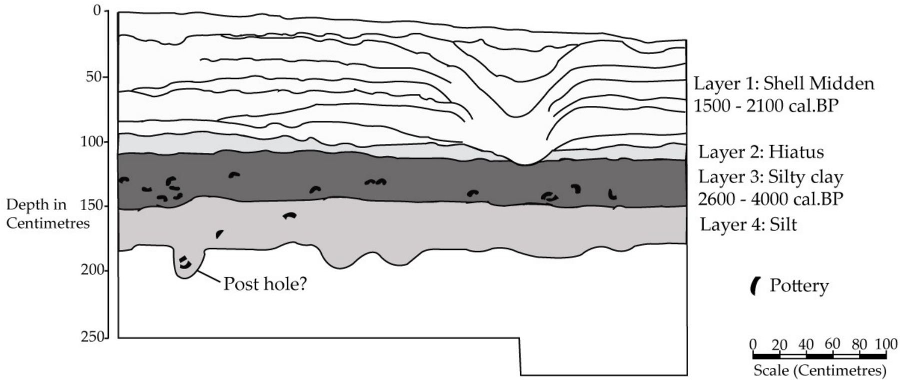

Figure 2a. The extent of the Nagsabaran shell midden with the locations of the excavated archaeological trenches indicated. Pits 9 and 10 are located on the southeastern corner of the shell midden (After Piper *et al.* in press).

Figure 2b. The vertical sequence of deposits excavated at Nagsabaran. The upper shell midden dates to between 1500 and 2100 cal. BP and the lower silty clay cultural horizon is between 2600 and 4000 cal. BP (After Piper *et al.,* in press).

A suite of 20 radiocarbon dates (18 charcoal, one river shell and one animal bone) taken during the 2000 and 2001 excavations, supplemented by four more in 2004 indicate that the shell midden dates to 2100 cal. BP to 1500 cal. BP (2 sigma) and the alluvial silts between 4000 cal. BP and 2600 cal. BP (see Hung 2008).

In the Metal Age, the human populations of Nagsabaran appear to have had two main sources of protein: terrestrial large mammals and shell fish. The shell midden consists primarily of the freshwater bivalve *Batissa childreni,* and smaller numbers of five species of gastropod, provisionally identified as *Thiara rudis, Thiara winteri, Melanoides granifera, Melanoides tuberculata* and *Melanoides maculate* (Garong 2000). The immense size of these shell middens emphasizes the importance of aquatic invertebrates to the local inhabitants of the Cagayan River Valley during this period. In contrast, Neolithic subsistence is dominated by large mammals, and mollusca are rare. This difference however, might yet turn out to be a result of depositional and erosional processes along the margins of the Cagayan River, rather than variation in human hunting and gathering strategies.

For example, during the mid-late Holocene it is estimated that the Cagayan River was at least one metre higher than its current level, and it was only after 2000BP, when the water level subsided, that the shell middens started accumulating along the banks of the river (Mijares 2007). A number of postholes were identified that had been inserted into the silty clay deposits or through the shell midden from various depths in the stratigraphic sequence. These possibly represent the remnants of raised-floor structures that extended out over the shallow margins of the river or the accumulating shell middens during the Neolithic and Metal Age respectively (Armand Mijares, *personal communication* 2008).

The small but significant animal bone assemblage recovered from excavations of Pits 9 and 10 at Nagsabaran provide some of the earliest insights into Neolithic subsistence strategies recorded in the Philippine archipelago so far. The following paper presents comprehensive results of the zooarchaeological study of the vertebrate remains from Nagsabaran. This includes the biometric and morphological reference data from both modern and archaeological specimens, essential for developing comprehensive comparative datasets to be incorporated into future studies.

Methods of Bone Analysis

Only the hand-collected and an un-quantified sample of bone either dry sieved through a 5mm mesh or wet sieved through a 1mm mesh from Nagsabaran were available for analysis during this study. This has inevitably influenced the amount of information recoverable on the biostratonomic and post-depositional processes acting upon the vertebrate assemblage and the community structure and composition of the animals present in the zooarchaeological record, and especially within classes of small terrestrial vertebrates and fish. Nevertheless, considerable amounts of meaningful information could be recovered from the animal bone assemblage at Nagsabaran.

For the purposes of this study, taphonomic terminology follows Piper (2003), which is modified from Lyman (1994). Important taphonomic alterations, all teeth, and other selective elements were photographed and archived using a Pentax M20 digital camera that permitted close-up images of butchery and other bone surface modifications through its Super Macro facility. Each bone fragment was analysed using a low power binocular microscope, and the maximum length of the fragment measured, unless it clearly demonstrated some modern breakage that had reduced its size. For the larger assemblages at depths between 0 – 70 centimetres and 100 – 140 centimetres (below modern ground level – bmg) the mean length and standard deviation was calculated for each excavated spit to identify levels of fragmentation. This figure excludes the human bone, which is likely to have had a very different taphonomic history compared to the animal remains.

Distinctive fragments of large mammal bone were identified to the highest taxonomic level possible using the modern comparative reference collection stored in the Zooarchaeology Section of the National Museum of the Philippines and the faunal comparative collection and digital database housed at the Archaeological Studies Program, University of the Philippines.

Most of the criteria for biometric analyses of the cervid and suid post-cranial elements recovered at Nagsabaran follow von den Driesch (1976). However, due to the fragmentary nature of the bone assemblage a number of alternative measurements from diagnostic anatomical locales have also been used. These are all recorded in Tables 8 and 13. For teeth, a standard measurement for the length of the tooth was taken, and then the width of each molar column measured. As cervid and suid molars change in shape as they wear, all measurements were taken at, or as close to, the enamel-root junction as possible. This location provides a point of reference where the analyst can be confident that all measurements of archaeological and comparative specimens will be comparable. To compensate for inter-analyst preferences, the lengths of the pig M1s and M2s were measured at the enamel-root junction and at the occlusal surface (in brackets) so that they can be compared irrespective of which measurement has been used by other specialists (see Tables 9a - 11). The only deer taxon known from northern Luzon is *Cervus mariannus*. However, to increase confidence in identification, the tooth morphology and biometrics were compared with the small samples of comparative images and measurements of skulls and mandibles from a range of different cervid taxa from the Philippines and Borneo held at the Field Museum for Natural History, Chicago (FMNH). The articular ends of post -cranial elements were compared with the only complete skeleton of *C. mariannus* (Osteo 879) held at the National Museum of the Philippines. Both cranial and post-cranial biometric data were also compared with a small, but important collection of measurements from the Late Pleistocene site of Callao Cave, Peñablanca in northern Luzon (Piper and Mijares 2007).

Linear enamel hypoplasia (LEH) is a defect of the molars acquired during their developmental stage, that manifests itself as lines in the enamel surface of pig teeth. These defects are considered to indicate physiological stress, and in particular nutritional deficiencies, during the early growth of the animal (Dobney *et al*. 2007). LEH is not randomly located on teeth, but occurs at specific heights on the molar crown. It has been suggested that birth and weaning are the direct causal effects of two distinctive peaks in LEH on the 1st permanent molar. Other defects on the 2nd and 3rd permanent molars are possibly related to the effects of nutritional stress during the animal's first and second winters respectively (Dobney and Ervynck 1998). Studies show that there are strong differences in the frequencies of stress induced LEH that are useful indicators of former husbandry practices and environmental conditions (Ervynck and Dobney 1999). Importantly, there also appear to be marked differences in the levels of stress suffered by domestic pigs in comparison to their wild counterparts that can be used to differentiate between the two (Dobney *et al*. 2007). All pig molars were studied under a low-powered microscope and any LEH defects identified and their height above the enamel-root junction measured and recorded as specified by Ervynck and Dobney (1999).

All the analytical data, with the exception of the tooth and post-cranial biometrics, were entered into a modified version of the York System database (Harland *et al*. 2001). The system provides a fast and efficient way to manipulate zooarchaeological data and present results. NG numbers listed in the tables correspond to the unique numbers issued to each important animal bone fragment recorded in the database.

Results

Taphonomy

In total 1194 animal bones and bone fragments recovered from the 2004 excavations of Pits 9 and 10 at Nagsabaran were sent to the authors for study. These include 17 pig teeth and mandibular fragments returned to the Philippines by Professor Alan Cooper of the University of Adelaide following ancient DNA analysis.

Both squares show similar distributions of animal bone concentrations, with more than 802 (~67%) of the entire assemblage being recovered from the upper 50 centimetres bmg (Figure 3). The values recorded between 90–110 centimetres are actually enhanced by the numerous fragments of human bone, with another much smaller concentration occurring between 110 and 140 centimetres bmg. This latter concentration corresponds well with a peak in ceramic concentrations described by Hung (2008) within a discrete stratigraphic horizon between 120 and 150 centimetres bmg that dates to *c.*2600 – 4000 cal. BP.

Bone fragments from all stratigraphic levels do show varying intensities of taphonomic modification, but are generally in a well-preserved condition. So there appears to be no natural taphonomic agent that would have produced the spatial distribution of animal bones observed throughout the archaeological sequence, where many are concentrated in particular horizons and not others. Furthermore, the fact that the animal bone concentrations closely map peaks in numbers of ceramic sherds and other cultural materials recovered from the site suggests that they represent periods of high human activity on the site. In contrast, the low numbers of bone fragments between the base of the shell midden and the peak at about 100 centimetres bmg does represent a genuine hiatus (at least in this part of the site).

