

New Dimension in HCMR: A Case of Zooarchaeological Approach- Pig Domestication in Japan

A. Matsui

Nara National Research Institute for Cultural Properties, Japan

ABSTRACT

The domestic pig, *Sus scrofa*, is one of the hallmark species representing the global manipulation of wild animals by humans. It is now clear that unraveling the zoological nomenclature of the genus *Sus* in Europe and Asia (there are currently 15 subspecies designations) requires more than the use of traditional methods detailing cranial morphological criteria. One of the fundamentally important issues in zooarchaeology in East Asia and Japan, including the Ryukyu (Okinawa) archipelago, has been the timing and nature of the domestication of the pig from its wild cousin, the wild boar research on this problem in Japan dates to before the 1930's. Therefore, we applied mtDNA and stable carbon and nitrogen isotope analysis in order to separate the domestic pigs from the wild boars in bone samples recovered from the Japanese mainland, Ryukyu archipelago, Korea, and Vietnam. The results demonstrate that the domestic pig and wild boar can be distinguished by these methods. Carbon and nitrogen isotope analysis shows that two feeding patterns developed during domestication, one based on consumption of human leftovers and human excrements (high ^{15}N content) and the other utilizing cultivated C4 plants. We conclude that the isotopic signatures of *Sus* remains from archaeological sites in East Asia form three clusters. Two clusters reflect two different methods of raising pigs in Korea. In addition, wild boars consuming solely natural C3 plants show features similar to sika deer. Genetic relationships were examined using 574-bp mitochondrial DNA control region sequences for prehistoric *Sus* bones on the Ryukyu Islands, domestic pigs on the Ryukyu archipelago and the Asian continent, and modern wild boars. Some of the *Sus* samples from Yayoi sites (ca. 2,000 cal. BP) and the Premodern sites (ca. 16-19th c. AD) clustered phylogenetically with East Asian domesticated pigs. This indicates that domestic pigs were bred on Okinawa during the Yayoi Period, 2000 years ago. Furthermore, it is apparent that the *Sus* sp., although we may not call them domestic pigs, that had been bred appeared by at least 7000 BP on Okinawa.

Key words: animal domestication, stable isotopic analysis, ancient DNA, D-loop, diet, pig, wild boar *Sus scrofa*, zooarchaeology

A myth of not eating habit in Japanese history

Before the end of the Jomon period that was flourished since 15000 BP depending on the regions of the Japanese archipelago, meat was commonly consumed by people who made their livelihood by hunting, gathering and fishing with some manipulated plants. Once rice paddy cultivation was diffused in the Yayoi period from China via Korea probably 7th to 5th BC., the ratio of meat eating habit dropped and the archetypal Japanese-style diet with rice and a main dish was established. As the Buddhist tenet against killing was introduced in the middle of sixth century AD., and the concept of *kegare* (uncleanness) of beasts or meat eating developed in the Early Heian era, that is 9-11 AD. Japanese people began avoiding meat eating and took animal protein mainly from seafood until in the closing days of the Tokugawa Shogunate or the end of the Edo period in 1868 and people began to eat land mammals again since the Meiji period being under the influence of European culture.

The above may be the story that the majority of most Japanese believe about the history of their eating habits, or their dietary culture. However, through my research on bones and other faunal remains found at various sites though various periods in Japan, I have become aware of numerous animal bones with artificial damage marks apparently made by edged tools when chopped or when the flesh was stripped, showing that the animals were eaten. I began to believe that throughout all periods people in Japan have been eating meat regularly not only for some specific classes but for the ruling classes and holy classes, like monks and the Shinto priests (Matsui, 1994¹). Of course, the word “people in Japan” here includes various social classes from Buddhist monks and Shinto priests to aristocrats and warriors who handed down heritages of the ancient to the medieval and Pre-modern periods, that is called the Shogunate or Edo era. Although rural areas and impoverished neighborhoods in urban marginal areas where prominent relics rarely remain are unfortunately not often targeted for excavation, it seems certain that meat eating had been rooted deeply in the lives of the Daimyo, or senior samurai in Edo period and urban residents (Matsui, 2011).

Then, what is the reason for this discrepancy? My assumption is that the conventional view of anti-meat-eating history is mainly based on literary documents and folkloric narrative researches with an influence of *kokugaku* (*the Japanese classics*) in the Edo period which emphasized the uniqueness of Japan. However, written records scarcely include “facts” that writers did not wish people of the same and later periods to know. Interview-based folkloric researches may also involve similar hesitation by the informers. Some information that were difficult to mention, such as the realities regarding sex and meat eating, are less likely to be recorded either in written or oral forms.

