Zooarchaeology of the Earliest Farming Period

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ABSTRACT

This paper is a summary of Nōkō kaishiki no dōbutsu kōkogaku (Zooarchaeology of the Earliest Farming Period; Rokuichi Shobō, 2019). Part I discusses the use of animal resources in the Tokai area, central Japan in the earliest known farming period. Chapter 1 summarizes the findings from and questions raised by preceding studies and introduces the aims of the present research. Subsequent chapters analyse animal remains from the Yayoi period and investigate shellfish gathering (chapter 2), fishing (chapter 3), and hunting (chapter 4) activities. Chapter 5 investigates conditions in the Final Jomon period just prior to the introduction of farming. Chapter 6 examines the usage of animal resources in the earliest farming period. Part II discusses remaining tasks and questions outlined in Part I. Chapter 7 investigates methods used in research on animal remains, chapter 8 presents the methodology of zooarchaeology, and chapter 9 considers the social contributions of the research results. This study presents the results of real observation of approximately 53 000 animal remains and approximately 25 000 contemporary vertebrate specimens.

KEYWORDS: use of animal resources, shell gathering, fishing, hunting, earliest farming period, zooarchaeology, Japan

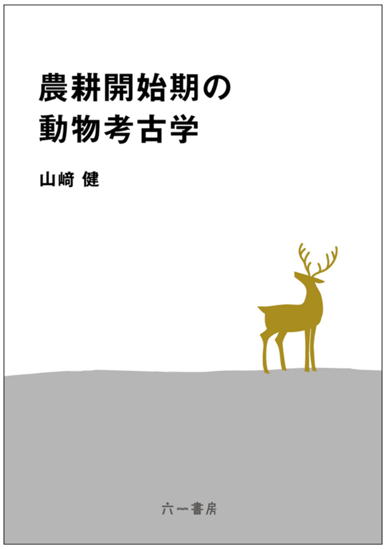

Figure 1. Zooarchaeology of the Earliest Farming Period (Yamazaki 2019)

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Part I. Case study of the Tokai area (Ise Bay coast and Mikawa Bay coast)

Chapter 1. Study aims

The aim of the present study is to examine usage of animal resources by (prehistoric) people during the earliest period of farming, based on analysis of animal remains from the Final Jomon period to the Yayoi period (1300 BC–AD 300).

The Jomon period began approximately 16 000 years ago and is defined by the hunter-gatherer society of Japan at that time. This period is divided into seven stages: the Incipient, Earliest, Early, Middle, Late, and Final. The following Yayoi period was a time when agrarian society became dominant and rice paddy cultivation began.

Usage of plants greatly changed in the Yayoi period relative to the Jomon period and earlier. Consequently, research on subsistence in the Yayoi period has so far primarily been based on evidence of plant usage, such as rice cultivation and dry-field farming. Research on animal remains from the Yayoi period is sparse in comparison to that regarding the Jomon period (Kaneko 1980). However, since the transition from Jomon to Yayoi involved a change in the social organization from hunter-gatherer to agrarian, then animal usage could be expected to change in addition to plant usage. Specifically, if animal usage was found to have changed with the emergence of farming, that would mean that people living in the Yayoi period were likely to have specialized in agriculture, and we could conclude that subsistence activities changed markedly in the Yayoi period. However, if animal usage did not change along with the introduction of farming, then it is unlikely that people living in the Yayoi period specialized in agriculture, even though they did cultivate some plants. We could then conclude that subsistence activities did not change greatly in the Yayoi period.

Research on fishing and hunting in the Yayoi period has mainly centered on the analysis of fishing and hunting tools and not on the analysis of animal remains. Researchers investigating the Yayoi period have presented different interpretations of typological changes in fishing and hunting tools and have stated that “fishing activities advanced greatly and hunting activities did not advance in the Yayoi period.” They have determined that the effects of typological changes in fishing tools would have been an “increase in volume of catch” and interpreted this as a “development in fishing activities” (Wada 1982, 1988). They also thought that “fishing villages appeared” at a significant point in the evolution of fishing tools and have stated that “food-collecting activities became focused on fishing” (Tanaka 1986; Shimojō 1989). On the other hand, the typological changes in hunting tools during the Yayoi period have also been interpreted as reflecting an increase in killing power and differentiation between hunting tools and weapons rather than as simply the development of hunting (Sahara 1964; Matsugi 1989). Researchers have also suggested that fighting broke out at a significant point during the development of hunting and have described how hunting implements changed to weapons (Sahara 1975; Matsugi 1984).

In addition, research on animal remains from the Yayoi period has focused on domestication (Anezaki 1999, 2004, 2007; Nishimoto 1991, 1993). Zooarchaeologists have not actively discussed hunting but have observed that hunting decreased (Nishimoto 1997).

Taking into account the influence of the standard concepts that represent the Yayoi period—agriculture, division of labor, war, and animal domestication—researchers have asserted that fishing activities advanced but hunting activities did not advance in the Yayoi period. However, the point may be made not that "fishing advanced, while hunting did not advance," but rather that "research on fishing advanced, while that on hunting did not." Researchers investigating the Yayoi period have simply considered aspects that fit into the existing research framework rather than examine those that do not.

Japanese archaeologists have carefully excavated shell mounds from the hunter-gatherer societies of the Jomon period and have also collected micro remains. However, they often do not appropriately investigate shell mounds from the agrarian societies of the Yayoi period onward. Research conducted in this manner is less the result of the distance [divergence] between theory and artifacts than a slighting of artifacts for the sake of theory. That tendency has contributed to the paucity of research on animal remains from the Yayoi period in contrast to that of the Jomon period.

Research area

In the present study, Tokai, a region that has a large distribution of shell mounds from the Final Jomon period to the Yayoi period, was selected as the research area. The Tokai region is located in the center of Japan's Honshu Island and borders the Pacific Ocean. In this area, there are two bays: Ise Bay and Mikawa Bay. Chapters 2 to 4 focus on studies of the inner part of Ise Bay, where animal remains from the Yayoi period are deposited. Five sites from the inner part of Ise Bay are discussed (Figures 2, 3). Micro remains have been collected by sieving sediments from these sites. Of these five, the Tamanoi site is from the Final Jomon period, and all other sites are from the Yayoi period. Chapter 5 focuses on studies of the Mikawa Bay coast, where remains from the Final Jomon period are deposited.

Chapter 2. Shellfish gathering

Shell mounds decreased in number and size during the Yayoi period (Iwase 2003). Clams (*Meretrix lusoria*) excavated from the sites became significantly larger after the latter half of the Early Yayoi period.

Estimated length and height of shells

For clams, this study investigates a major type of shellfish that was excavated from the sites along with shell size (length and height). However, most clams found were damaged,

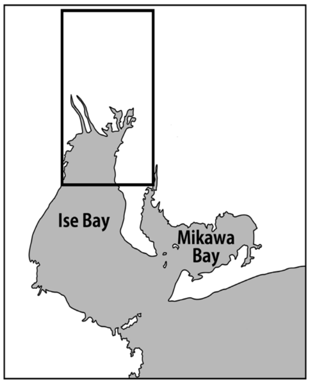


Figure 2. Studied areas
The Tokai area, located in the middle of Honshu Island, faces the Pacific Ocean. Ise Bay is shown on the western side of the overview, with Mikawa Bay to the east.

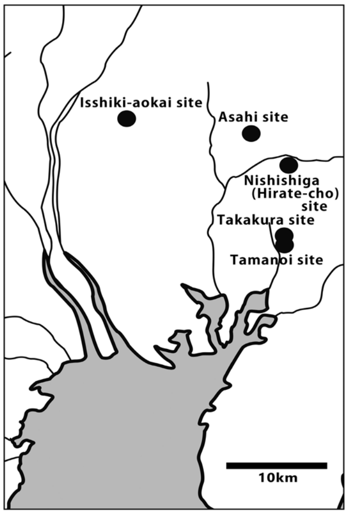


Figure 3. Location of the archaeological sites (detail of inner part of Ise Bay)

thus there were very few shells for which length and height were measurable. Of the clams that were excavated from the Asahi site, the length of shells was measurable in 16.7% of the specimens, and the height in 14.4%. To increase the number of analytical samples, the length and height of shells is estimated from excavated shell fragments. First, the length and height of shells, and the length of external ligaments of the intact excavated clams was measured using digital calipers (Figure 4). Next, the correlation between length of external ligaments, length of shells, and height of shells was calculated and an equation was derived for estimating the length and height of shells from the length of external ligaments.

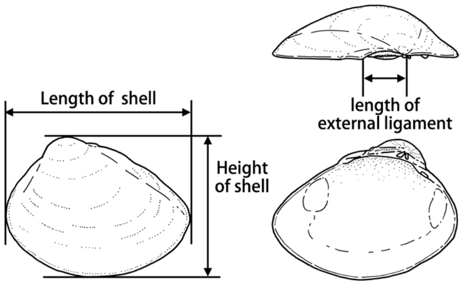


Figure 4. Measured areas

Regression analysis was performed on 431 samples for which measurement was possible for the length of external ligaments and length of shells (length of shell: 26.69–114.50mm). A strong correlation was observed between the length of external ligaments and length of shells ($R^2=0.958$, $p<0.01$). The equation for estimating the length of shells (Y: mm) from the length of external ligaments (X: mm) of excavated clams was $Y=0.01335X^2+2.68574X+9.42915$.

Similarly, regression analysis was performed on 605 samples for which measurement was possible for the length of external ligaments and height of shells (height of shell: 22.78–89.36mm). A strong correlation was found between the length of external ligaments and height of shells ($R^2=0.966$, $p<0.01$). The equation for estimating the height of shells (Y: mm) from the length of external ligaments (X: mm) of excavated clams was $Y=0.00277X^2+2.27748X+8.3817$.

Changes in the size of clams

The results of estimation of the *length* of shells of 2354 excavated clams (Figure 5) showed that length became significantly greater after the first half of the Early Yayoi period ($p<0.01$). Similarly, estimation of the *height* of shells of 2369 excavated clams also showed a significantly greater height after the first half of the Early Yayoi period ($p<0.01$) (Figure 6).

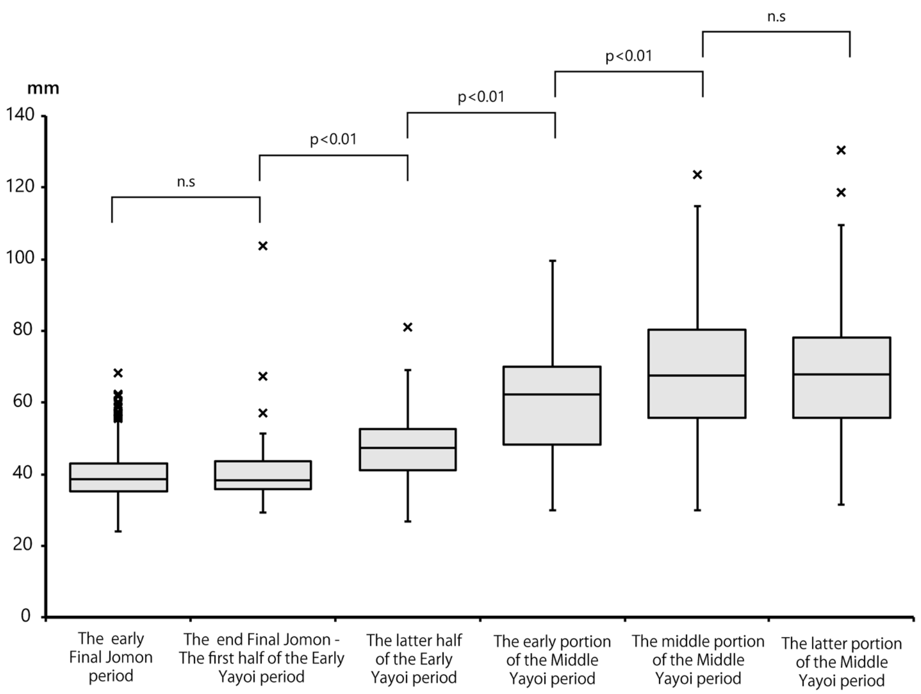


Figure 5. Changes in the length of clam shells
Significant differences in the length of clam shells were observed between those from the end of Final Jomon and those from the latter half of Early Yayoi; between those from the latter half of Early Yayoi and those from the early Middle Yayoi period; and between those from early Middle Yayoi and those from the middle of the Middle Yayoi period.