The bones recovered from the shell midden (c. 0 – 100cm bmg) are generally a light yellowish brown in colour, whereas those beneath in the silty clay sediments are a more dark orange-brown. The highest

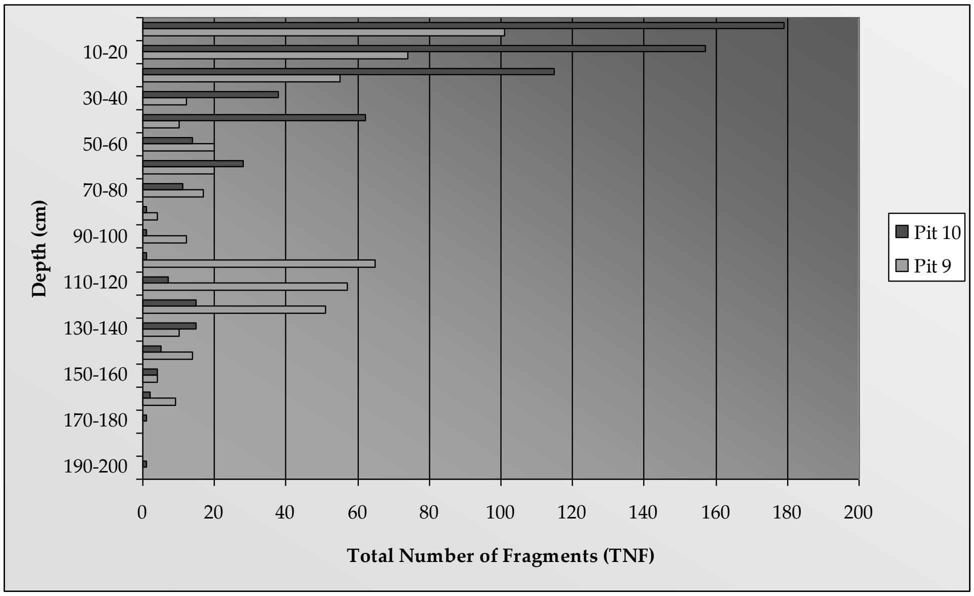

Figure 3. Distribution of hand-collected animal bones recovered from Pits 9 and 10 at Nagsabaran.

proportion of weathered and abraded bones, showing the greatest intensities of modification was recovered from the upper 20 centimetres of the shell midden (Tables 1 and 2). Weathering is caused by changes in temperature and bone moisture content, whilst the fragment lay on or close to the surface of the ground. Modifications consist of longitudinal hairline cracking, and in moderate to severe cases some flaking of cortical bone surfaces (see Behrensmeyer 1978). In Pit 10, where the upper 10-centimetres was subdivided into 5-centimetre spits, the results demonstrate that the highest concentrations of abraded and weathered bone is actually restricted to very close to the modern ground surface.

A second, less pronounced peak in taphonomic modification was identified in the deeper bone concentrations, between 110 centimetres and 140 centimetres bmg. Instead of the typical weathering shown by elements in the shell midden, those bones recovered from the silty clays demonstrate an evenly ‘worn’ and polished appearance across their surfaces, termed by Piper (2003) as erosion. Erosion results from chemical and physical properties of sediments surrounding the bones acting in particular ways upon their surfaces and structure. In this case, the peak in eroded bones simply corresponds to the highest concentration of fragments recovered from the silty clay deposits.

Table 1. The number of weathered and abraded bones recorded by level in Pit 9, Nagsabaran (NISP – Number of identified specimens; Prop. = proportion).

Level	NISP (No. of measured fragments)	No. weathered fragments	Prop. Weathered frags.	No. Abraded frags.	Prop. Of abraded frags.
0-10	79	37	0.47	56	0.71
10-20	47	9	0.19	13	0.28
20-30	51	10	0.20	16	0.31
30-40	8	1	0.13	2	0.25
40-50	10	0	0.00	5	0.50
50-60	16	4	0.25	4	0.25
60-70	13	1	0.08	1	0.08
70-80	15	2	0.13	6	0.40
100-110	53	36	0.68	29	0.55
110-120	48	21	0.44	11	0.23
120-130	41	18	0.44	15	0.37
130-140	9	6	0.67	4	0.44

Table 2. The number of weathered and abraded bones recorded by level in Pit 10, Nagsabaran (NISP – Number of identified specimens; Prop. = proportion).

Level	NISP (No. of measured fragments)	No. weathered fragments	Prop. Weathered frags.	No. Abraded frags.	Prop. Of abraded frags.
0-5	84	47	0.56	49	0.58
5-10	63	29	0.46	7	0.11
10-20	130	14	0.11	10	0.08
20-30	91	42	0.46	20	0.22
30-40	29	5	0.17	0	0.00
40-50	39	11	0.28	4	0.10
50-60	11	1	0.09	1	0.09
60-70	15	2	0.13	1	0.07
120-130	13	4	0.31	0	0.00
130-140	13	3	0.23	0	0.00

Calculations of bone fragment size identified a notable difference between skeletal elements recovered from the shell midden and the underlying clays that are unlikely to be a result of selective hand-collection (Tables 3 and 4). Variation in the maximum length suggests that skeletal elements of greater size survived better in the midden than in the underlying deposits. The higher mean length in the shell midden assemblage also indicates a greater average size, and the higher standard deviation, greater variability in fragment size. The small fragment size in bones from the clay sediments is partly responsible for the poor levels of taxonomic identification and implies greater levels of anthropic or post-depositional breakage than that observed in the bone accumulations from the shell midden[1].

Table 3. The maximum length, mean length and standard deviation of bone fragments recovered from Pit 9, Nagsabaran.

Depth	NISP	No. measured fragments	Max. length (mm)	Mean Length (mm)	Standard Deviation
0-10	101	79	123.58	44.25	16.18
10-20	71	47	75.16	51.18	31.89
20-30	54	51	104.93	42.64	21.9
30-40	12	8	74.37	39.96	16.19
40-50	10	10	95	48.51	19.94
50-60	18	16	80.48	36.08	14.85
60-70	20	13	70.7	34.56	19.57
70-80	15	15	29.11	23.12	5.66
110-120	55	48	47.99	21.25	9.79
120-130	43	41	61.2	25.34	12.32
130-140	10	9	40.7	26.54	10.41

Table 4. The maximum length, mean length and standard deviation of bone fragments recovered from Pit 10, Nagsabaran.

Depth	NISP	No. measured fragments	Max. length (mm)	Mean Length (mm)	Standard Deviation
0-5	98	84	55.45	25.92	15.54
5-10	79	63	73.33	42.26	14.11
10-20	144	130	86.3	33.86	14.29
20-30	114	91	56.55	29.2	12.9
30-40	34	29	87.11	32.93	16.5
40-50	55	39	116.16	30.55	18.8
50-60	15	11	58.32	35.78	12.12
60-70	28	15	66.05	39.08	14.09
120-130	13	13	40.36	22.7	8.01
130-140	15	13	44.69	26.65	12.85

Breakage types are generally longitudinal, irregular or irregular transverse – a characteristic of dry or old bone breakage (Behrensmeyer 1978; Johnson 1985). There were however several instances of spiral

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[1] Greater bone fragmentation often reduces levels of skeletal element and taxonomic identification in an assemblage.

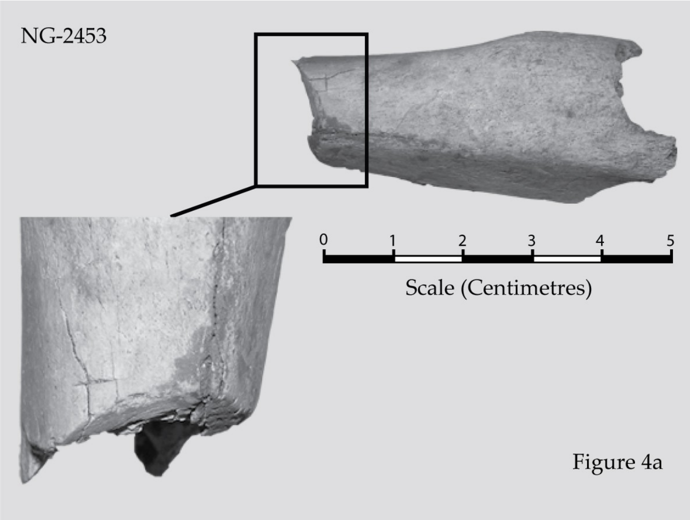
fracture indicative of deliberate green bone breakage during carcass processing for marrow extraction. This was typified by a pig (*Sus* sp.) humeral shaft fragment that had been struck with a sharp, heavy object and then split open (Figure 4a). In total 18 fragments of bone with cut or chop marks were recorded in the archaeological assemblage. Most of these consisted of fine incisions across bone surfaces, perpendicular to the long axis of long bone shafts, or close to articular ends (N = 32). The latter were presumably a result of cutting the muscle and tendons in order to disarticulate the carcass. The incisions were typically deep in comparison to their width, with steep V-shaped profiles and never more than a few millimetres in length. The most parsimonious explanation is the use of metal implements in the process of butchery. The deepest fragments with evidence of butchery were recorded in Pit 10, Level 7 at just 60 – 70 centimetres bmg and probably all date to within the last 1,000 – 1,500 years.