Zooarchaeology revealed the meat eating habit in Japanese History

Archaeology, on the other hand, has the advantage of being able to reveal “facts” people in the past attempted to hide away through excavation. In particular, food-related information which is rarely recorded in written documents may be brought to light by excavating middens at premises, where people of the time buried the evidences of meat eating in their backyards.

Archaeological excavations have unearthed wild boar bones at Shimotakabora site in Izu Oshima in the Initial Jomon: 10000-7000 BP., and other island sites where no wild boar naturally inhabited. Likewise, in Hokkaido across the Tsugaru Straits where no wild boar lived, wild boar bones have been found at the sites of the Late or the Final Jomon settlements, approximately dated around 2000 BP. and later, as well as Epi-Jomon settlements of the same period as Yayoi mainly in the Oshima Peninsula of southern Hokkaido. There are several Jomon sites in Honshu where a number of mandible bones of infant wild boar alone are buried; such “special charred” conditions also suggest the possibility of wild boar keeping. Furthermore, it has been known since before World War II that the Okhotsk people that prospered in East Hokkaido from the 6th to 12th centuries had kept many Sakhalin domesticated pigs.

Since 1989 when Toyohiro Nishimoto of the National Museum of Japanese History reported the existence of domesticated pigs at Shimogori-Kuwanae Site in Oita City (Early Yayoi), domesticated pigs in Yayoi period became a major topic of archaeology. The evidence presented by Nishimoto (1991²) included pyorrhea typically seen when kept by humans, as well as morphological changes such as undeveloped jaws due to soft food, short nose, and wider face.

I myself have reported that among small Rukyu wild boar (*Sus scrofa riukiuanus*) remains found in Gushibaru Shell Midden in Ie Island, Okinawa (parallel Yayoi), there were remains of individuals as large as the Japanese wild boar (*Sus scrofa leucomystax*) in 1997 (Matsui, 1997). After a long deliberation and comparison with other specimen, I proposed that the individuals were domesticated pigs from outside Okinawa. I received no particular response from the academic society, anticlimactically.

Because it is easy to distinguish domesticated pigs from wild boars with their flesh and skin but is very difficult to differentiate fractured bones, many researchers disagreed with Nishimoto’s Yayoi domesticated pig theory.

Controversy of pigs or wild boar by ancient mtDNA

Actually, in the same issue of a journal titled *Quaternary Journal of Archaeology*, two researchers concluded that there were no domesticated pigs in the Yayoi period; archaeologist Makoto Watanabe from an archaeological point of view (Watanabe 2004), and geneticist Tomoo Ozawa (Ozawa 2004) based on a mitochondrial DNA lineage analysis. Their clear denial in the journal seemed to be easily accepted by many archaeologists who do not understand genetic principles. One of many journals annually featuring the trends of the academics summed up the controversy over the existence of Yayoi domesticated pig saying that it had been conclusively proven that domesticated pigs did not exist during that period. However, Watanabe's theory hardly seemed (at least to me) logically convincing, and our group found out that Ozawa's conclusion was based on the amplification and comparison of a mitochondrial control region which is not necessarily effective for distinguishing domesticated pig from wild boar. In fact, with efforts of Naotaka Ishiguro of Gifu University and others (Morii 2002), we adopted a method to divide a sequence too long to amplify at once into three fragments, then amplify and connect them together. We constructed a phylogenetic tree consisting of Japanese wild boar, Ryukyu wild boar, Northeastern Asian wild boar, native Chinese domesticated pig, and other extant *Sus* species, put amplified genes from *Sus* bones from archaeological sites, and succeeded to determine each of their genealogical positions.

As a result, we figured out that the Ryukyu wild boar belongs to the strain of Southeast Asian wild boars, contrary to conventional assumption to categorize it as a variety of Japanese wild boar, and judging from unique base in unique position, *Sus* remains from Shimizu Shell Midden (Parallel Yayoi) in Kume Island are also likely to be of Southern origin as well, while having similarities to the Ryukyu wild boar. Having examined many specimens we collected from Miyashita Shell Midden in Goto Islands, Nagasaki (Early Jomon), Agata Shell Midden in Imabari, Ehime (Early Yayoi), and the Kitasaya Site of Miyamae-gawa Sites in Matsuyama, Ehime (the end of the Yayoi or the beginning of the Kofun), we also found the existence of individuals having genes common among modern East Asian indigenous domesticated pigs and not seen in Japanese wild boar. This means that domesticated pigs from the continent had been brought into the Japanese Archipelago during the Yayoi period or earlier, although specimens from Miyashita Shell Midden, which is dated as old as the Late Jomon, need to be reexamined including the dating of the bones.