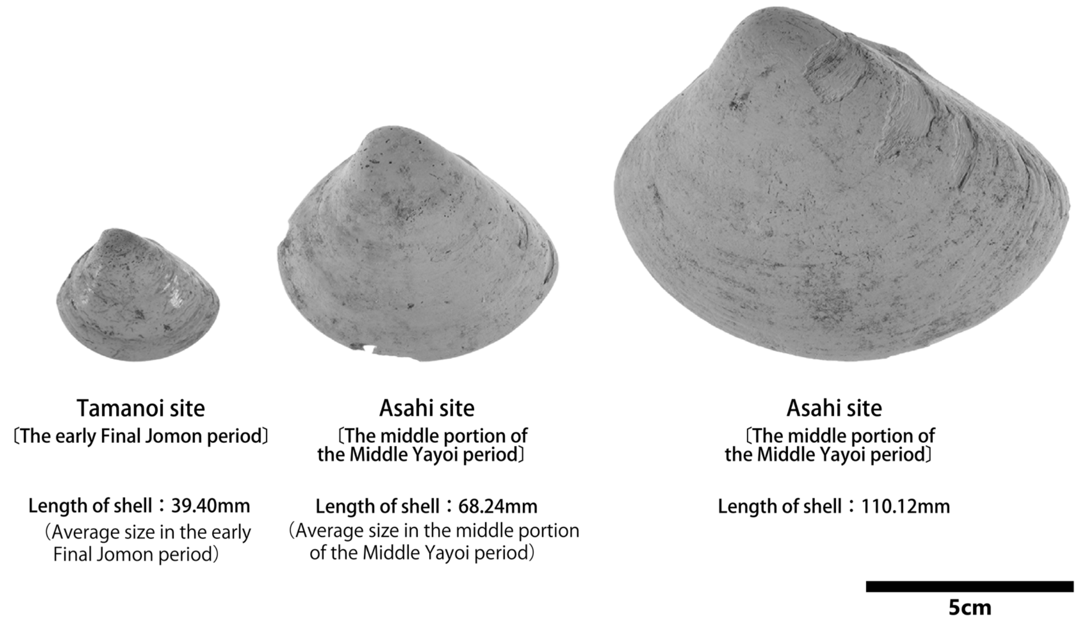


Figure 6. Excavated clams (Completed material)

After the first half of the Early Yayoi period, the amount of shellfish collected declined, and so the capture pressure on clams decreased, allowing more individuals to increase in size. Clam shell remains excavated from this period became larger, so we can infer that people of the Yayoi period preferred to collect large clams. I postulate that the reason for decreased shell collecting in the Yayoi period was that the shellfish-gathering season overlapped with the farming season. Based on shell growth-line analysis, it is believed that during the Jomon period shellfish were collected between spring and early summer (Koike 1983; Horikoshi 1984). The spring tide season is best suited for shellfish gathering because the water moves a great distance from the shore at low tide; however, this coincides with peak season for cultivating fields. I suggest that because farming began on a large scale during the Yayoi period, shellfish gathering occurring at the same time decreased (Yamazaki & Oda 2009).

Chapter 3. Fishing

Chapter 3 examines fish remains excavated from five sites along the inner part of Ise Bay and discusses changes in fishing activities (Figure 7). Samples of sediment from the study sites were filtered and fine fish bones collected.

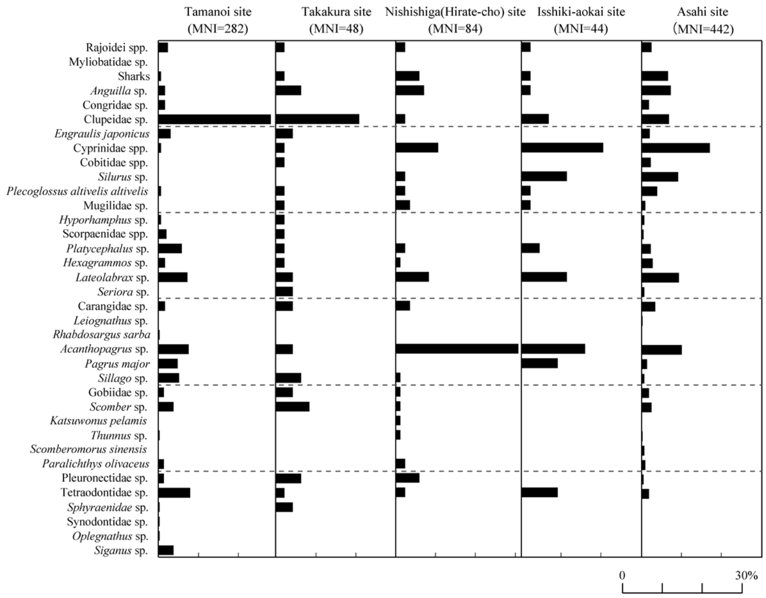


Figure 7. Composition of fish remains

Fishing grounds

Fishing grounds at each site were investigated with regard to the habitat of fish whose remains were excavated from these sites. The fish remains excavated from Ise Bay were first categorized based on the habitat and ecology of the fish (Table 1). Excavated fish were sorted into three large categories (Classes I, II, and III) based on horizontal distribution; subsequently, these groups were further subdivided based on ecology (Classes a, b, and c).

Fishing activities at each site reflected geographical conditions (Figure 8). From the Asahi site, Isshiki-aokai site, and Nishishiga (Hirate-cho) site, located in alluvial lowlands, freshwater fish (Group I) and migratory fish distributed in the coastal mid to lower layers (Group IIb) were excavated in great numbers. Among these sites, freshwater as well as coastal areas were utilized as fishing grounds. In particular, small carp (*Cyprinus carpio*) were excavated in abundance (Nakajima *et al.* 2010). For this reason, I suggest that people of the Yayoi period living in lowlands actively used fish that were farmed in shallow local freshwater areas such as paddy fields.

In contrast, fish that migrate within the coastal surface layers (Group IIa) were excavated in abundance from the Tamanoi and Takakura sites located in highland areas. Among these sites, mainly coastal regions were used as fishing grounds, whereas freshwater areas were relatively unused.

Table 1. Fish types

Fish groups	Living Environment and Ecology
Ia	Genuine freshwater fish
Ib	Diadromous fish
IIa	Migratory fish that swim in the coastal surface layers
IIb	Migratory fish that live in the intermediate to basal layers of the coast
IIc	Fish that live permanently within the bay
III	Fish that live in the bay entrance to outer sea
IV	Fish that do not fall in the above categories

Fish remains were categorized into groups depending on living environment and ecology in Ise Bay.

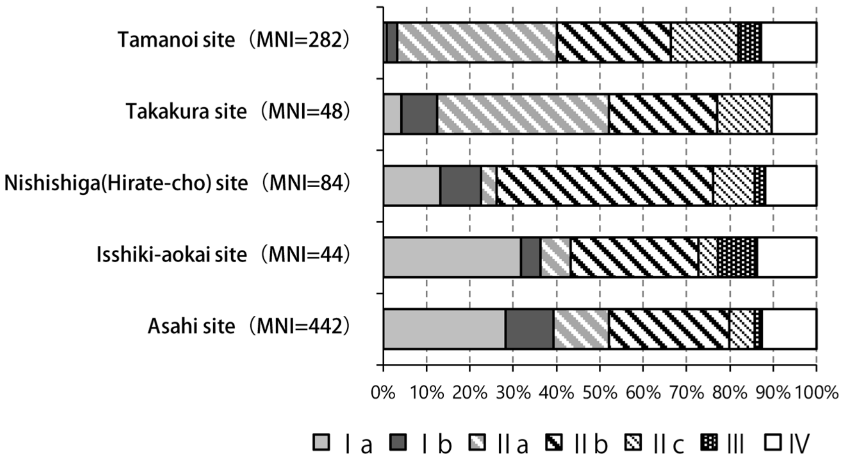


Figure 8. Comparison between fish types

Fishing seasons

Fishing seasons were determined by analyzing Japanese pilchards (*Sardinops melanostictus*), a major species found in coastal fisheries. Groups of fish that seasonally migrate along the inner part of Ise Bay are Groups IIa and IIb. In particular, fish of Group IIa migrate in schools within the coastal surface layer; therefore, they were likely to have been caught together by net fishing. At each site, the Group IIa family that was most abundantly excavated was *Clupeidae* spp. Japanese pilchard and dotted gizzard shad (*Konosirus punctatus*) were identified based on bones of the head, first vertebrae, and second vertebrae. *Clupeidae* spp. was found more abundantly during excavation in comparison to other seawater fish; among them, the pilchard comprised the majority belonging to the *Clupeidae* spp. excavated from the sites. The fishing season of the pilchards was therefore made the focus of this study.

First, an equation for estimating body length from measurements of the abdominal vertebrae was created using present-day Japanese pilchard specimens. Next, the abdominal vertebrae of pilchards excavated from the sites were measured and body lengths were estimated using the equation. Finally, the pilchard fishing season at each site was estimated based on the timing of the Japanese pilchard migration within Ise Bay.

Regression analysis was performed by measuring the body length and abdominal vertebrae of present-day Japanese pilchard specimens (Figure 9). A strong correlation

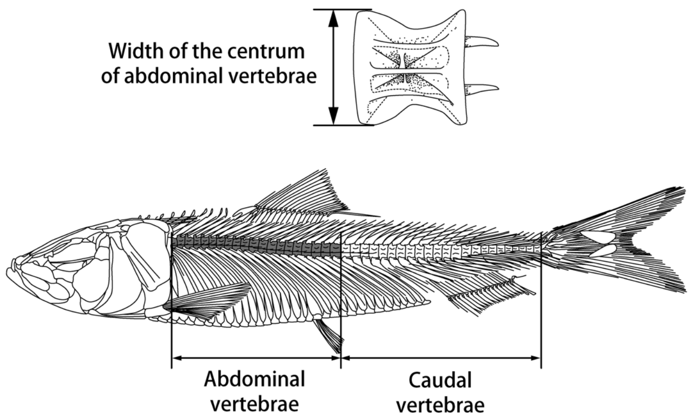


Figure 9. Measured parts of the abdominal vertebrae

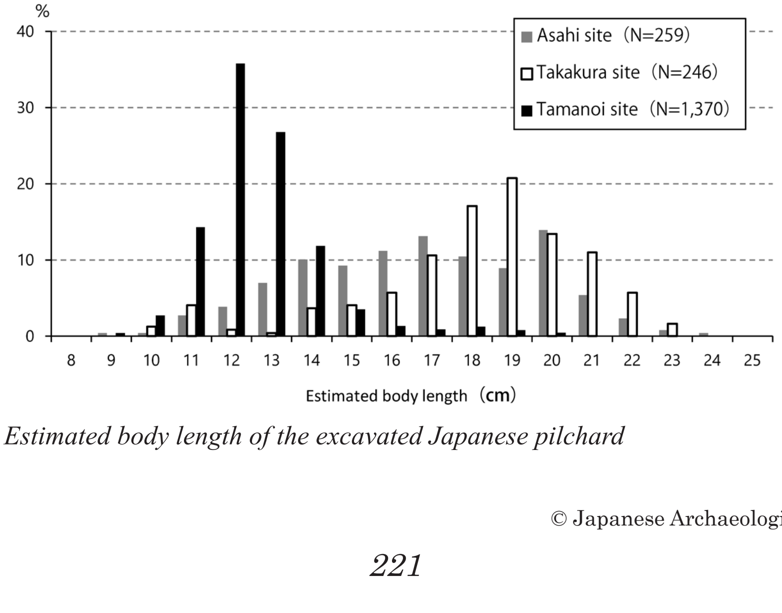


Figure 10. Estimated body length of the excavated Japanese pilchard

was observed between body length and the transverse diameter of the centrum ($R^2=0.947$, $p<0.01$). The equation for estimating body length (Y: mm) from the transverse diameter of the abdominal vertebrae centrum of pilchards was: $Y=0.453X^2+3.59X+4.541$. The body length of pilchards excavated from the study sites was estimated using this equation. The estimated body length of pilchards excavated at the Tamanoi site was between 11 and 13cm, and the estimated body length of those excavated at the Takakura site was between 18 and 19cm (Figure 10). The body length of the pilchards excavated at the Asahi site was widely distributed between 14 and 20cm.

The Japanese pilchard spawns outside Ise Bay between January and May and subsequently migrates to Ise Bay to feed (Funakoshi & Yanagibashi 1983). Pilchards are born in the winter-spring season and migrate between July and October (Japan Fisheries Resource Conservation Association 2002). Large pilchards (body length approximately 18–20cm) migrate during the winter-spring season, whereas small pilchards (body length approximately 10–15cm) migrate during the summer or fall (Figure 11). Therefore, the pilchard fishing season at the Tamanoi site in the Final Jomon period is thought to have been summer or fall. In contrast, the pilchard fishing season at the Takakura site in the Early Yayoi period is thought to have been winter or spring. Species of the *Clupeidae* spp. family, primarily the Japanese pilchard, were excavated in great abundance at

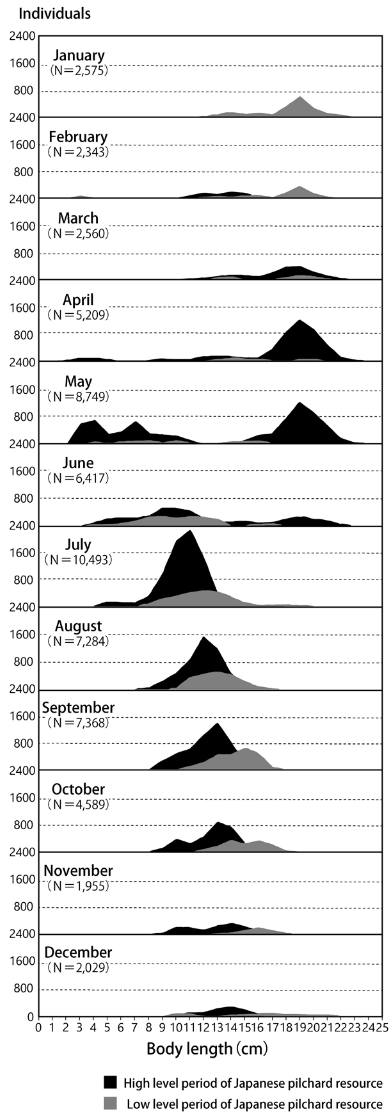


Figure 11. Body length composition by month (1952–2011) for the Japanese pilchard in Ise Bay
This graph shows the body length composition by month for the Japanese pilchard (approx. 60 000 individuals) that migrated to Ise Bay. This information was created from 60 years of data presented within the business report of the Aichi Fisheries Research Institute.

the Tamanoi and Takakura sites. For this reason, the estimated pilchard fishing season represents the overall fishing season at these sites. By comparing the Tamanoi site (Final Jomon period) and the Takakura site (Early Yayoi period), located in the Atsuta Plateau, the fishing season was found to have switched from summer-fall to winter-spring.