In total 43 (4%) fragments of bone had been burnt or calcined. These pieces were randomly distributed throughout the stratigraphic sequences as just one or two fragments, to a depth of 150 centimetres bmg in Pit 9.

Another modification identified in several fragments was differential damage to one end of the bone (N = 5). The numerous small pits on adjacent surfaces of the bone surrounded by surface digestion and a 'hollowing' out of the medullary cavity is indicative of carnivore gnawing (Figure 4b). The deepest fragment recovered was from Pit 9 at 60 – 70 centimetres bmg.

A fragment of discarded antler burr possessed extensive chop mark traces around its circumference for the purpose of removing the beam and tynes. Close examination of the burr indicated that the antler had been naturally shed by the deer and must have been collected specifically for working, rather than being removed from a hunted animal.

Three complete and two fragmentary bone tools were recorded in the bone assemblage. A female pig lower canine (NG-2192) had been split longitudinally and then notched at the mid-point to produce a fishing gorge. The total length of the gorge was 37.88 millimetres, with an antero-posterior width of 5.81millimetres and a bucco-lingual width of 5.93 millimetres (Figure 5a). A second gorge recovered from Pit 9 (70 – 80cm bmg) had been fashioned from a deliberately split dog (*Canis familiaris*)



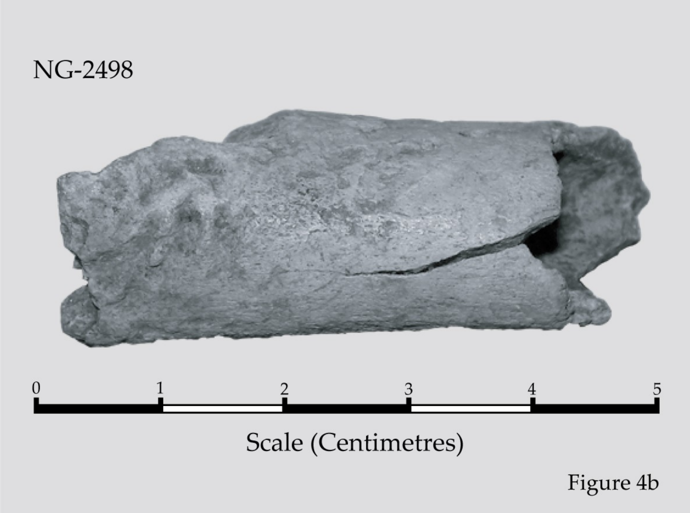
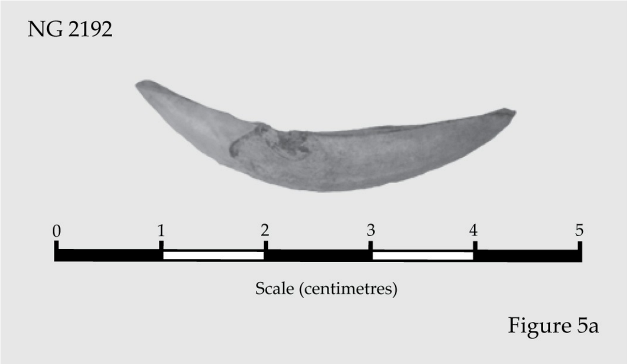


Figure 4a. A pig (*Sus* sp.) right humeral shaft fragment from Pit 10 (60 – 70cm bmg) that has been split for marrow extraction using a sharp, heavy implement.

Figure 4b. The extensive pitting and differential destruction of the end of the bone evidenced in this specimen from Pit 9 (60 – 70cm bmg) is characteristic of carnivore gnawing.

upper right canine (NG-2499). The split surface had been neatly ground, after the notch had been gouged out at the mid-point. The specimen had a total length of 40.79 millimetres and a maximum bucco-lingual width of 5.51millimetres, matching closely the dimensions of the pig canine gorge (Figure 5b).

A small splinter of long bone shaft from Pit 9 at 80 – 90 centimetres bmg (NG-2208) appears to have been utilized as an 'expedient' bone tool.



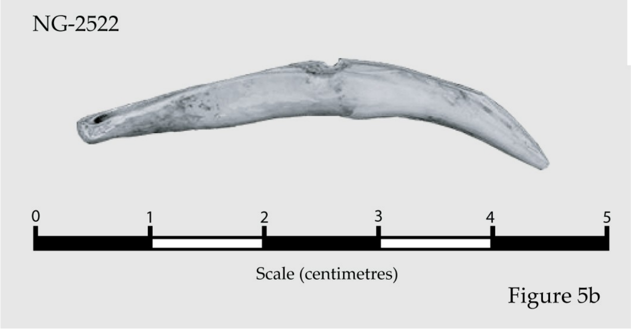


Figure 5a. A fishing gorge produced from a longitudinally split female pig (*Sus* sp.) lower canine.

Figure 5b. A fishing gorge produced from a longitudinally split dog (*Canis* cf. *familiaris*) right upper canine.

The remnant fragment is 21.09 millimetres in length and has a maximum width of 3.94 millimetres. There is no evidence of grinding to produce a desired shape, but the point and bone surfaces are heavily polished, possibly through use. A teleost fin spine from the unsegmented portion of either the dorsal or anal fin demonstrating some slight modification and use wear on the pointed tip was recovered from Pit 10 'burial pit' at 70-80 centimetres bmg. These tough, sharp spines have a canal near the base that passes through the bone where they articulate with the pterygiophores that could accommodate a cord or thread. It is conceivable that this type of tool was used as a needle or other piercing instrument. The final fragment from Pit 10 at 100 – 110 centimetres bmg (NG-2467) is much more 'formal'. The small fragment of long bone has a stepped fracture 25.53 millimetres from a blunt, shaped end. The shaft has been deliberately shaped on six facets around its circumference (diameter 4.16mm). The diameter remains the same along the fragment's short length and it is unclear whether it once tapered to a point.

Taxonomic Representation and biometric analyses:

With the exception of several human remains that were probably associated with the burials recorded in Pits 9 & 10, and three rat-sized murid appendicular elements from Pit 9, 90 – 100 centimetres and Pit 10, 20-30 centimetres, all the identifiable mammal bones were of deer (*Cervus* sp.) or pig (*Sus* spp.; Tables 5a & 5b). There are no grounds to think that any of the long bone shaft fragments recorded in Pit's 9 & 10 at Nagsabaran came from species other than pig and deer[2].

In total 81 fragments of deer were identified, accounting for ~25% of the identifiable ungulate bones. Deer bones occur throughout the archaeological record from the first 5 centimetres bmg to a depth of 160 centimetres bmg, and corresponding to an age of at least ~2600 cal. BP – 4000 cal. BP. Though small, the assemblage is dominated by loose teeth, cranial and mandibular fragments and long bone shafts. There is a noticeable lack of axial fragments for both pig and deer, as well as many of the high utility elements such as the femur, humerus, scapula and pelvis. This might be a result of human breakage and post-depositional destruction as indicated by the butchery data and large numbers of small fragments of long bone in the assemblage (see below). Alternatively, it might truly reflect selective deposition of certain elements in the proximity of the area covered by the archaeological excavations of Pits 9 and 10. Reconstruction of a partial mandible recovered from the upper 5 centimetres of deposit in Pit 10, and portions of two crania (as evidenced by the loose teeth and small pieces of skull) also identified in Pit 10 at 40 – 50 centimetres bmg suggests that at least some almost complete cranial elements were being deposited on the site (Figure 6).

Four left lower 2nd molars suggest a minimum number of four individuals in the assemblage. All the dental measurements possible on the zooarchaeological remains of deer from Nagsabaran and modern comparative data of *Cervus mariannus* known to be from Luzon and held in the FMNH are presented in Tables 6 and 7. The archaeological cervid teeth are morphologically identical to *C. mariannus* and equal in length with their modern contemporaries. In the mandible the labio-lingual widths of the teeth also overlap considerably. They also overlap with the

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[2] In 2000 the almost complete skull of a bovid was recovered by the Taiwanese-Filipino team from Pit 1, in a silty clay layer associated with red-slipped pottery. Charcoal dates from this layer in Pit 1 suggest that the skull exceeds 3500 cal. BP (Hung 2008). It has not yet been established whether the skull is from an extinct native Tamaraw or an introduced water buffalo.