Changes in fishing activities

In sites in alluvial lowlands, both coastal and freshwater areas were used for fishing. On the other hand, at highland sites, the coast was a major fishing area and freshwater areas were rarely used. Based on comparison between the Final Jomon period and the Yayoi period, the fishing season at the highland sites changed from summer-fall to winter-spring. I suggest that the people of the Yayoi period spent time previously devoted to fishing on other subsistence activities, resulting in this change in fishing season (Yamazaki 2015; Table 2).

Chapter 4. Hunting

In chapter 4, sika deer (*Cervus nippon*) remains were analysed to estimate the season of death on the basis of observed tooth development. It was discovered that the main deer hunting season was during the winter at the Asahi site in the Yayoi period. In this chapter, I also show that people at the Asahi site acquired deer antlers by methods other than hunting.

Animal resource use at the Asahi site

The Asahi site is a valuable site from which a large volume of vertebrate remains was excavated; these can be used to comprehensively investigate animal resource use in the Yayoi period. Approximately 94% of the mammalian remains excavated from the Asahi

Table 2. Fishery activities at each site

	Site	Date of Fish remains	Mainly fish remains	Fishing Area (Major Fishing Method)	Fishing Season (The pilchard fishing)
Alluvial lowland	Asahi	The latter half of the Early Yayoi period - The latter portion of the Middle Yayoi period	Cyprinidae spp. and *Acanthopagrus* sp.	Coastal and freshwater area (Spear and pole fishing)	Year-round
	Nishishiga (Hirate-cho)	The latter half of the Early Yayoi period/The middle portion of the Middle Yayoi period	Cyprinidae spp. and *Acanthopagrus* sp.	Coastal and freshwater area (Spear and pole fishing)	Unknown (lack of samples)
	Isshiki-aokai	The latter portion of the middle Yayoi period	Cyprinidae spp. and *Acanthopagrus* sp.	Coastal and freshwater area (Spear and pole fishing)	Unknown (lack of samples)
Highland	Tamanoi	The early Final Jomon period	Clupeidae spp. (Mainly Japanese pilchard)	Coastal area (Net fishing)	Summer and Fall
	Takakura	The latter half of the Early Yayoi period	Clupeidae spp. (Mainly Japanese pilchard)	Coastal area (Net fishing)	Winter and Spring

site were of boar (*Sus scrofa*), sika deer (*C. nippon*), and dogs (*Canis lupus familiaris*) (Figure 12). Very few other mammals were discovered. In particular, boar was the most abundant of the mammalian remains found, and most were piglets or young boars (Figure 13). For this reason, I conclude that boar domestication was at an early stage at the Asahi site.

People living at the Asahi site, which is located in the alluvial lowlands, actively fished for carp (*C. carpio*), catfish (*Silurus* sp.) or other fish in lowland swamps around the site, and hunted wild birds such as duck (*Anatinae* spp.) or goose (*Anserinae* spp.) as well. Boar, the most abundant mammal present, also prefers lowland swamps as their habitat. In addition, people living at this site selectively hunted deer in forests some distance from the site. Remains of hardly any other forest mammals, such as raccoon dog, fox, or weasel, were excavated. Accordingly, the study discusses hunting activities on the basis of deer excavated from the Asahi site.

Sika deer hunting season

I conducted X-ray imaging on the mandibles of 144 present-day sika deer skeletons (74 male, 66 female, 4 unknown), whose ages in months were apparent, in order to observe tooth-development stages. Tooth development was classified into ten stages, referring to the text by Brown & Chapman (1991a, 1991b). The correlation between tooth development stage and age in months was determined by regression analysis. In all 42 cases in which more than three lower teeth remained, a strong correlation was observed between tooth-development stage and age in months (Table 3). This information was used to formulate an equation and estimate the season of death of deer excavated from the study sites, even from damaged samples.

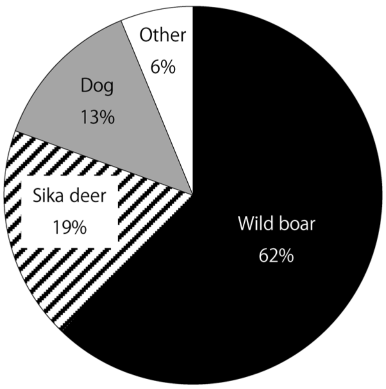


Figure 12. Composition of the mammalian remains excavated from the Asahi site

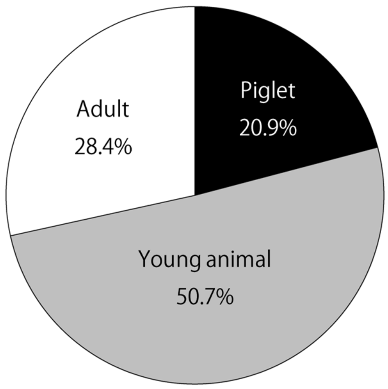
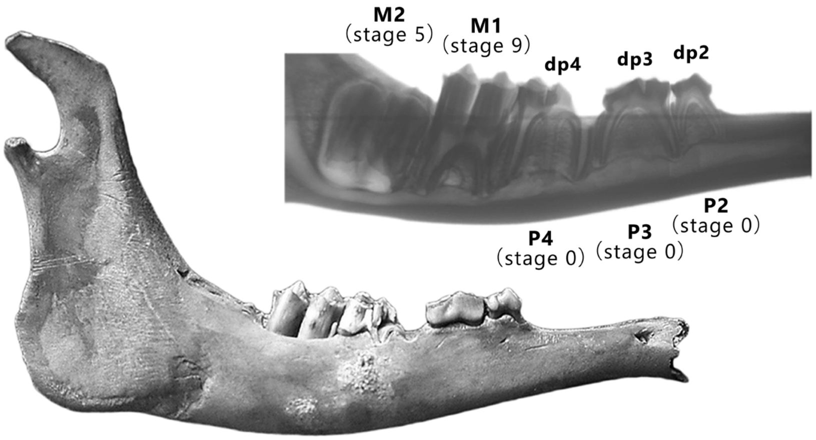


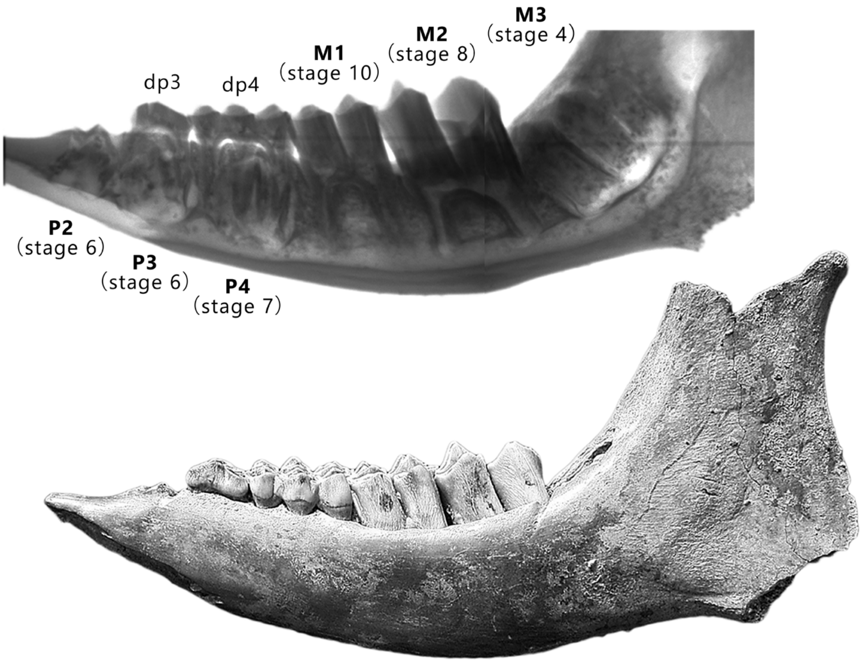
Figure 13. Ages of boar excavated from the Asahi site

Table 3. Equation used for age estimation (X: total score, Y: estimated age in months)

Remaining teeth in mandible	Range of total score	Cubic regression equation	R^2	*P*
P2+P3+P4	1<x<25	$y=0.002x^3-0.078x^2+1.423x+7.953$	0.893	<0.01
P2+P3+M1	3<x<27	$y=0.003x^3-0.194x^2+4.399x-17.435$	0.943	<0.01
P2+P3+M2	0<x<26	$y=0.002x^3-0.081x^2+1.838x+1.007$	0.968	<0.01
P2+P3+M3	0<x<25	$y=0.002x^3-0.071x^2+1.398x+7.932$	0.937	<0.01
P2+P4+M1	3<x<27	$y=0.003x^3-0.188x^2+4.248x-16.641$	0.944	<0.01
P2+P4+M2	0<x<26	$y=0.002x^3-0.084x^2+1.836x+1.049$	0.968	<0.01
P2+P4+M3	0<x<25	$y=0.001x^3-0.061x^2+1.277x+8.015$	0.940	<0.01
P2+M1+M2	4<x<28	$y=-0.001x^3+0.027x^2+0.581x-3.003$	0.969	<0.01
P2+M1+M3	3<x<27	$y=0.002x^3-0.132x^2+3.504x-14.041$	0.945	<0.01
P2+M2+M3	0<x<26	$y=0.001x^3-0.053x^2+1.542x+1.459$	0.964	<0.01
P3+P4+M1	3<x<27	$y=0.003x^3-0.188x^2+4.196x-16.262$	0.946	<0.01
P3+P4+M2	0<x<26	$y=0.002x^3-0.088x^2+1.851x+1.052$	0.969	<0.01
P3+P4+M3	0<x<25	$y=0.001x^3-0.053x^2+1.189x+8.075$	0.946	<0.01
P3+M1+M2	4<x<27	$y=0.002x^3-0.071x^2+1.906x-8.378$	0.940	<0.01
P3+M1+M3	3<x<27	$y=0.002x^3-0.129x^2+3.417x-13.562$	0.950	<0.01
P3+M2+M3	0<x<26	$y=0.001x^3-0.055x^2+1.540x+1.494$	0.967	<0.01
P4+M1+M2	4<x<28	$y=0.001x^3-0.036x^2+1.435x-6.427$	0.973	<0.01
P4+M1+M3	3<x<27	$y=0.002x^3-0.132x^2+3.391x-13.249$	0.952	<0.01
P4+M2+M3	0<x<26	$y=0.001x^3-0.063x^2+1.575x+1.471$	0.968	<0.01
M1+M2+M3	4<x<28	$y=-0.0002x^3+0.019x^2+0.564x-2.461$	0.962	<0.01
P2+P3+P4+M1	4<x<35	$y=0.002x^3-0.134x^2+3.403x-12.827$	0.945	<0.01
P2+P3+P4+M2	0<x<34	$y=0.001x^3-0.064x^2+1.616x+1.552$	0.966	<0.01
P2+P3+P4+M3	0<x<33	$y=0.001x^3-0.033x^2+0.914x+8.334$	0.943	<0.01
P2+P3+M1+M2	4<x<36	$y=0.0004x^3-0.033x^2+1.530x-7.224$	0.972	<0.01
P2+P3+M1+M3	3<x<35	$y=0.002x^3-0.118x^2+3.175x-12.205$	0.951	<0.01
P2+P3+M2+M3	0<x<34	$y=0.001x^3-0.051x^2+1.462x+1.719$	0.966	<0.01
P2+P4+M1+M2	4<x<36	$y=0.0005x^3-0.038x^2+1.603x-7.477$	0.972	<0.01
P2+P4+M1+M3	3<x<35	$y=0.002x^3-0.115x^2+3.080x-11.675$	0.952	<0.01
P2+P4+M2+M3	0<x<34	$y=0.001x^3-0.052x^2+1.450x+1.770$	0.966	<0.01
P2+M1+M2+M3	4<x<36	$y=0.0001x^3-0.015x^2+1.173x-5.321$	0.969	<0.01
P3+P4+M1+M2	4<x<36	$y=0.001x^3-0.044x^2+1.692x-7.831$	0.974	<0.01
P3+P4+M1+M3	3<x<35	$y=0.002x^3-0.112x^2+3.010x-11.285$	0.953	<0.01
P3+P4+M2+M3	0<x<34	$y=0.001x^3-0.052x^2+1.438x+1.814$	0.967	<0.01
P3+M1+M2+M3	4<x<36	$y=0.0002x^3-0.020x^2+1.240x-5.560$	0.972	<0.01
P4+M1+M2+M3	4<x<36	$y=0.0004x^3-0.029x^2+1.370x-6.097$	0.973	<0.01
P2+P3+P4+M1+M2	4<x<44	$y=0.0005x^3-0.044x^2+1.700x-7.866$	0.973	<0.01
P2+P3+P4+M1+M3	3<x<43	$y=0.001x^3-0.080x^2+2.451x-8.572$	0.950	<0.01
P2+P3+P4+M2+M3	3<x<43	$y=0.001x^3-0.041x^2+1.289x+2.192$	0.964	<0.01
P2+P3+M1+M2+M3	4<x<44	$y=0.0003x^3-0.032x^2+1.462x-6.595$	0.972	<0.01
P2+P4+M1+M2+M3	4<x<44	$y=0.0004x^3-0.034x^2+1.484x-6.639$	0.973	<0.01
P3+P4+M1+M2+M3	4<x<44	$y=0.0004x^3-0.036x^2+1.497x-6.655$	0.974	<0.01
P2+P3+P4+M1+M2+M3	4<x<52	$y=0.0003x^3-0.033x^2+1.443x-6.284$	0.973	<0.01



No.1　60A-shell layer



No.2　61A-SDⅢ (layer 1)

Figure 14.　X-ray images of mandible of a sika deer excavated from the Asahi site

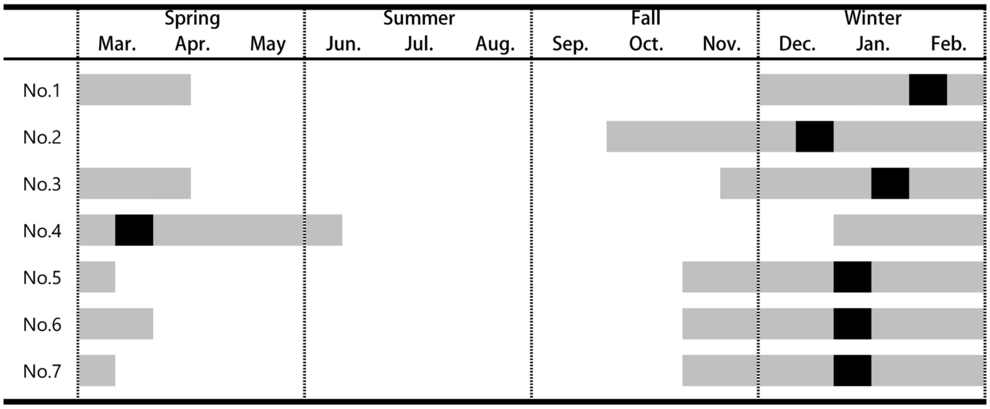


Figure 15. Period of death of sika deer excavated from the Asahi site
■: Predicted age in months, ■: The 95% prediction interval.

Using the derived equation, I estimated the season of death of deer excavated from the Asahi site (Figure 14). I found that the deaths of deer excavated from the Asahi site were concentrated in winter (Yamazaki *et al.* 2012, Figure 15).

Figure 16. Sixth lumbar vertebra of the sika deer with embedded stone arrowhead

Reconstruction of sika deer hunting

The sixth lumbar vertebrae of a deer with a stone arrowhead stuck inside was excavated from the Asahi site (Figures 16, 17). I performed an X-ray computed scan image to accurately determine the angle of incidence of the stone arrowhead and determined that the Yayoi hunter shot the arrow almost horizontally towards the lower abdomen of the deer diagonally from the right side. The stone arrowhead had not reached the spinal cord of this deer. Proliferation of bone was observed surrounding the embedded stone arrowhead, thereby leading to the conclusion that it did not inflict a fatal wound and that the deer escaped with the arrowhead stuck in its body. However, this deer was excavated from the Asahi site, so it is understood that it was later captured by the people living at this site.

Next, I created a replica of this specimen for exhibitions using a 3D printer on the basis of the X-ray computed scan data obtained from the analysis (Yamazaki *et al.* 2014; Figure 18). Bones in this replica were made from transparent materials and the stone arrowhead was made from colored materials, so it was possible to clearly see and touch the replica to understand that the stone arrowhead did not reach the spinal cord.

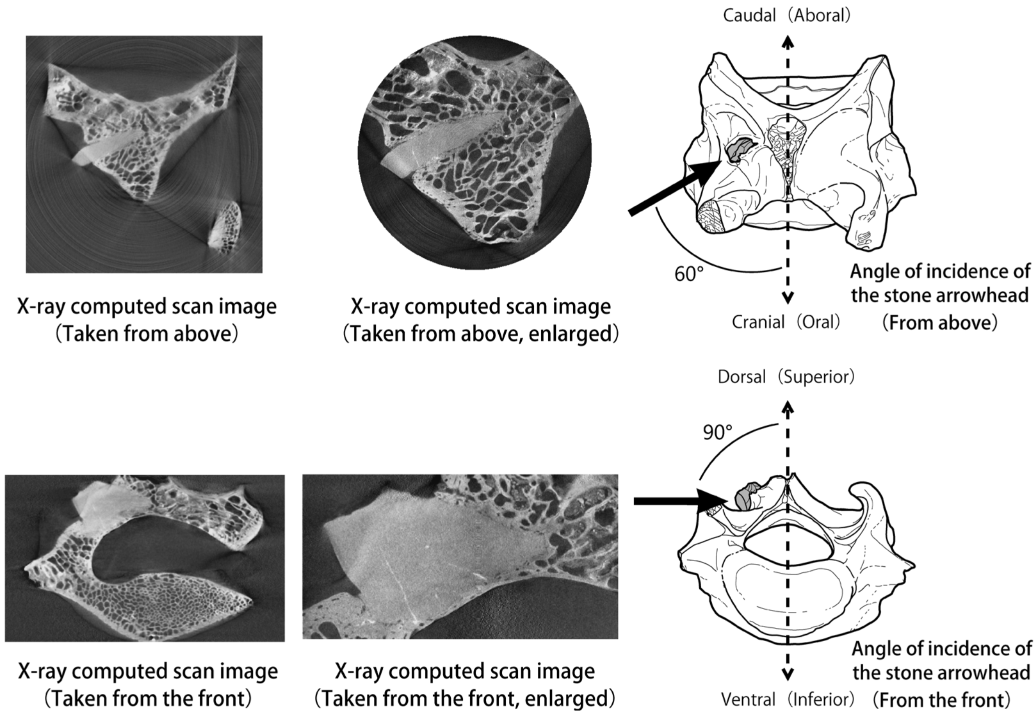


Figure 17. Angle of incidence of the stone arrowhead

Figure 18. Replica created with a 3D printer

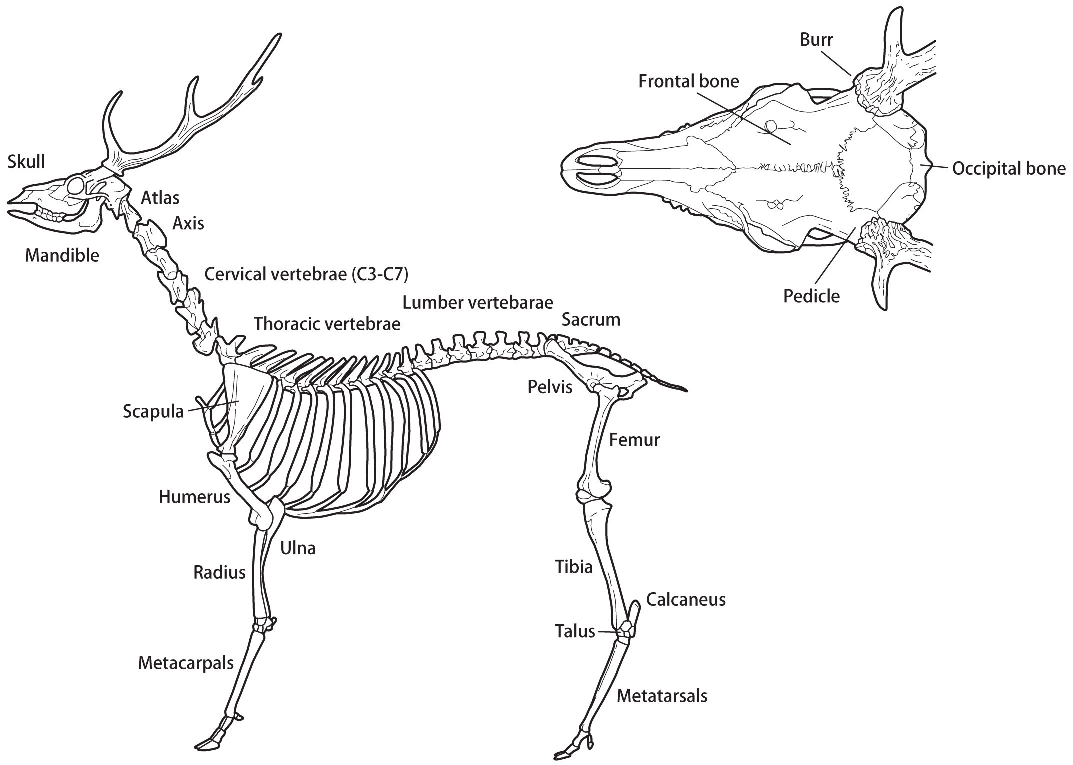


Figure 19. The skeleton of a deer

Trade of antlers

Deer antlers and bones were the main materials used for making bone and antler implements, so I investigated the acquisition of these materials.

Antler, mandible, scapula, ulna, metacarpal, and metatarsal were the parts of the deer used as material for making tools found at the Asahi site (Figure 19). In examining the rate of usage of materials for bone and antler implements, it was evident that in the case of mandibles, scapulas, and ulnas only part (approximately 10%–20%) of the available resources was utilized. In contrast, antlers were completely utilized (100%) and most (more than 94%) of the metacarpals and metatarsals were utilized (Figure 20).

I investigated the volume of excavated parts that were used for bone and antler implements and discovered that the method of acquisition was different for antlers and parts other than antlers (Figure 21). Parts other than antlers were obtained from the carcasses of hunted deer at the Asahi site. The people living at this site also used antlers attached to bone from the carcasses, obtained by breaking the cranium (Figures 22, 23),

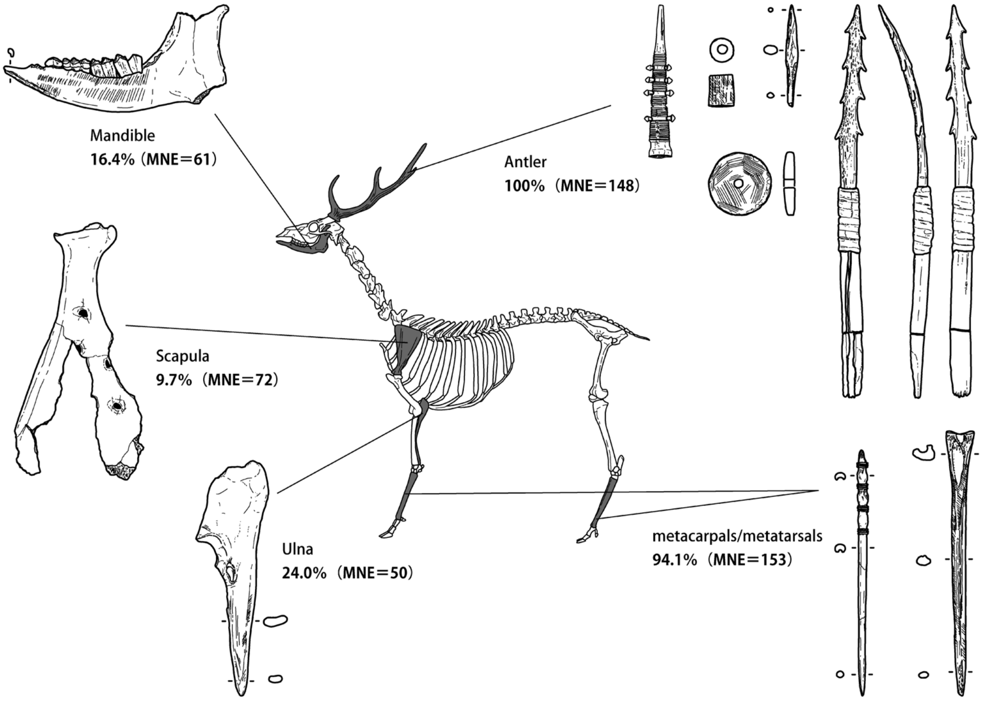


Figure 20. Parts used as materials for instruments, and their usage rate

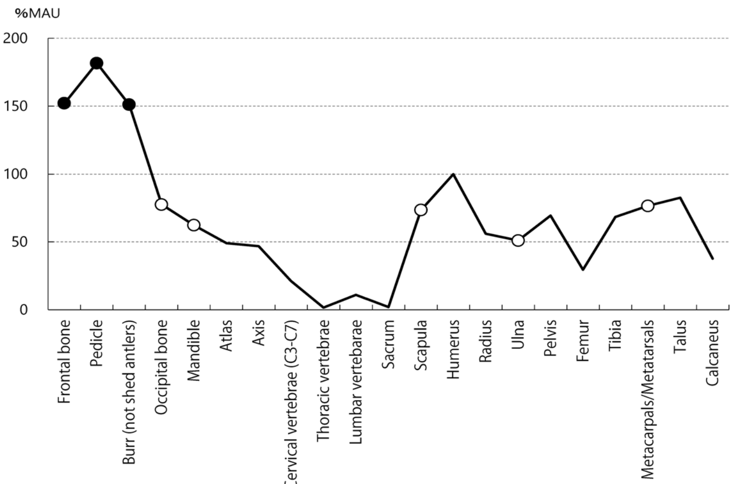


Figure 21. Excavated volume of parts used as materials for tools (Asahi site)
Out of the parts that became tools, ● indicates parts that are greater in number than the number of remains of the hunted individual, and ○ indicates the parts that are equal in number to the number of remains of the hunted individual.