Table 5a. The Number of Identified Specimens (NISP) recovered from each spit within Pit 9

Level / Taxon	Elasmo-brach	Sparidae	Chelonia	Muridae	Canidae	Cervidae	Suidae
1		1				8	24
2	1					11	10
3						6	1
4						1	3
5							2
6				1			2
7							4
8					1		
9						1	1
10				1			
11			1				2
12		1				5	5
13		1				7	3
14		2					1
15						2	3
16						1	1
17				1			

Table 5b. The Number of Identified Specimens (NISP) recovered from each spit within Pit 10

Level /Taxon	Elasmobrach	Sparidae	Muridae	Cervidae	Suidae
1a				5	20
1b				4	23
2		1		2	61
3			1	8	24
4	1	1		3	7
5				9	10
6					8
7				1	3
8					1
9					
10					
11				3	1
12	1			1	1
13		1			3
14		1			1
15					
16		1			

small sample of *C. mariannus* teeth recovered from the Late Pleistocene site of Callao Cave in the Peñablanca region of northern Luzon, indicating that there has been no observable size change in the lower dentition of *C.*

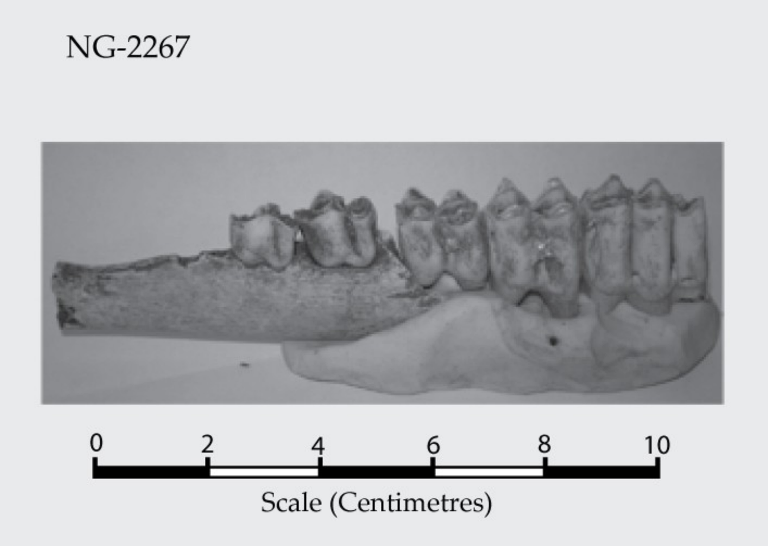

Figure 6. Reconstructed deer (*Cervus mariannus*) left mandible from Pit 10 (5 – 10cm bmg).

mariannus over the last ~50,000 years or so (see Piper and Mijares 2007). The greater widths of the maxillary molars in the archaeological assemblage in this study are a consequence of analytic inconsistency. Cervid maxillary molars widen considerably towards the enamel – root junction. This dimension is easily measured in loose teeth, but difficult and unreliable in comparative specimens when the molars are still securely embedded in the maxilla. The authors advise caution when recording and interpreting measurements taken on cervid maxillary molars.

Measurements for all intact articular ends and extremities of the deer are presented in Table 8. There are no *C. mariannus* comparative skeletons from Luzon in either the National Museum of the Philippines, or at FMNH, though two from Mindanao were available. Unfortunately, *C. mariannus* is extremely variable in size across its Philippine range and individuals from Mindanao are markedly smaller than those from Luzon (see Piper and Mijares 2007). The biometric data from Nagsabaran adds limited but important new zooarchaeological information for use by others in the future.

By far the most common large mammal in the archaeological record was the pig, accounting for c.75% (227) of all identifiable fragments. The pig occurs throughout the stratigraphic sequence, from the upper 5 centimetres to a depth of 160 centimetres in Pit 9, corresponding to an age of between 2600 cal. BP and 4000 cal. BP (see Hung 2008). Similar to the deer, the small robust extremities of the feet such as the metapodials and phalanges are noticeably rare, accounting for just 15 (6.6%) fragments. Axial elements (vertebrae and ribs) including the scapula and pelvis are just as rare, with only 22 fragments being identified within the whole animal bone assemblage. Loose teeth of the maxilla and mandible and cranial fragments indicate that both these elements were commonly deposited in the archaeological record.

Morphometric analyses of the dental elements indicate clearly that two different pig taxa are present within the archaeological assemblage (Table 9). The two pig taxa at Nagsabaran are so vastly different they could be easily separated on the size and morphology of both the molars and 4th premolar, but in particular the maxillary and mandibular 3rd molars. The Wallacean suids (e.g. *Sus philippensis*, *S. cebifrons* and *S. celebensis*) differ from the Island and mainland Southeast Asian species in that they have a very simplified globular talonid (Cucchi *et al.,* 2009). The endemic Philippine pigs (excluding those on Palawan) also have a small body size and this is reflected in the dimensions of the molars and premolars. Thus, the smaller of the two taxa corresponds in size and morphology with the endemic warty pigs of the Philippine archipelago (excluding Palawan and some of the islands in the Sulu Sea) *Sus philippensis* and *S. cebifrons* (Figure 7a; see Groves, 1997 for the biogeographic distribution of pigs in the Philippines). The larger specimens are of a similar size to members of the *S. scrofa/verrucosus* clades resident in Borneo (*S. barbatus*) and the rest of Island Southeast Asia (*S. scrofa, S. verrucosus* and *S. barbatus*) and mainland Southeast Asia and Taiwan (Figure 7b; *S. barbatus* and *S. scrofa*; taxonomy follows Groves 2007). The size of the teeth in the archaeological specimens exceeds those of the Palawan bearded pig *S. ahoenobarbus*, eliminating it as the possible introduced taxon. None of these taxa is native to the Philippine archipelago, so one or more non-native pig taxa must have been introduced by people by at least 4000 cal. BP. A well-preserved fragment of pig left maxilla (NG-2515) from Pit 9 130-140 centimetres bmg still possesses an in wear M1, erupting M2 and the P4 still in the crypt, suggesting an age of between 12 and 18 months old at death (Bull and Payne 1982). The dimensions of the M1 and size of the M2 clearly place this individual within the larger group of pigs recovered from Nagsabaran. The deepest and chronologically oldest fragment from the large-sized pig taxon is a damaged upper M2 from Pit 9 (140-150cm bmg) with a minimum length of 23.88 millimetres. This specimen has a corresponding date of between 2600 – 4000 cal. BP (Table 9b; see Hung 2008 for dates).

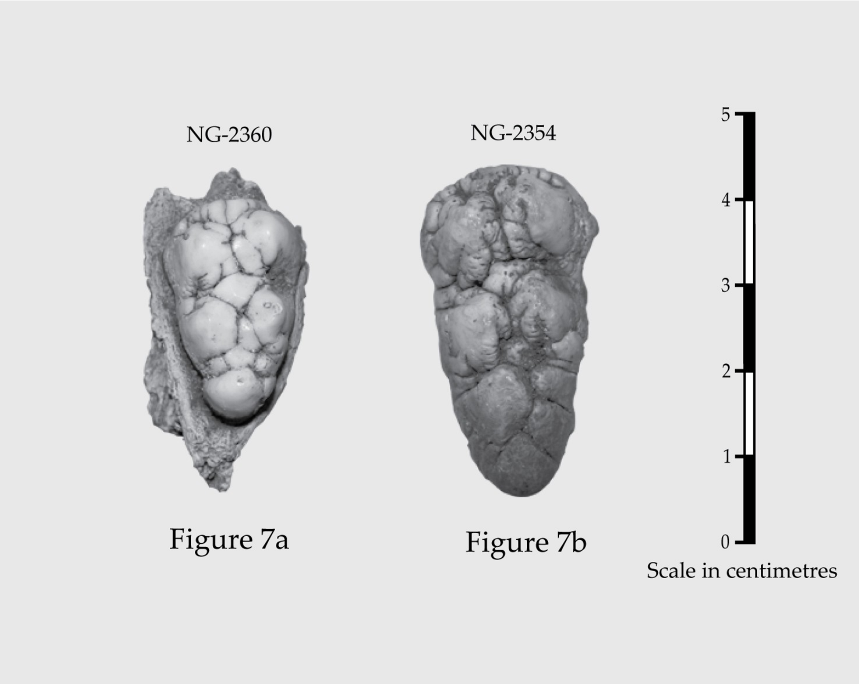

Figure 7a. An example of a lower left 3rd molar from Pit 10 (20-30cm bmg) at Nagsabaran with the morphology and size equivalent to the Philippine endemic warty pig (*Sus philippensis*).

Figure 7b. An example of a lower left 3rd molar from Pit 10 (10-20cm bmg) at Nagsabaran with the morphology and size of the introduced pig taxon (*Sus* sp.)

Close examination of the pig teeth using low powered microscopy produced no evidence of Linear Enamel Hypoplasia (LEH) in the M1 – M3 in either taxa represented in the archaeological record.

Unfortunately, most zoological collections of Island Southeast Asia mammals consist almost exclusively of cranial material, and rarely possess more than one or two complete skeletons of any taxon. Though many of the pig skeletal elements from Nagsabaran were noted as being relatively 'big' or 'small' in relation to each other, it is currently difficult to make reliable comparisons between the post-cranial elements and modern comparatives to ascertain from which of the two pig taxa each of the measurable skeletal elements comes from. The data presented here in Table 13 acts as reference for future research, when more skeletal elements from a greater number of individuals have been added to the accumulating dataset. Certainly, once material from archaeological sites that contain only one or other of the taxa (e.g. Pleistocene sites with just the endemic warty pigs present) are excavated we can then begin to differentiate post-cranial elements of the different pig taxa from sites such as Nagsabaran.