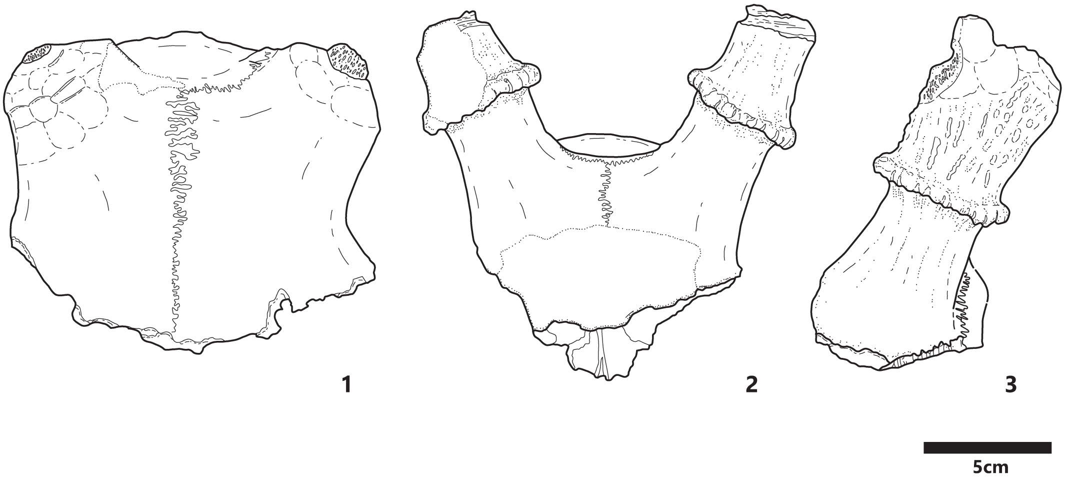


Figure 22. Examples of usage of "bone-attached antlers" at the Asahi site
This figure shows the remains of cut-off antlers excavated from the Asahi site.
1: the frontal bone and pedicle of the sika deer. Traces in the pedicle suggest that it was cracked by impact.
2: the frontal bone, pedicle, and burr of the sika deer. There are traces of dividing by grooving in the antlers.
3: the left frontal bone, pedicle, and burr. The traces on the antler stem and tine suggest that it was cracked by impact.

Figure 23. Bone-attached antlers (restoration from contemporary specimen of sika deer)

but this was not the only source of antlers. Since we were unable to ascertain whether they themselves collected the naturally shed antlers themselves or whether they acquired them through trade, I examined antlers attached to bone, rather than shed antlers. The result of this study revealed that antlers were acquired by various methods of trade (Yamazaki 2007).

Deer antlers are shed in spring, and they regrow every year. The velvet antler grows rapidly in the summer and becomes stiff in the fall. I have already revealed that deer were hunted primarily in winter. I hypothesize that deer were hunted in winter for two reasons: subsistence during the farming off-season and acquisition of antlers.

Chapter 5. The circumstances prior to the beginning of farming

The situation in the Final Jomon period just prior to the beginning of farming is discussed in chapter 5. Just before farming began, the people of the Jomon period lived dispersed among small sites. They moved among multiple sites, staying in each for short periods of time. Specific resources were excavated in large quantities from sites of the latter half of the Final Jomon period. The study investigated the large-scale production of shell bracelets in the Atsumi Peninsula and determined that a network spread over quite a wide area was formed.

Changes in the latter half of the Final Jomon period

Chapters 2, 3, and 4 discuss the usage of animal resources in the earliest farming period in the inner part of Ise Bay. Due to the small amount of remains/artifacts from the Final Jomon period in that area, however, the book could not sufficiently discuss the circumstances of the earliest farming period in detail.

Chapter 5 takes up the Mikawa Bay coast, where a large number of vertebrate remains from the Final Jomon period have been reported. I discovered that a significant change occurred in the latter half of the Final Jomon period (Yamazaki 2013a). A large site was created in the first half of the Final Jomon period, but in the latter half of the Final stage, people had dispersed to smaller-scale sites. Shell midden layers also decreased in number and size.

Furthermore, shell midden layers no longer contained vertebrate bones. A multilateral study on animal remains found the Ikawazu shell mound to be a settlement where people lived permanently throughout the year in the first half of Final Jomon (Niimi 1991; Toizumi 1991). However, at that site in the latter half of Final Jomon, vertebrate bones were no longer deposited in the shell midden layers. People living at the Ikawazu shell mound still deposited shells there but began to deposit fish and mammalian bones in different locations. I suggest that there was a change from a settlement morphology in which people resided year-round and deposited shells, fish, and mammals in the same place to a settlement morphology in which people migrated among multiple sites, one at which shells were deposited and others at which fish and mammals were deposited.

Concentration of specific remains/artifacts

In the latter half of the Final Jomon period, sites emerged from which over 5000 items such as stone arrowheads and polished stone axes have been excavated. Within the inner part of Mikawa Bay, a shell midden layer with a maximum height of 2.5m was formed within an area of 185×40m in the Onishi shell mound (Iwase ed. 1995, 1996). The volume of this shell midden is 5877m^3, and is mainly comprised of clam shells, with hardly any soil. The Onishi shell mound is described as a workspace for opening and processing clam shells in the coastal area (Toizumi 2000, 2008).

I hypothesize that a network spread over quite a wide area was formed. Many of the sites along the Mikawa Bay coast were reduced in scale in the latter half of the Final stage; only sites at the mouth of Mikawa Bay reached their developmental peaks in the latter half of the Final stage. The people of the Hobi shell mound, located at the tip of the Atsumi Peninsula, had humeri that were among the strongest in the Japanese archipelago; for that reason, these people are thought to have worked actively on transportation of materials by sea (Kaifu & Masuyama 2018).

Large-scale production of shell bracelets

Shell bracelets made from bittersweet clams (*Glycymeris albolineata*) are widely distributed in the Tokai area. However, the Atsumi Peninsula is the only site from which these shell bracelets have been excavated in large quantities (Figure 24, 25).

Shellfish for food were collected from areas different from those for materials for shell bracelets. Jomon people of the Atsumi Peninsula collected shellfish for food on the Mikawa Bay side of the peninsula, near the study sites. In addition, they collected shellfish to use as material for shell bracelets in the open sea side of the Atsumi Peninsula. Collection of material for shell bracelets was an independent activity carried out separately from food gathering.

Excavated shell bracelets exhibit two kinds of marks: traces of abrasion by water currents and signs of predation by other species. Because of the marks of predation, it is suggested that the materials used for shell bracelets were from empty shells, buffeted by the waves (Figure 26). Therefore, I conclude that the materials used for shell bracelets were shells that washed up on the beach (Yamazaki & Oda 2007a). The bittersweet clams that were used as materials for shell bracelets live at depths of 5–10m in the open sea. There is a big difference between the collection of live clams and empty shells: if the people of the Jomon period collected bittersweet clams by diving into the sea, they would have needed to acquire specialized skills. However, collecting beached shells on the shore requires no special equipment or skill.

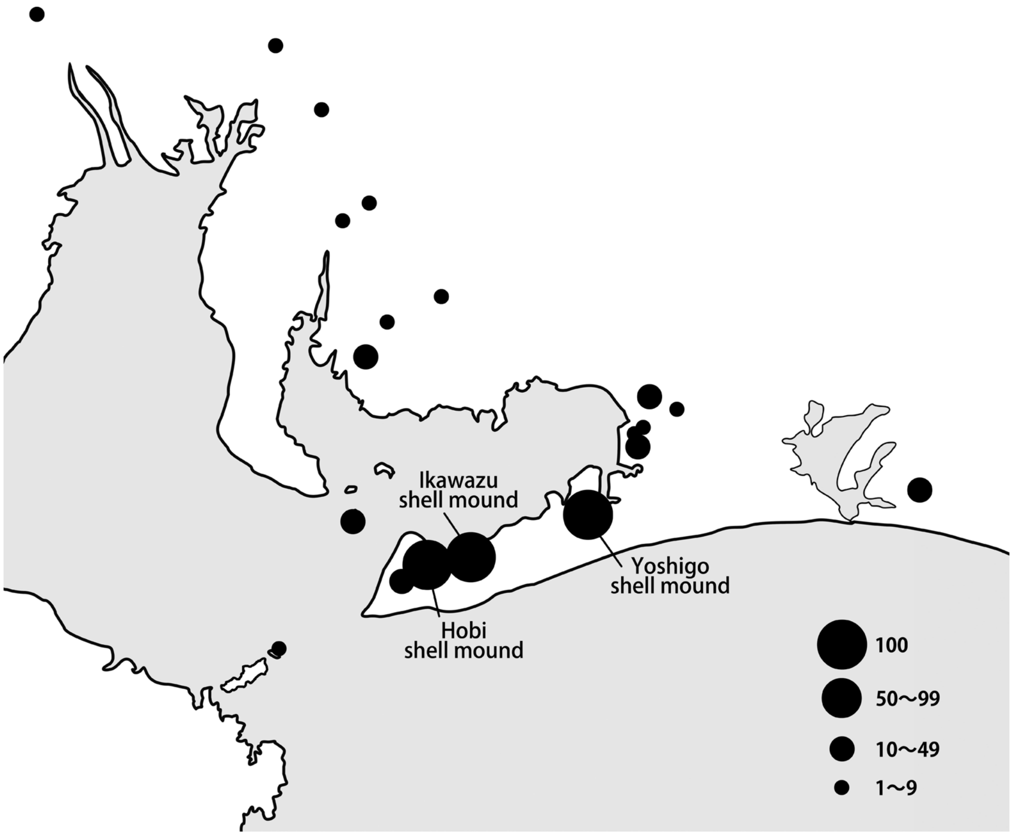


Figure 24. Distribution of shell bracelets made from bittersweet clams in the Tokai region.

I studied present-day beached shells at 22 locations along the coast of the Atsumi Peninsula (Yamazaki & Oda 2006). Of the 3672 beached shells, the most abundant were of bittersweet clams, the same kind used to make shell bracelets. At one location on the seaward side of the Atsumi Peninsula, bittersweet clams were washed up in large quantities (Figures 27, 28). Based on the study as well as an additional 10 years of previous investigation, I confirmed that bittersweet clams wash up on the seaward side of the Atsumi Peninsula. Similarly, bittersweet clams are known to have been washed up in various other locations in Japan near sites from which a large volume of shell bracelets made of bittersweet clams have been excavated. During the Jomon period, there were several locations scattered along the seaward side of the Atsumi Peninsula where bittersweet clams washed up in large numbers.

Furthermore, shell bracelets from the latter half of the Final Jomon period have been excavated in greater volume. The ratio of incomplete to complete shell bracelets also

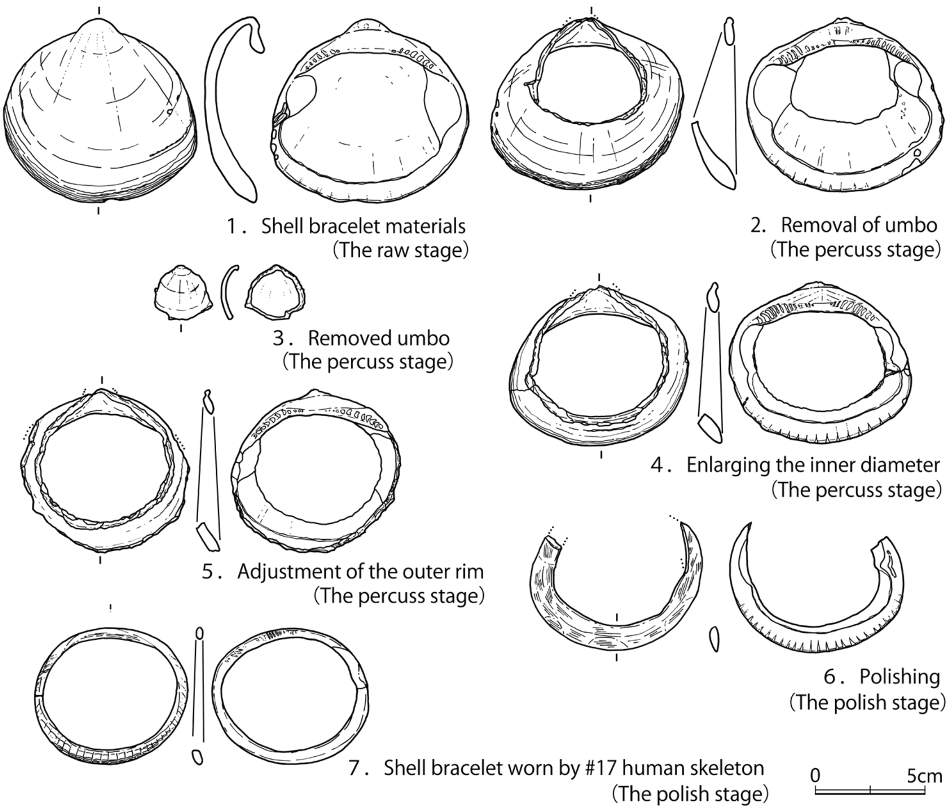


Figure 25. Process of making a shell bracelet from bittersweet clams

Figure 26. Traces of predation observed on the inner side of the shell

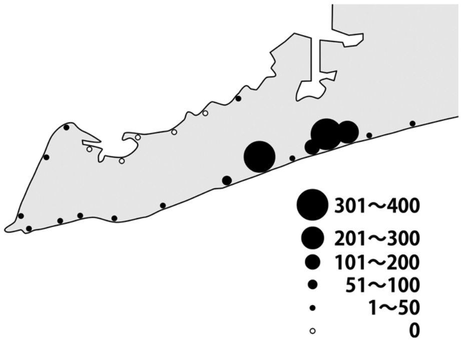


Figure 27. Distribution of shellfish washed up on the shore of the Atsumi Peninsula

Figure 28. Bittersweet clams seen washed up on the shore

increased. The study therefore concludes that the transport of shell bracelets out of the area increased during the latter half of the Final stage.

Chapter 6. Conclusion

During the earliest farming period (from Final Jomon to Yayoi) along the Ise Bay and Mikawa Bay coasts, animal resource usage changed in the following manner.

Communities prior to the beginning of farming

During the latter half of the Final Jomon period, before the farming of crops began, communities that had formed at large sites gave way to relatively smaller, more dispersed sites. Such communities moved among multiple locations, staying in each for short periods of time.

Chapter 5 discusses the changes that took place in deposited shells versus animal remains along the Mikawa Bay coast, but it is highly likely that changes of a similar nature took place during the latter half of Final Jomon in the inner parts of Ise Bay. Shell middens decreased in number and in size within this area and vertebrate bones were no longer deposited in shell middens.

Shellfish gathering

The number of shell mounds as well as the size of shell middens decreased in the Yayoi period. After the latter half of the Early Yayoi period, the size of excavated clams significantly increased. I suggest that shellfish gathering, which occurred during the farming season, decreased.

Fishing

At sites located in alluvial lowlands, coastal as well as freshwater areas were major fishing grounds. People of the Yayoi period living in lowlands proactively fished for species that reproduced in shallow freshwater areas such as paddy fields.

In contrast, coastal areas were the main fishing grounds of sites located in higher areas. In the Yayoi period, people living in higher areas used the time and energy previously spent on fishing for other subsistence activities. The fishing season changed from summer-fall to winter-spring in the Early stage of the Yayoi period.

Hunting

At the Asahi site, where the use of vertebrate resources can be comprehensively studied, vertebrates that came close to the lowlands near the site were used proactively. Boar domestication was at an early stage.

People living at the Asahi site hunted deer in forests at some distance from the site. The main deer hunting season was winter. Antlers were acquired by hunting and through trade. Deer were hunted in winter for two reasons: subsistence during the farming off-season and acquisition of antlers.

Timing of changes in subsistence

In the inner parts of Ise Bay, such changes in vertebrate resource usage occurred in the latter half of the Early Yayoi period. In contrast, this change was likely to have occurred after the middle portion of the Middle Yayoi period along the Mikawa Bay coast, where the size of clams did not change between the Final Jomon period and the Early Yayoi period. Large clams from after the middle portion of the Middle Yayoi period have been excavated.

The cultivation of plants began at the same time in the Ise Bay and Mikawa Bay coastal areas. Millet appeared in the late Final Jomon period, and rice in the first half of the Early Yayoi period (Nakazawa 2017). Both were brought into Japan from the Eurasian

Continent via the Korean Peninsula together with farming technology. However, there was a difference in timing of the change of vertebrate resource usage between the Ise Bay coast and the Mikawa Bay coast. The change occurred early on the inner part of Ise Bay and later on the Mikawa Bay. Even though rice was grown on the Mikawa Bay coast, there was a period lasting for several hundred years in which overall subsistence activity did not change.

Part II. Future prospects

Chapter 7. Animal remains research methods

Burnt vertebrate bones

Animal remains are greatly affected by the sites' decompositional environment. In Japan, animal remains are difficult to preserve because of the high temperatures, pluvial climate, and soil acidity caused by volcanic ash, which cause them to decompose and eventually disappear from most sites. However, the presence of shells reduces the surrounding acidity, helping to preserve the remains. For this reason, zooarchaeology research on the Jomon period is concentrated on the Pacific coast, along which shell mounds are distributed. Shell gathering decreased with the start of farming during the Yayoi period. Shell mound formation consequently decreased, and animal remains became even harder to preserve.

When burnt, vertebrate bones are less affected by the depositional environment; therefore, they can also be excavated from sites other than shell mounds. Burnt vertebrate bones were investigated in chapter 7 and the subject of analysis was from Niigata Prefecture, which is located on the Sea of Japan coast where shell mounds are distributed sparsely.

The book collectively studies sites from the Jomon period in Niigata Prefecture where animal remains were excavated (Yamazaki 2013b). Burnt bones were discovered the most frequently in that area. Shell mounds were located in coastal areas, cave sites in the mountainous areas, and wetland sites in lowland areas. The sites from which burnt bones were excavated were, in contrast, more widely distributed throughout what is now Niigata Prefecture (Figure 29). Burnt bones are not affected by site environment, which constitutes a significant advantage for research on animal remains that are otherwise easily affected by the depositional environment.

I analyzed 8826 (66.93g) burnt bone items from the Rokutanda-minami site and identified 34 taxonomical groups of fish (Yamazaki 2012a, 2018; Figure 30). Remains of salmon (*Salmonidae* sp.), carp (*Cyprinidae* sp.), and sweet fish (*Plecoglossus altivelis altivelis*) that live in freshwater areas were excavated from this site. Salmon in particular was found in abundance, indicating that people from this region fished for salmon

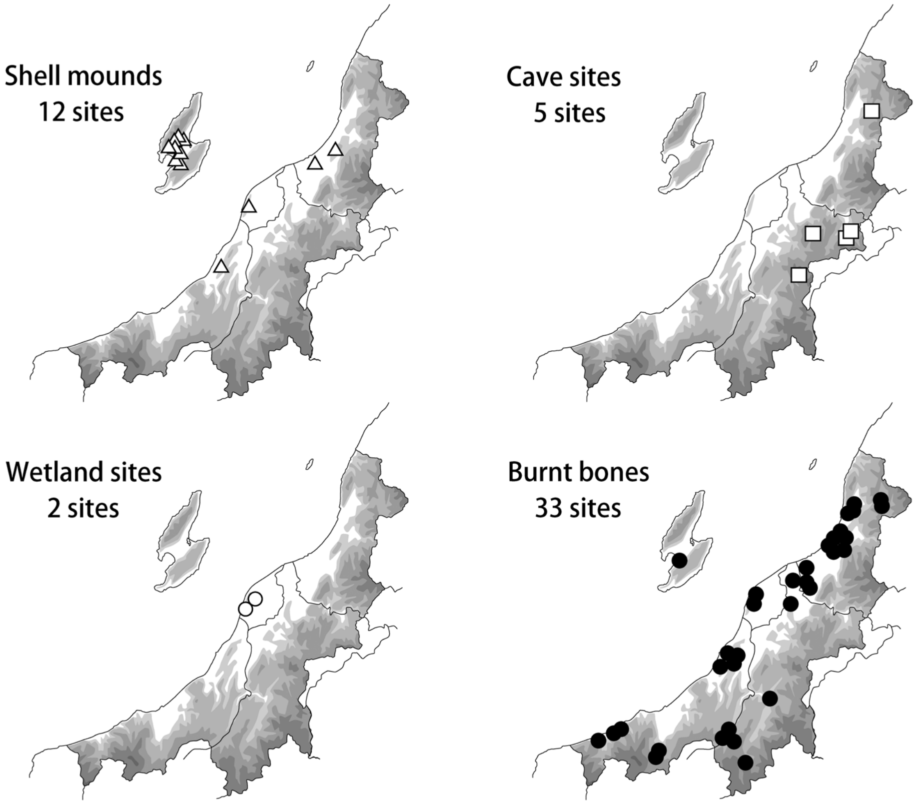


Figure 29. Jomon period sites from which animal remains were excavated (Niigata Prefecture)

intensively. Remains of saltwater fish found at this site included the Japanese pilchard and mackerel (*Scomber* sp.), which swim in the surface layers; the bastard halibut (*Paralichthyidae* sp.) and righteye flounder (*Pleuronectidae* sp.), which reside in the lower layers; and the black seabream (*Acanthopagrus* sp.) and Japanese seabass (*Lateolabrax* sp.), which prefer brackish waters. Inhabitants of this site not only fished for salmon but also undertook multiple fishery activities in the sea. Thus, burnt bone analysis enabled us to investigate the usage of animal resources.

What archaeologists should do at the excavation site

Japan has few zooarchaeologists, so they are often requested to analyse animal remains by other archaeologists. Although many high-quality books have been published on the subject of zooarchaeology, such literature is often written specifically for zooarchaeologists, with few works treating the subject from the archaeologists' point

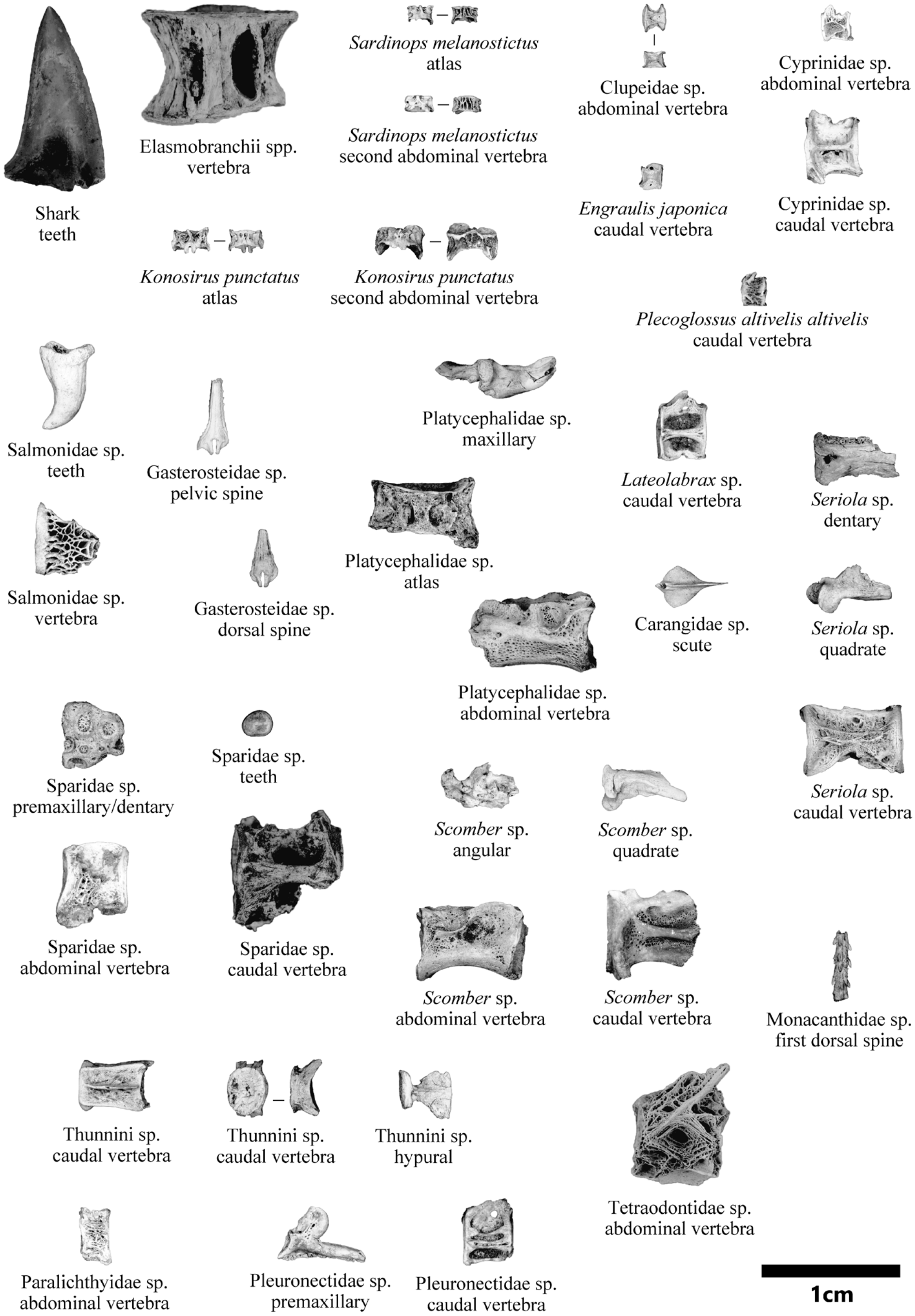


Figure 30. Burnt fish remains excavated from the Rokutanda-minami site (Jomon period)

of view. They may not provide information on “what archaeologists should do at the excavation site” based on the assumption that zooarchaeologists will be asked to perform the analysis of animal remains. This chapter summarizes points that archaeologists should consider when requesting analysis of excavated animal remains.