Two tibiae fragments of a rat-sized murid were recovered from Pit 9, 90 – 100 centimetres bmg and Pit 10, 20 – 30 centimetres bmg. In addition to the mammal bone, 30 fragments of fish bone were identified within the archaeological bone assemblage. These consisted of one unidentified vertebra, two freshwater fish vertebrae, fifteen unidentifiable fin spines and loose teeth, seven premaxillae and two dentaries of Sparidae (sea breams) and one unmodified and two modified elasmobranch (shark, skate or ray) vertebrae. The central neural canal of one of the elasmobranch vertebra (NG-2542) had been enlarged and showed evidence of use wear, probably from being strung on a cord for something like a necklace (Figure 8).

The absence of other robust skeletal elements of Sparidae, and the complete lack of other reef fishes from the assemblage is somewhat confusing. The most likely explanation is either the selective recovery of certain diagnostic fish bones, or that the majority of the small fish bones reside in the sieved part of the assemblage, which was unavailable for study in this project.

Finally, a single fragment of the non-diagnostic proximal end of a turtle right humerus was recovered from Pit 9 at 100 – 110 centimetres bmg. The size and morphology of the skeletal element is consistent with that of a member of the batagurids, or hard-shelled terrestrial turtles.

Discussion

The stratigraphic distribution of animal bones recovered from Pits 9 and 10 at Nagsabaran suggest two major episodes of human activity on the site that correspond well with those identified via other material culture (see Hung 2008). The oldest and deepest horizon is located within the silty clay sediments between c.100 and 150 centimetres bmg. The younger bone assemblage is inter-mixed with the huge shell midden and is located from depths close to ground level to ~70 centimetres bmg.

Below the shell midden

The bone assemblage from the silty clay (from c.100 – 200cm bmg)

Table 6. Dental measurements of cervid teeth recovered from Nagsabaran. l = length; w = maximum width; Wa = width anterior lobe; Wm = width middle lobe (M3's only); Wp width posterior lobe.

Location	Max. Depth (cm)	Element	Side	P4l	P4w	M1l	M1Wa	M1Wp	M2l	M2Wa	M2Wp	M3l	M3Wa	M3Wm	M3Wp
Mandible															
Pit 9	0-10	P4	R	13.09	8.61										
Pit 9	0-10	M1	L			15.58	10.19	D							
Pit 9	10-20	M1	R			13.32	10.53	10.73							
Pit 9	20-30	M2	R						17.07	12.61	12.15				
Pit 9	110-120	M2	L						17.56	12.12	11.93				
Pit 10	0-0.05	Mandible	L	13.48	8.82	15.58	11.56	11.38	18.17	12.51	12.22	25.41	12.08	11.36	7.15
Pit 10	10-20	Mandible	R	12.66	8.55	15.37	11.57	11.79							
Pit 10	20-30	M3	R									D	12.79	12.43	D
Pit 9	110-120	M2	L						17.09	11.97	D				
Pit 9	110-120	M3	L									24.06	11.71	11.18	7.48
Pit 9	110-120	Mandible	L						17.34	12.31	12.67	24.7	12.53	12.56	7.81
Maxilla															
Pit 10	30-40	M1	L			13.4	16.65	16.61							
Pit 10	30-40	M2	L						16.37	18.95	18.83				
Pit 10	30-40	M3	L									16.42	18.36	17.92	
Pit 10	40-50	P4	R	10.32	15.09										
Pit 10	40-50	P4	L	10.35	15.11										
Pit 10	40-50	M1	R			13.34	16.47	16.56							
Pit 10	40-50	M2	R						16.67	19	18.9				

Table 7. Measurements of modern *Cervus mariannus* from Luzon Island held at the Field Museum of Natural History, Chicago. Only those with numerical codes have been formerly accessioned: SC Sims specimens originate from a mountain province in Luzon; Dr. S.A. Francisco: a cranium from Calatagan, Batangas; 170984 and 175731 are from Kalinga Province. L = length; Wa = width anterior crowns; Wm = width middle lobes (M3 only); Wp width posterior crowns (After Piper and Mijares 2007; Data recorded by P.J.Piper and J. Ochoa).

Accn No.	Sex	P4(L)	P4(W)	M1(L)	M1(Wa)	M1(Wp)	M2(L)	M2(Wa)	M2(Wp)	M3(L)	M3(Wa)	M3(Wm)	M3(Wp)
Mandibular													
Sims 1909/1	F?	12.18	8.7	14.3	0	11.6	15.9	12.8	13.14	24.02	12.77	12.94	7.46
Sims 1909/2	?	\	\	14.43	9.6	10.64	17.42	11.05	11.12	\	\	\	\
Sims 1909/3	?	13.92	9.62	14.27	10.3	11.48	18.34	12.07	11.98	25.28	11.4	10.8	5.86
Sims 1909/4	?	\	\	15.24	10.85	10.73	17.41	11.73	11.96	\	\	\	\
Sims 1909/5	?	\	\	14.55	10.97	11.3	17.69	13.18	12.13	22.9	11.9	\	\
Sims 1909/6	?	13.66	8.84	13.56	10.6	11.12	16.11	12.28	12.3	23.3	12.66	11.96	6.5
Sims 1909/7	?	12.25	7.7	12.8	10.05	11.42	15.8	12.29	12.46	23.77	12.06	10.89	6.06
170984	M	13.27	8.04	13.21	9.76	10.46	15.99	11.18	11.31	\	11.49	10.52	5.9
Maxillary													
SC Sims 1909/1	F?	9.92	14.4	15.12	15.67	16.34	16.87	18.18	17.84	17.24	\	\	16.82
SC Sims 1909/2	?	\	\	14.1	13.75	13.95	17.78	\	\	\	\	\	\
SC Sims 1909/3	?	11.17	14.42	14.34	16.28	16.42	17.97	18.66	17.56	18.3	17.5	\	15.5
SC Sims 1909/4	?	\	\	14.3	15.7	15.4	16.78	15.84	15.3	\	\	\	\
SC Sims 1909/5	?	\	\	14.92	16.98	17.04	18.28	16.86	16.44	17.74	\	\	\
SC Sims 1909/6	?	10.43	15.2	13.82	16.65	\	15.2	18.45	18.55	17.36	17.8	\	16.89
SC Sims 1909/7	?	9.6	13.4	13.1	16.44	16.88	16.1	18.58	18.68	16.86	16.9	\	15.52
Dr. S.A. Francisco	M	9.7	14.2	12.66	17.03	16.96	15.39	18.56	18.76	16.12	17.94		15.3
170984	M	9.03	13.56	12.4	15.93	15.67	15.39	16.91	16.78	16.32	16.8	\	\
175731	M	\	\	13.03	15.05	14.8	15.06	16.72	\	\	\	\	\

Table 8. Biometric records of all the measureable post-cranial elements of deer from Nagsabaran excavations: For cuboid-navicular, radius and scapula: M-Lw = Medio-lateral width; A-Pw = Antero-posterior width; For the metapodials: GLm = Greatest length medial; GLl = Greatest length lateral; M-Lwp = Medio-lateral width of the proximal end; A-Pwp = Antero-posterior width of the proximal end; M-Lwc = Medio-lateral width of the condyles; A-Pwc = Antero-posterior width of the condyles; For the distal end of humerus: Wc = width of the condyle.

Dbase No.	Depth	Bone type	Side	Mlw	C
NG-2106	0-10	Calcaneum	L	24.05	28.39
NG-2150	10-20	Calcaneum	L	24.47	30.93

Dbase No.	Depth	Bone Type	Side	M-Lw	A-Pw
NG-2158	0-20	Cuboid-navicular	L	34.07	28.11

Dbase No.	Depth	Bone Type	Side	GLm	GLl	M-Lwp	A-Pwp	M-Lwc	A-Pwc
NG-2159	10-20	Metatarsal	L	187	185	29.47	28.55	31.86	18.17
NG-2292	0.05-10	Metacarpal (proximal)	R	\	\	29.05	\	\	\

Dbase No.	Depth	Bone type	Side	Wc
NG-2123	0-10	Humerus (distal)	L	40.74

Dbase No.	Depth	Bone type	Side	M-Lw	A-Pw
NG-2154	10-20	Radius (distal)	L	34.69	18.53

Dbase No.	Depth	Bone type	Side	M-Lw	A-Pw
NG-2172	20-30	Tibia (distal)	L	35.74	\
NG-2173	20-30	Tibia (distal)	L	\	26.35

contains a high proportion of fragments demonstrating slight surface polishing and rounding of fracture margins consistent with post-depositional movement. Furthermore, rates of fragmentation are greater than those observed in the bone assemblages from the overlying shell midden, and the small standard deviation in fragment size indicates that the bones have been broken to a relatively uniform size. The bone assemblage is not really consistent with the high concentrations of skeletal elements that might be expected from a true midden, such as that recorded in the shell mound, but consists more of dispersed bone fragments indicating the local presence of people on the site, rather than defining an area of specific activity or bone discard. Thus, it is likely that the bones within the silt clay have been re-distributed short distances in a sedimentological facies with moderate to high transport, or are located on the periphery of an area of more intensive human activity close by.

Figure 8. An Elasmobranch vertebra with the central neural canal enlarged, possibly to thread a cord. The internal edges of the specimen show some slight wear to support the interpretation of its use as a bead.

The small numbers of identifiable bone fragments from below the shell midden suggest that the meat diet of the human occupants of Nagsabaran consisted almost exclusively of deer and pig, supplemented with some reef and freshwater fish. Morphometric studies of the teeth clearly show that two different pig taxa are present in the archaeological record, the endemic *Sus philippensis/cebifrons* and a possible member of the *S. scrofa* group. The latter is not native to Luzon, and must have been

Table 9a. Measurements of the pig mandibular teeth recovered from Nagsabaran. L = length; Wa = width anterior crowns; Wm = width middle crowns; Wp width posterior crowns. For the lengths of the M1 and M2, the tooth was measured at the base of the enamel and at the occlusal surface (in brackets).

Dbase No.	Location	Max. Depth	Element	Side	P4l	P4w	M1l	M1Wa	M1Wp	M2l	M2Wa	M2Wp	M3l	M3Wa	M3Wm	M3Wp
NG-2278	Pit 10	0-0.05	M2	R						20 (21.96)	15.55	15.7				
NG-2279	Pit 10	0-0.05	M1	L			14.72 (D)	12.64	D							
NG-2303	Pit 10	0.05-0.1	P4	L	11.72	9.07										
NG-2304	Pit 10	0.05-0.1	P4	R	12.21	8.69										
NG-2305	Pit 10	0.05-0.1	P4	L	12.56	7.91										
NG-2307	Pit 10	0.05-0.1	P4	R	11.84	6.71										
NG-2310	Pit 10	0.05-0.1	M1	R			12.68 (13.33)	9.01	D							
NG-2500	Pit 10	0.05-0.1	Mandible	R									24.88	14.81	12.53	9.05
NG-2334	Pit 10	0-0.05	Mandible	R			12.64 (13.35)									
NG-2097	Pit 9	0-10	Mandible	R	13.21	10.05	14.11 (18.06)	11.47	12.14	21.71 (23.00)	15.5	15.71				
NG-2098	Pit 9	0-10	M2	L						19.15 (22.06)	14.73	15.44				
NG-2099	Pit 9	0-10	M1	L			15.82 (16.07)	11.49	10.68							
NG-2100	Pit 9	0-10	M3	L									37.55	17.02	17.71	14.27

Table 9a. (cont.)

Dbase No.	Location	Max. Depth	Element	Side	P4l	P4w	M1l	M1Wa	M1Wp	M2l	M2Wa	M2Wp	M3l	M3Wa	M3Wm	M3Wp
NG-2101	Pit 9	0-10	M3	R										17.71	17.98	
NG-2335	Pit 10	10-20	Mandible	R						14.30 (20.53)	13.73	13.92				
NG-2505	Pit 10	10-20	P4	R	13.45	9.74										
NG-2512	Pit 10	10-20	Mandible	R			14.86 (16.02)	10.15	10.99							
NG-2513	Pit 10	10-20	Mandible	L			14.83 (16.27)	9.98	11.18							
NG-2167	Pit 9	20-30	M2	R						21.38 (22.07)	14.42	14.89				
NG-2394	Pit 10	20-30	dp4	R												
NG-2405	Pit 10	30-40	M1	L			13.01 (14.1)	9.2	9.33							
NG-2406	Pit 10	30-40	M1	R			12.61 (14.05)	8.95	9.14							
NG-2441	Pit 10	50-60	P4	L	12.03	7.58										
NG-2244	Pit 9	130-140	P4	R	14.97	10.56										

Table 9b. Measurements of the pig maxillary teeth recovered from Nagsabaran. L = length; Wa = width anterior crowns; Wm = width middle crowns; Wp width posterior crowns. For the lengths of the M1 and M2, the tooth was measured at the base of the enamel and at the occlusal surface (in brackets).

Dbase No.	Location	Max. Depth	Element	Side	P4l	P4w	M1l	M1Wa	M1Wp	M2l	M2Wa	M2Wp	M3l	M3Wa	M3Wm	M3Wp
NG-2102	Pit 9	0-10	M3	R									38.93	\	19.09	14.33
NG-2156	Pit 9	10-20	Maxilla	R	11.2	13.03	15.43 (18.09)	14.94	14.71	21.3 (21.33)	18.41	17.15				
NG-2161	Pit 9	10-20	M3	L									23.4	16.33	14.12	9.11
NG-2353	Pit 10	10-20	Maxilla	L	11.43	13.54	15.41 (18)	14.95	14.35							
NG-2354	Pit 10	10-20	M3	L									38.93	21.01	18.28	14.4
NG-2359	Pit 10	10-20	M3	R									23.98	15.59	13.31	7.45
NG-2360	Pit 10	10-20	Maxilla	L									24.34	15.47	13.33	7.98
NG-2503	Pit 10	10-20	P4	L	10.34	11.48										
NG-2508	Pit 10	10-20	P4	L	10.99	12.33										
NG-2509	Pit 10	10-20	Maxilla	R									\	15.87	\	\
NG-2511	Pit 10	10-20	M1	R			13	11.12	11.42							
NG-2514	Pit 10	10-20	Maxilla	L									24.4	15.72	14.31	8.28
NG-2392	Pit 10	20-30	M1	R			13.38	11.19	11.47							
NG-2393	Pit 10	20-30	Maxilla	R			13.32	11.07	11.46							
NG-2176	Pit 9	30-40	M1	L			15.70 (16.86)	14.39	14.97							
NG-2200	Pit 9	60-70	dp3	R												

Table 9b. (cont.)

Dbase No.	Location	Max. Depth	Element	Side	P4l	P4w	M1l	M1Wa	M1Wp	M2l	M2Wa	M2Wp	M3l	M3Wa	M3Wm	M3Wp
NG-2201	Pit 9	60-70	M1	R			16.00 (18.62)	14.21	14.16							
NG-2515	Pit 9	130-140	Maxilla	L			UN (17.87)	15.01	15.15							
NG-2253	Pit 9	140-150	Maxilla	R	10.02	10.2	13.5	11.14	11.87	16.58	13.76	13.95	23.86	16.37	13.93	7.1
NG-2521	Pit 9	140-150	M2	?						22.88						

Table 10. Dental measurements of the modern comparative *Sus philippensis* from Luzon held at the FMNH Chicago. L = length; Wa = width anterior crowns; Wm = width middle crowns; Wp width posterior crowns. For the lengths of the M1 and M2, the tooth was measured at the base of the enamel and at the occlusal surface (in brackets; Data recorded by P.J. Piper and J. Ochoa – measurements of dp4's available on request).

Accn No.	Locality	Sex	P4L	P4W	M1L	M1Wa	M1Wp	M2L	M2Wa	M2Wp	M3L	M3Wa	M3Wm	M3Wp
Mandible														
41889	Manila Bay	M	12.73	9.23	13.64 (14.07)	9.85	10.39	17.15 (17.67)	12.75	12.67	25.34	14.36	13.4	9.04
62271	Luzon	M	12.13	8.62	13.44 (15.59)	8.85	9.26	16 (17.08)	11.58	11.59	\	\	\	\
62270	Luzon	F	11.7	7.55	11.66 (12.3)	8.58	9.07	15.41 (15.64)	10.68	11.36	\	12.82	11.39	\
Maxilla														
41889	Manila Bay	M	10.19	13.7	12.86 (14.57)	13.05	12.95	16.85 (17.91)	16.62	15.22	22.74	17.68	\	\
62271	Luzon	M			13.56 (14.73)	11.4	11.98	16.24 (17.73)	14.35	14.31	\	\	\	\
62270	Luzon	F	9.68	11.68	11.11 (12.06)	11.08	11.32	15.05 (15.97)	13.35	13.9	\	14.61	12.57	\

Table 11. Dental measurements of the modern comparative *Sus ahoenobarbus* from Palawan Island held at the FMNH Chicago. L = length; Wa = width anterior crowns; Wm = width middle crowns; Wp width posterior crowns. For the lengths of the M1 and M2, the tooth was measured at the base of the enamel and at the occlusal surface (in brackets; Data recorded by P.J. Piper and J. Ochoa – measurements of dp4's available on request).

Accn No.	Locality	Sex	P4L	P4W	M1L	M1Wa	M1Wp	M2L	M2Wa	M2Wp	M3L	M3Wa	M3Wm	M3Wp
Mandible														
42825	Iwahig	M	13.91	9.48	15.13 (16.89)	10.35	10.83	19.29 (20.12)	14.09	14.42	32.61	16.58	16.04	12.47
62830	Iwahig	M	14.53	8.86	16.15	11.22	11.63	20.43	14.5	14.3	35.75	16.5	14.71	11.66
62826	Busuanga	F	\	\	15.39 (16.95)	10.49	11.26	\	\	\	\	\	\	\
62827	Busuanga	M	\	\	17.14 (17.44)	11.3	11.61	\	\	\	\	\	\	\
Maxilla														
42825	Iwahig	M	11.66	12.94	15.59 (17.19)	12.78	12.96	19.53 (20.26)	16.01	15.95	29.65	17.4	15	11.66
62830	Iwahig	M	12.33	12.99	15.46 (17.38)	14.09	14.08	19.78 (20.66)	16.35	15.58	30.12	18.11	15.39	10.78
62826	Busuanga	F	\	\	16.5 (17.34)	12.26	12.71	\	\	\	\	\	\	\
62827	Busuanga	M	\	\	17.51 (18.56)	14.43	14.25	\	\	\	\	\	\	\

Table 12. Dental measurements of the mandibular molar toothrow of *Sus scrofa* from Taiwan. L = length; Wa = width anterior crowns; Wm = width middle crowns; Wp width posterior crowns. For the lengths of the M1 and M2, the tooth was measured just above the enamo-cementum junction. Measurements of the M1 and M2 lengths were taken at the occlusal surface (Data kindly supplied by Dr. Keith Dobney, University of Durham).