When zooarchaeologists are not permanently present at the excavation site, archaeologists should accurately record the information that is lost at the excavation site and be responsible for informing the zooarchaeologist. Information that is lost at the excavation site includes sediments of the excavated layer of animal remains [the sedimentary soil of the layer from which the animal remains were excavated] and the state of the animal remains when excavated. Insufficient records at the excavation site will limit productive research on animal remains.

When animal remains are found in quantity, archaeologists should draw a sketch showing the state of the animal remains. It is recommended that a digital photo be taken and printed out prior to removal of the bones (Figure 31). Archaeologists should then write numbers on the printed photo and identify the bones according to these numbers so that zooarchaeologists can match the photos with the bones later. Archaeologists should not wash the bones too thoroughly, as it may affect DNA analysis. Species identification and age estimation are based on cranium and limb diaphysis. Therefore, archaeologists should pick up these parts carefully so as to avoid damage.

Wet sieving is required for detailed zooarchaeological study. Samples are collected from certain shell middens during large-scale excavations. Poorly planned shell midden sample collections represent a huge burden for the subsequent steps. Wet sieving should be performed on limited shell midden soil, and the workload that fits within the budget and time period should be realistically estimated. Burnt bones are sometimes found in kilns/furnaces, waste disposal holes, and burnt dwellings. Although the cost-efficiency of unplanned wet sieving sediments is low, to record the site feature in cross-section, only

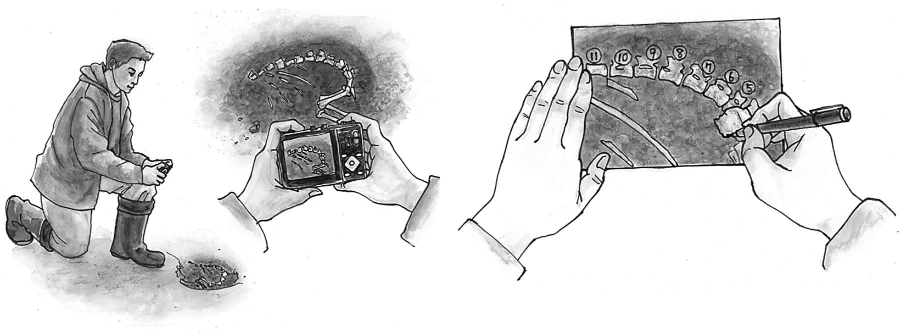


Figure 31. Numbering items on the printed photo before removing the bones

Figure 32. Test by sieving excavated soil

half of the sediments in the feature should be dug, and sieving should be tried in the part of the soil that was dug (Figure 32). The remaining half of the sediment in each strata from which burnt bones were excavated should be sieved in official method. The use of flotation along with wet sieving is recommended. In addition to burnt bones, this method allows the collection of carbonized nuts and seeds from the soil of the same site feature.

When non-specialists in zooarchaeology extract micro-artifacts from the sieve's remaining materials, only the materials judged as bone are delivered to zooarchaeologists. In other words, material that they were unable to recognize as bone do not reach zooarchaeologists for analysis. To prevent this limitation, it is desirable that zooarchaeologists be allowed to preliminarily extract micro-artifacts from un-sieved material.

Chapter 8. Zooarchaeology methodologies

Age evaluation

Among the most often excavated mammals in Japan (boar, sika deer, cow, horse, and dog), the sika deer is the only species whose bone age has not been previously studied. Chapter 8 presents the findings of a basic study on the age of present-day sika deer bones.

The whole body anatomy of sika deer was studied using skeletal specimens of 219 present-day individuals (68 males, 108 females, and 43 unknown) in the collection of the Tochigi Prefectural Museum. The state of epiphysiodesis was observed in 92 parts, which comprised 10 front limbs, 8 hind limbs, 20 phalanges, and 54 vertebrae (Figure 33). Aging-associated changes in epiphysiodesis were then divided into the following three stages: epiphysis and diaphysis are unfused and dissociated (score 0), epiphysis and diaphysis are fused but an epiphyseal line is present (score 1), and epiphysis and diaphysis are fused and an epiphyseal line is absent (score 2). The status of the diaphysis fusion was evaluated via the quantification of each of the three stages (Yamazaki 2016; Table 4).

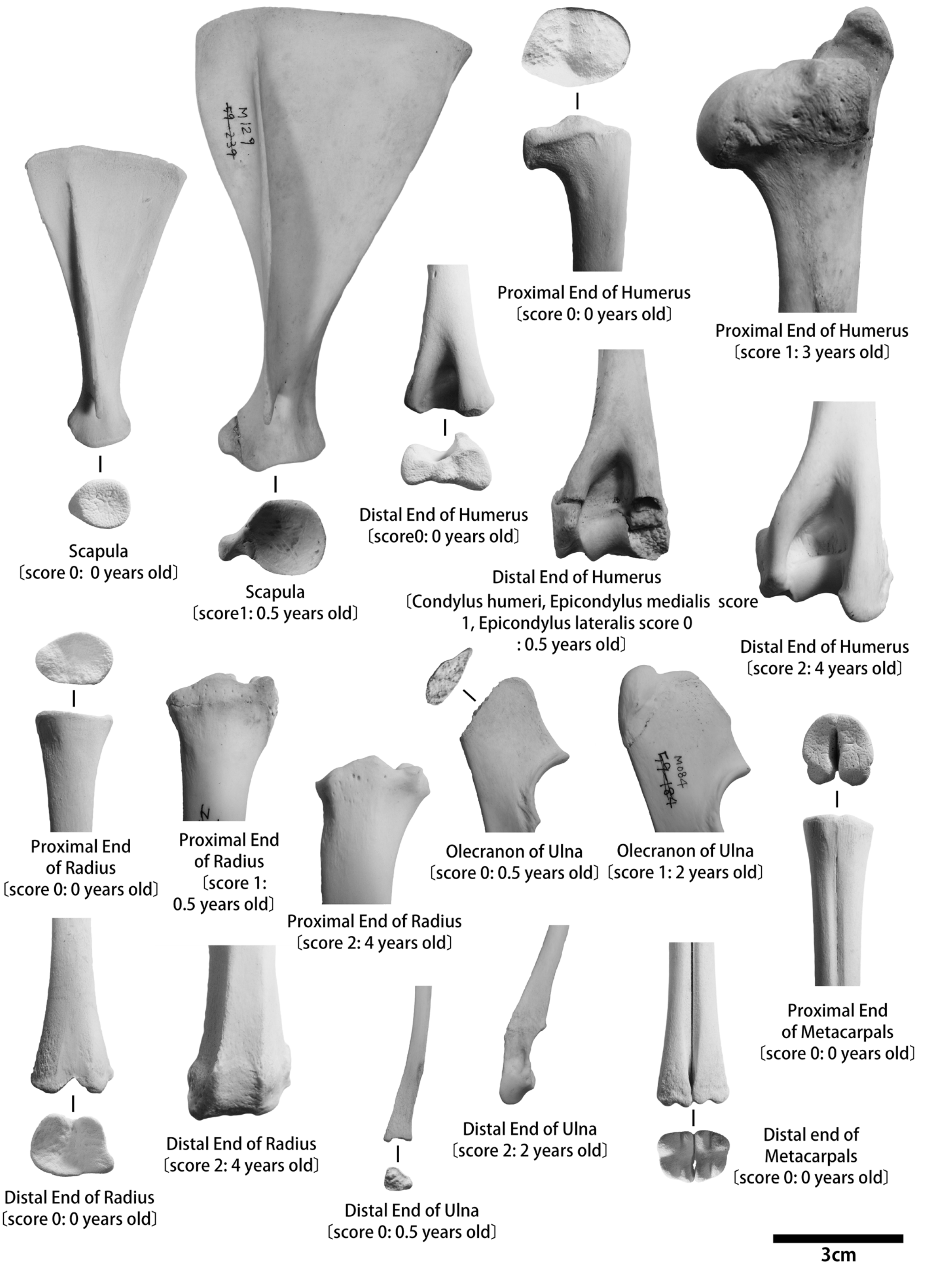


Figure 33. State of epiphysiodesis (front leg) of a contemporary sika deer

Table 4. Period of epiphysiodesis of the sika deer

		Element	N	Age (95% prediction intervals)					
				Score 0	N	Score 1	N	Score 2	N
Forelimbs	Scapula	Tuberculum infraglenoidale	212	0–0.5	129	0.5–1.5	7	1–2	76
	Humerus	Proximal end	212	0–2	163	1.5–4	6	3–5	43
		Distal end (Condylus humeri, Epicondylus medialis)	183	0–0.5	14	0.5–1.5	113	1–2	56
		Distal end (Epicondylus lateralis)	183	0–0.5	86	0.5–1.5	42	1.5–2	55
	Radius	Proximal end	213	0–0.5	12	0–0.5	44	0.5–1	157
		Distal end	213	0–2	162	2–3	5	2–4	46
	Ulna	Proximal end (Olecranon)	210	0–2	161	2–4	5	3–5	44
		Distal end	210	0–2	163	2	1	2–5	46
	Metacarpals	Proximal end	200	0–0.5	7	—	0	0–1	193
		Distal end	199	0–1.5	156	2	1	2–3	42
Hindlimbs	Pelvis	Acetabulum	212	0–0.5	107	0.5–1.5	30	1–2	75
	Femur	Proximal end	210	0–1.5	156	2–4	9	3–5	45
		Distal end	211	0–1.5	158	2–3	9	3–4	44
	Tibia	Proximal end	212	0–1.5	160	2–4	8	3–5	44
		Distal end	212	0–1.5	146	1–2	9	1.5–3	57
	Calcaneus	Tuber calcanei	197	0–1.5	154	2–4	6	3–5	37
	Metatarsals	Proximal end	201	0	5	—	0	0–0.5	196
		Distal end	201	0–1.5	156	2–3	4	2–4	41
Phalanges	Proximal phalanx	Proximal end	195	0–0.5	128	0.5–1.5	15	1–2	52
		Distal end	195	—	0	—	0	0	195
	Middle phalanx	Proximal end	195	0–0.5	128	0.5–1.5	7	1–2	56
		Distal end	195	—	0	—	0	0	195
	Distal phalanx	Proximal end	195	0	5	0.5	4	0–1	186
Vertebral column	Atlas	Dorsal tubercle	189	0	8	0.5–1.5	147	2–4	34
		Ventral tubercle	189	0	8	0.5–1	126	0.5–2	55
	Axis	Head of vertebra (dens, cranial articular process)	185	0	9	0–1	51	0.5–1.5	124
		Foosa of vertebra	187	0–2	76	0.5–4	90	5–6	21
	Cervical vertebrae (C3–C7)	Head of vertebra	943	0–2	276	0.5–4	493	4–6	174
		Foosa of vertebra	932	0–2	505	0.5–5	337	5–10	90
	Thoracic vertebrae	Head of vertebra	2423	0–3	994	0.5–5	1161	4–13	268
		Foosa of vertebra	2424	0–3	1220	0.5–6	974	5–13	230
	Lumber vertebrae	Head of vertebra	1142	0–2	361	0.5–2	638	3–6	143
		Foosa of vertebra	1143	0–3	430	0.5–4	582	3–6	131
	Sacral vertebra (S1)	Head of vertebra	189	0–2	86	0.5–2	78	3–4	25
		Foosa of vertebra	187	0–2	53	0.5–3	113	4–6	21

Score 0: Epiphysis and diaphysis are unfused and dissociated.
Score 1: Epiphysis and diaphysis are fused but an epiphyseal line is present.
Score 2: Epiphysis and diaphysis are fused and an epiphyseal line is absent.