Museum No	Species	Notes	M1l	M1Wa	M1Wp	M2l	M2Wa	MWp	M3l	M3Wa	M3Wm	M3Wp
19230	wild	Oxford University Museum. DNA no = GL231.	15.9	9.3	10	21.9	12.9	12.9	\	\	\	\
1906-496	wild	Natural History Museum, Paris. Labelled Porcula caivana	\	10.8	11.9	21.3	14.1	15.8	32	15.5	15.3	12.2
19241	wild	Oxford University Museum. DNA no = GL233	17.3	10.8	12.3	25.3	16.1	16.1	\	\	\	\
69763	wild	Natural History Museum, Berlin	15.8	9.4	10.2	\	11.5	12.6	\	\	\	\
69764	wild	Natural History Museum, Berlin	13	7.6	8.6	\			\			
A243,10	wild	Natural History Museum, Berlin. Old museum no., not in catalogue.	17.1	10.9	11.4	22.1	14.6	13.8	36.2	16	14.6	13.7
308882	?	Smithsonian MSC, Washington DC. Female	16.2	9.9	10.6	\	\	\	\	\	\	\
333189	?	Smithsonian MSC, Washington DC	16.5	9.1	9.7	\	\	\	\	\	\	\
358647	?	Smithsonian MSC, Washington DC	16.5	9.5	10.5	\	\	\	\	\	\	\
358646	?	Smithsonian MSC, Washington DC. Male. Photo to be taken?	\	11	11	20.5	15	14.4	34.8	17	15.8	12.8
358648	?	Smithsonian MSC, Washington DC. Female	\	\	\	\	\	\	\	\	\	\
308871	?	Smithsonian MSC, Washington DC. Male	\	13.1	\	\	\	\	\	\	\	\

Table 13. Biometric records of all the measurable post-cranial elements of pig from Nagsabaran excavations: For cuboid-navicular, radius and scapula: M-Lw = Medio-lateral width; A-Pw = Antero-posterior width; Hc = height of the cup; For the metapodials: GLm = Greatest length medial; GLl = Greatest length lateral; M-Lwp = Medio-lateral width of the proximal end; A-Pwp = Antero-posterior width of the proximal end; M-Lwc = Medio-lateral width of the condyles; A-Pwc = Antero-posterior width of the condyles; For the distal end of humerus: Wc = width of the condyle; Mwd = Maximum width of the distal end; Mmc = Maximum depth of the medial epicondyle; Mdl = Minimum depth of the lateral epicondyle.

Dbase No.	Depth	Bone type	Side	GLl	GLm	Dl	Bd
NG-2128	0-10	Astragalus	L	45.11	39.02	24.6	21.07

Dbase No.	Depth	Bone type	Side	GL	Mlw	C
NG-2209	80-90	Calcaneum	L	62.42	15.48	23.07

Dbase No.	Depth	Bone type	Side	Wc	Mwd	Mmc	Mlc
NG-2152	10-20	Humerus	R	27.42	35.59	27.99	24.8
NG-2200	60-70	Humerus	L	26.32	34.1	21.46	18.1
NG-2330	10-20	Humerus	R	\	35.86	26.46	15.55
NG-2496	10-20	Humerus	L	26.33	36.06	24.62	17.46

Dbase No.	Depth	Bone type	Side	M-Lw	A-Pw
NG-2185	40-50	Radius	R	22.7	15.48
NG-2316	5-10	Radius	R	27.49	18.69

Dbase No.	Depth	Bone type	Side	A-Pw
NG-2425	40-50	Tibia	L	24.84

Dbase No.	Depth	Bone type	Side	Bp	Dp	Bd	SD	GL
NG-2323	5-10	Basal Phalanx	\	12.32	10.81	10.82	9.16	29.45

introduced from elsewhere in the region, probably as a managed or domestic population. The absence of this larger species of pig from the Late Pleistocene and early Holocene archaeological record of Peñablanca also argues against it being an extinct native of the Philippine archipelago (Piper unpubl. Data). Furthermore, the only other suid species identified in northern Luzon is from the Middle Pleistocene deposits of Solana in the Cagayan Valley. The three molars possess a comparatively simple structure that includes a small ectoconulid, endoconulid and preconulid between the protoconulid/metaconulid and hypoconid/entoconid (de Vos and Bautista 2001). The original species designation of *Celebochoerus cagayanensis* was rejected by de Vos and Bautista (2001) as premature.

Hence, there is currently no evidence before the Neolithic period of any pig taxa within northern Luzon that demonstrate the complex molar morphology and size of the largest specimens from Nagsabaran that would suggest they represent an extinct native.

The deepest identifiable archaeological element of the 'larger' pig taxon is an isolated upper M2 recovered from Pit 9 at a depth of 140 – 150 centimetres bmg: this corresponds to an age of ~2600 – 4000 cal. BP. This currently represents the earliest evidence for a domesticated pig population into the Philippine archipelago. To establish with greater certainty the age of the introduced domestic pig, a right lower 4th premolar (NG-2244) from Pit 9 level 14 (130 – 140cm bmg) Quadrant QB, Accn. No. 2004-12-16 (Figure 9) was sent to the radiocarbon laboratory at Waikato for radiocarbon dating. The tooth was split transversely in antiquity into two almost equal-sized fragments. It has a total length at the enamel-root junction of 14.97 millimetres and a width of 10.56 millimetres (Table 9a). The maximum antero-posterior width of the tooth is 16.03 millimetres. The specimen has a total height from the tip of the longest root to the top of the crown of 29.38 millimetres. The crown is in slight wear with some loss of the enamel surfaces.

Figure 9. The buccal aspect of the right permanent 4th pig premolar from Pit 9 level 14 (130 – 140bmg) sent to Waikato for ^{14}C dating.

The P4 returned a date of 3940±40BP (WK-23397) or 4500-4200 cal. BP (OxCAL Version 3), supporting associated charcoal dates and the typological chronology established from the ceramics recovered from the site (Hung 2008; Piper *et al*. in press).

This discovery has important implications for our understanding of the origin and timing for the introduction of domesticated pigs to Island Southeast Asia. Dobney *et al*. (2008) have shown fairly convincingly that what they term the 'Pacific Clade' of pigs was introduced to New Guinea and the Pacific Islands via a route through Peninsula Malaysia, Sumatra, Java and the Lesser Sunda Chain. These pigs appear to have reached Flores and New Guinea by approximately 3500 cal. BP. The genetic and morphometric studies indicate that these pigs are very different to those introduced to the Philippines, the latter probably being translocated from China via Taiwan (Cucchi *et al*. in press; Larson *et al*. 2007a, b). Dobney *et al*. (2008: 70) state that 'a separate, probably later, human-mediated dispersal involved other mainland East Asian domestic pigs moving through the Philippines to Micronesia'. With the discovery of pigs on the Batanes islands in the northern Philippines dating to around 3000 cal. BP (Yang *et al*. in prep.) and at Nagsabaran by an even earlier date, there is now zooarchaeological support for the mainland - Taiwan to the Philippines hypothesis. However, the dates of greater than 4000 cal. BP suggest that the translocation from Taiwan to the Philippines occurred much earlier in prehistory than previously envisaged and pre-dates the introduction of the Pacific Clade to the region. Further, more detailed discussion on the importance of the Neolithic introduction of domestic pigs to the Philippines for our understanding of origins, timing and patterning of pig translocation and human migrations can be found in Piper *et al.* (2009).

From comparisons of the recovered dental elements, it appears that wild pigs and deer outnumber the teeth of introduced pigs at Nagsabaran. This would suggest that wild game contributed the greatest amount of protein to the diet. However, the hunting of wild boar and deer remains an integral part of both hunter-gatherer and forager groups alike across the region, even today. Furthermore, in Island Southeast Asia (as with many locations) we must be careful when assigning relative importance to a particular 'resource' through abundance and frequency in the archaeological record alone. Many indigenous human populations in the islands differentiate between wild pigs used for general eating purposes, and domestic pigs kept specifically for ritual and ceremonial function (Piper, personal observations; see also Barker 2007; Hayden 2003 for discussion). The less frequent slaughtering of domestic pigs is likely to make their remains less abundant in the archaeological record and mask their overall social and ideological importance. In the future, with larger sample sizes it might be possible to differentiate patterns of slaughter that could be used to interpret the various 'functions' of the two pig taxa.

The only identifiable fish remains are the premaxillae and dentary of Sparidae or sea breams. These carnivorous fish are commonly found in coastal reefs but also inhabit brackish estuaries and deep waters (Broad 2003; Kottelat *et al*. 1993). These normally solitary fish gather in large shoals during the summer spawning season, and this presents the best time to catch them (Leach 2006). In general, this fish can be caught using nets, with a baited hook or gorge.