To date, age estimation of sika deer was only possible using a teeth-based procedure, thereby requiring jaw bones excavated in good condition from specific sites. The results of the present study allow age estimation of sika deer excavated from a wide range of sites.

Ethnoarchaeology and experimental archaeology

As part of a study on the middle range theory, which allows studying the relationship between human activities related to usage of vertebrate resources and its evidence, I conducted a study on experimental archaeology and ethnoarchaeology.

Currently in Japan, only food resources (meat) are obtained from hunted boar and sika deer. Therefore, it is hard to obtain a model of vertebrate resource usage that does not involve food resource use. Furthermore, in contemporary Japan, it is hard to study ethnoarchaeology in a manner similar to Binford and Brain's work (Binford 1978, 1981; Brain 1976, 1981) because the Japanese law prohibits abandoning the remnants of hunted or butchered vertebrates.

Therefore, the study of vertebrate resource usage was performed by accompanying people living a nomadic lifestyle in the Zavkhan Province of Mongolia (Yamazaki 2012b). Mongolia is an area where several vertebrate resources are used and the vertebrate remains can be researched after disposal. The process of formation of animal remains can be divided into the following stages: hunting, carving, usage, disposal, and post-disposal. For each stage, the relationship between human activities related to vertebrate resource usage and traces left on bones as a result was observed, and the artefactual and non-artefactual factors related to the formation of animal remains was recorded (Figure 34). In addition, the adequacy of Brain's model (Brain 1976, 1981), which represents the effect of dogs on animal remains and has been frequently used in Japan, was verified (Figures 35, 36).

Next, animal carcasses were carved according to traditional Mongolian procedures. Skeletal specimens of butchered goats were prepared, and the relationship between human activities related to vertebrate resource usage and traces left on bones as a result was recorded (Figure 37). Studies in the fields of ethnoarchaeology and experimental archaeology complement each other. Ethnoarchaeological studies aim to record the overall formation processes. Overlapping traces from multiple activities are often observed on vertebrate bones, thereby preventing a full understanding of the traces left from carving alone. To tackle this limitation, I conducted a study in the field of experimental archaeology and revealed the relationship between vertebrate carving and traces left on bones.

Chapter 9. Contribution to society

Most archaeological excavations conducted in Japan are urgent pre-excavation investigations associated with construction works. Whenever archaeological sites have to be destroyed for the sake of development of land, Japanese archaeologists conduct excavation investigations prior to construction to record information in an archaeological site that will disappear. Approximately 8000 excavation investigations per year are performed in Japan. Archaeologists are expected to contribute to society by providing the

Slaughter using traditional procedures

Blood is collected from the thoracic cavity

The prayer wheel is turned close to the head

Remove front and back legs below the joint

Hide is stripped off by hand

The intestine is removed

The blood that collects in the thoracic cavity is scooped out with a cup

The upper half of the body is separated from the lower half

Salt is sprinkled on the stripped off hide

Figure 34. Slaughter and field dressing of sheep using traditional procedures

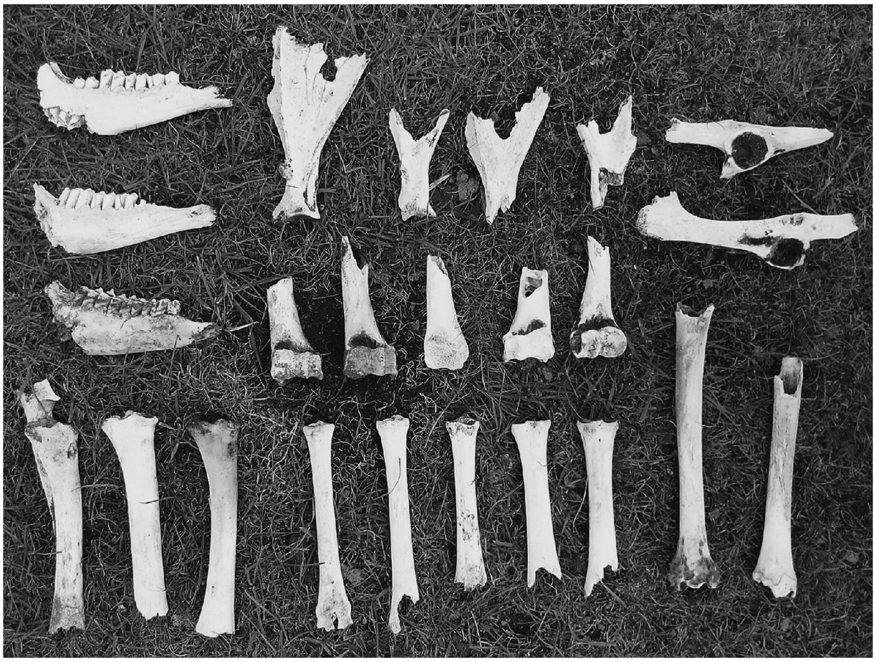


Figure 35. Sheep and goat bones found disposed of around the yurt

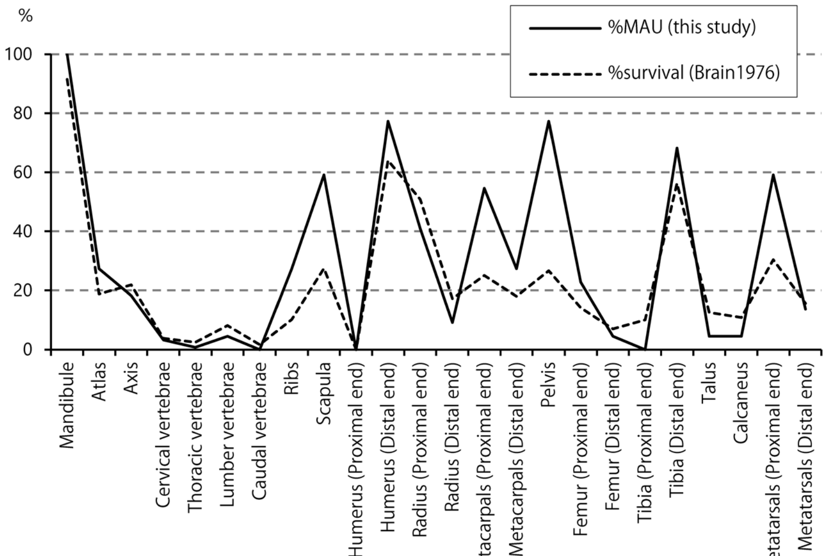


Figure 36. Comparison between "sheep and goat bones gathered in Mongolia" and "goat bones gathered in Southern areas of Africa"

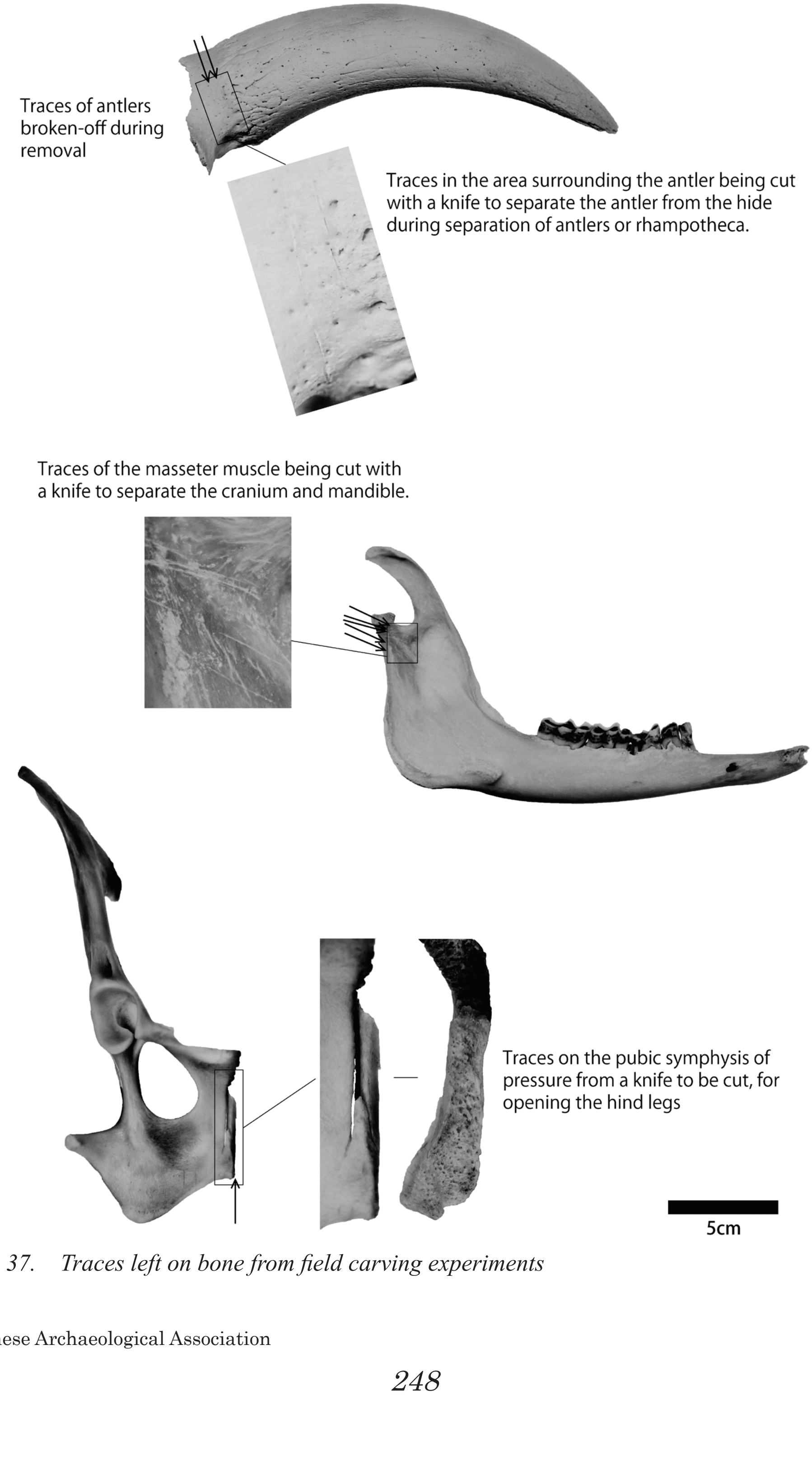


Figure 37. Traces left on bone from field carving experiments

results obtained from excavation investigations.

Chapter 9 presents information pertaining to the use of those results (Yamazaki 2010). Results of studies on animal remains and plant remains excavated from archaeological sites were used for nature restoration projects, with the aim of restoring natural environments that disappeared in the past.

The literature on nature restoration projects states that the projects should aim to restore natural environments of the Jomon or Yayoi periods. However, actual nature restoration projects have not regenerated the nature of the Jomon or Yayoi periods but have instead regenerated the state of nature from the time period of approximately 50–60 years ago. The reason why the nature from 50–60 years ago has been regenerated is that this period corresponds to the childhood of the people who took part in the projects. Childhood memories of the authors are described in the literature related to nature restoration projects, which share the following common logic: there was plenty of beautiful nature in my childhood, and that nature had existed, without changing, from the past (the Jomon or Yayoi period). However, that nature has been destroyed in association with modern economic growth, so we must take action to regenerate that nature.

Such authors have assumed that the natural landscape from their childhood had not changed since the Jomon or Yayoi periods. However, they have not presented academic arguments to support that assumption. Diverse nature existed in Japan, and different types of relationships were formed between nature and the people living in the archipelago. Authors of the literature on nature restoration projects have over-simplified the history of such human-nature relationships. Although they are using the past as evidence, they are actually disregarding history.

Our investigation into “How are our study results being used?” led us to an answer to another question that it raised, “How should we present the results of our study?” Some environmental archaeologists have also made statements similar to those made by the authors of the nature restoration project. Today, we are strongly expected to contribute to society through the results of our archaeological study; however, people are mainly interested in study results with which modern society can easily empathize. When presenting our results, we must ask ourselves, “Have we changed the past so that it fits the ideal of the present? Have we neglected the past that is not ideal from the point of view of the present?” Further discussion is necessary to explore ways in which archaeology can contribute to society.

Notes

Figure 7 created from data in Kubo (1998, 2008), Kōketsu & Yamazaki (2005), Yamazaki (2003), Yamazaki & Oda (2007b), Yamazaki & Miyakoshi (2005), Watanabe (1987, 2003), Watanabe & Isotani (1982), Watanabe & Tanaka (1986, 1992, 2000), Watanabe *et al.* (2002).

Figure 9 created from Ochiai ed. (1994) and Suzuki *et al.* (1980).

Figure 12 and 13 created from Niimi (2000), Nishimoto (1992, 1994), Nishimoto *et al.* (1992), Toizumi *et al.* (2009), Yamazaki & Oda (2007b).

Figure 16 and 17 created from Miyakoshi *et al.* (2011).

Figure 19 created from Suto ed. (1995) and Nishimoto (1999).

Figure 24 created from data in Kawazoe (2005, 2006).

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