Shell midden

The recovery of animal bones from open sites in tropical environments is a rare occurrence. The burial environment is normally acidic and notoriously aggressive towards all types of organic remains. The survival of the animal bones so close to modern ground surface at Nagsabaran is undoubtedly a result of their incorporation within a huge shell midden, which has very different post-depositional properties to the local natural sediments. Shell is made of calcium carbonate for one thing, which is known to produce burial environments favourable for bone preservation.

The vertebrate remains from the shell midden show a number of taphonomic features associated with being close to a ground surface, such as surface cracking and exfoliation as a result of exposure to weathering. Fragments of long bone shafts and articular ends have survived well, and these have the greatest abundance (>70%) in the archaeological record. High frequencies of small splinters of long bone in the archaeological record are not unusual. The deliberate or natural breakage of just one long bone shaft can produce large numbers of small bone fragments. What are less consistent are the low frequencies of some of the other skeletal elements. Some of this can possibly be explained as a result of post-depositional destruction. For example, several maxillae and mandibles could be re-constructed from small fragments of bone and loose teeth, indicating that these structures had been deposited consistently throughout the archaeological record. This implies that there has been varying degrees of post-depositional impact on different types of skeletal structure, with the more compact elements of the appendicular skeleton being more resistant to trampling and soil compression. This does not however, explain the low occurrences of large ungulate extremities such as the metapodials and phalanges. These small, dense elements are generally resistant to biostratonomic and post-depositional destruction, and might be expected to be more abundant in such a well-preserved animal bone assemblage, if they had been deposited in the first place. Furthermore, there is no indication that the skulls and mandibles have been deposited as grave goods with the human bodies recovered from Pits 9 and 10 as is often the case in Southeast Asia (Medway 1973). The small numbers of human bones could be easily differentiated from *all* the animal bones (not only by morphology) by their very different taphonomic signature. Thus, it is likely that the shortage of extremities in the archaeological record truly reflects the fact that they were not deposited on this part of the site in any great numbers in the first place. Perhaps, the disparity in body part representation is a result of practices of carcass processing, the extremities having been removed elsewhere at an earlier stage in the butchery process. Certainly, the numerous cut marks on bone surfaces, often located close to articular surfaces suggests systematic carcass disarticulation. Several examples of spiral fracturing and deliberate splitting of bones using heavy, sharp implements is characteristic of marrow extraction. The evenness of edge shape of the chop marks and the deep, thin V-shaped morphology of many of the cut marks in the upper 100 centimetres bmg of the shell midden, suggests that carcass processing was undertaken with the use of metal implements. The recovery of an iron dagger from one of the inhumations recovered from within the shell mound would indicate that metal tools were available during the later periods of midden deposition (see Hung 2008).

Several skeletal elements show clear evidence of gnawing damage to one or both ends of the bone. The pitting on adjacent surfaces of the bone, surface digestion and a hollowing of the pulp cavity is indicative of carnivore gnawing. There are no natural bone modifying carnivores in the Philippine archipelago, and the most parsimonious explanation for these types of damage is the presence of dogs (*Canis familiaris*). A familiar sight is a dog with a bone between its front paws, as it gnaws and licks the end – and this is exactly the type of behaviour that causes the modifications observed on the bones recovered from the archaeological record. The presence of dog gnawed bones to a depth of 60–70 centimetres bmg provides direct evidence for their presence on the site dating back at least

1,500 years.

Dog remains are relatively rare in the archaeological record of the Philippines. A partial skeleton and various skeletal elements have been reported from Ille Cave in association with Metal Age artefacts (Ochoa 2005). De Vera (1983) identified deer '(*Cervus* sp.), Pig (*Sus* sp.), macaque (*Macaca* sp.), 'feloids' (civets and cats) and other carnivores (Carnivora)' excavated from deposits dating to post 4000BP at Minori Cave Chamber D in the Peňablanca region of northern Luzon. With the absence of native large mammalian carnivores in Luzon, presumably '*other carnivores*' refers to the remains of introduced domestic dogs. Ongpin (as reported in Alba 1994) claimed to have recovered dog remains from deposits at Lemery, Batangas dating to between 10,000BP – 6000BP. These dates are surely questionable, especially as it was reported that horse bones were identified from the same prehistoric horizon. On Palawan, the only island in the Philippines considered part of the Sundaic biogeographic region (Esselstyn *et al.* 2004) Ochoa (2009) identified several foot bones of a canid dating between 12,000 and 8,000BP. Attempts at differentiating the wild dog *Cuon alpinus* from the domestic *Canis domesticus* using comparative material held at FMNH proved inconclusive. However, the Terminal Pleistocene/Early Holocene dates for these remains would suggest that they are more likely to be from wild stock, rather than a very early introduction of domestic dog to the Philippines (Ochoa 2009). This conclusion is supported by a record of possible wild dog (*Cuon* cf. *alpinus*) from Madai Cave in Borneo dating to 10,000 years ago (Cranbrook 1988). The wild dog could possibly have crossed from Borneo to Palawan during a period of lowered sea level during the Middle or Late Pleistocene (Ochoa 2009).

The earliest domestic dog remains identified from the Island Southeast Asian region and Wallacea are a burial at the site of Lene Hara on Timor dated to 2967±50BP (Veth *et al*. 2005). In Borneo domestic dog has been identified in the Niah Caves complex, probably associated with Metal Age burials and deposits (see Clutton-Brock 1959; Piper unpubl. data). There is currently no solid evidence that the dog was introduced any earlier than this. However, for the dingo and New Guinea singing dog to have reached the Australasian region by 3500BP or earlier they must have been transported through Island Southeast Asia and Wallacea (Matisso-Smith 2007), and earlier dates for dogs somewhere in the region are to be expected from future excavations.

There is no change in the range of mammalian taxa present in the archaeological record in the shell midden. All the measurable teeth in the upper horizons fall comfortably within the range of *Cervus mariannus*, the only known species of deer on Luzon. Of the two pig taxa, the endemic wild pig is slightly more abundant in the archaeological record than the introduced taxon. This suggests that the subsistence focus at Nagsabaran remained on hunting and gathering (as evidenced by the huge shell midden), but included managed or domestic pigs, and dogs.

The low diversity of the hunted mammalian community reflects the impoverished nature of the Philippine island archipelago fauna. However, at least three intermediate-sized species that are considered to be long present in the Philippines are absent from the archaeological record, the long-tailed macaque (*Macaca fascicularis* subsp.), the common palm civet (*Paradoxurus hermaphroditus*) and the Malay civet (*Viverra tangalunga*) (Fooden 1991; Heaney 1998). This might be a result of the vagaries of the archaeological record. Alternatively, it might reflect their regional absence from northern Luzon between 4,000 and 1,000 years ago. It has still not yet been convincingly proven that any of these species has been long present in the Philippines (except Palawan) and both the common palm civet and long-tailed macaque are known to have been introduced to several island archipelagos in Wallacea (Heinsohn 2003; also van den Bergh *et al.* in press). Further zooarchaeological research is required to determine the status of these species in the Philippines.

The continuing presence of small numbers of Sparidae premaxillae and dentaries suggests a regular availability of this fish in the community. Its marked presence in the area could also indicate a preference for this species with its delicate flesh. The relative size of zooarchaeological specimens suggests the human inhabitants had access to marine fish from deeper water where the adults of this taxon are mostly found feeding on bottom-living invertebrates (Conlu 1986).

The fish gorges identified in the Nagsabaran assemblage produced from the canines of pig and dog have some parallels such as the fishing gorge from the Anaro site on the Batanes Islands fashioned from a male pig lower canine. The specimen measures 39.4 millimetres in length with a maximum bucco-lingual width of 7.06 millimetres making it comparable in size with the gorges from Nagsabaran (Campos, personal communication). The fragment of tooth has a notch gouged out half way along the shaft. The baited gorge works by rotating from a vertical position parallel with the line, to one perpendicular when swallowed, and jamming in the mouth of the fish. These implements could have been effective against carnivorous fish with relatively large mouth sizes such as Sparidae, as well as other coral reef fishes like snappers (Lutjanidae) and/or groupers (Serranidae). The gorges would probably have been too small to catch sharks and these were probably captured using nets or a noose (Kuang-Ti, 2001) .

Conclusions

The zooarchaeological study of the animal bones from Nagsabaran has produced evidence of the taphonomic processes involved in the accumulation of the bone assemblages, and human processing and discard practices during occupation of the site from ~4000 years ago until within the last millennium. The study shows that hunting remained an integral part of the subsistence strategy in the northern Philippines, even after the introduction of the domestic pig around 4,000 years ago, and these same strategies appear to have continued throughout several millennia, until fairly recently. The domestic dog is evident at the site from at least 1500 years ago.

The morphometric data reported here for pigs and deer in Luzon provide invaluable information for future studies and increases the current available dataset. Many more studies of a similar nature are required before we can fully interpret the long term changes in human subsistence strategies across the Philippine archipelago, and the transition from wholly hunter-gatherer life ways to an economic system that includes the keeping of domestic animals. As more zooarchaeological assemblages are recovered from sites in the Philippines and subject to intensive study our knowledge of changing human subsistence patterns and the palaeobiogeographic distribution of species will rapidly increase.

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