Application of stable isotopic analysis on pig bones

In order to prove the existence of domesticated pigs more convincingly, we further

studied the diet. Animal bodies including ours are made of what they have been eating since their birth. Thus there is a method to find out what an animal had eaten from the stable isotope ratio of carbon or nitrogen in animal bone. Due to the photosynthetic mechanism of plants, the stable isotope ratios of ^{12}C and ^{13}C differ between C3 plants such as acorns, rice, and wheat, and C4 plants such as millet. In addition, the isotope ratios of ^{14}N and ^{15}N tend to be larger in higher positions of the food chain. In North American anthropological studies this method has been established as a measure to clearly prove the shift from hunting and gathering economy where people focused on C3 plants, to a C4 plant corn growing economy by comparing stable carbon and nitrogen isotope ratios found in human bones. I asked Masao Minagawa, an expert of this method whom I have known for years, if it was possible to apply the method for distinguishing wild boars from domesticated pigs. That was where our joint study started (Minagawa et al. 2004). Seeking specimens for analysis, I traveled South Korea and Okinawa, collected bones identified as wild boars as well as deer and human bones for comparison from sites of Yayoi period in Okinawa, Kyushu, Chugoku, Shikoku, and Kinki regions, in addition to major archaeological sites in the Korean Peninsula of the same period. We were the pioneers of this method in the world, and the results exceeded our expectation. We analyzed isotope ratios of bones that have been understood to be of wild boars. The isotope ratios of wild boar remains from Jomon shell middens in the Kanto region turned out to be almost the same as those of plant-eating deer bones, showing a high “wildness.” On the other hand, bones from sites in Okinawa or the Korean Peninsula of the period parallel to the Yayoi included a high rate of those with high ^{13}C from millets, those with high ^{15}N from fish and other marine products, and those showing values similar to humans, suggesting human food scraps and manure (Matsui et al. 2005).

To our surprise, samples from Noguni B Shell Midden of the Early Jomon around 7900-6500 BP. in Yomitan Village, Okinawa showed high nitrogen isotope ratios, contrary to our expectations that they were typical wild boar. The values are probably the way they are because of the consumption of human food scraps, manure, or marine products. This site is dated from the initial stage of the Early Jomon and a radiocarbon dated to approximately 7900 years BP. It is suggested that wild boars found at a further earlier site, the aforementioned Shimotakabora Site (Initial Jomon) in Izu Oshima, Tokyo, may had been brought in by the Jomon people. The same phenomena are pointed out for Mediterranean islands such as Cyprus and Crete Island where wild boars, goats, sheep, and cattle are unearthed from sites dated 9000 BP at earliest, which is earlier than the period when wild boars in West Asia becomes domesticated as domesticated pigs. Remains of *Dama dama* and *Cervus elaphus* which have never been domesticated were also excavated from the same sites, suggesting that

the Ceramic or Neolithic people brought wild animals to the islands and released them. It seems the further research advances, the more difficult it becomes to draw a clear boundary between wild and domesticated animals.

CONCLUSION

Aside from individual domesticated pigs, the technique of domestication may have been introduced from West Asia and China and was applied to wild boars widely distributed in every region of the Eurasian Continent. In that case, it would be difficult to prove domestication from genetic lineage analysis. Besides, considering the number of offspring a female domesticated pig can produce during her life, it is much more efficient to introduce a superior sire to cross with local female wild boars than bringing a breeding pair. In fact, in Ie Island in Okinawa where I have been researching, large male wild boar bones apparently of a sire were found. Because mitochondrial genes are matroclinal, i.e., inherited only from the mother, it will as well be impossible to genetically prove the ancestry of domesticated pigs.

We are expanding our field further to Russian coastal oblasts, South Korea, Southern China, Taiwan, Vietnam, and Cambodia. Our plan is to conduct a comparative study on our achievements which are fragmentary at present; we would like to take a panoramic view covering whole East Asia.

We know too well that there still remain many questions to be addressed in order to prove the existence of domesticated pigs. For me it took more than 10 years to discuss the existence of domesticated pigs, as described above. The origin of our endeavor is inspiration we got when examining archaeological remains in our hands one by one. Seeking ways to prove this hypothesis led by inspiration, we looked for new researching methods and pursued new “facts” through joint studies with researchers from various fields. In moments when I realize I’m reaching such facts, I pause to appreciate my luck at having decided to be a researcher.

REFERENCES

Matsui, A. 1994 ‘Kusado Sengen: A Medieval Town on the Inland Sea’ “*The Illustrated History of Humankind Vol.4 New World and Pacific Civilizations - Cultures of America, Asia, and the Pacific*” Goran Burenhult ed. Weldon Owen Production. Australia, p.134

- Matsui, A. 1997 'Faunal remains recovered from Gushibaru shell midden. In *The site report of Gushibaru shell midden, Archaeological report of the Okinawa Prefecture 50*, pp. 49-70 (In Japanese). The Board of Education, Okinawa Prefecture Government.
- Matsui, A. 2011 'The Use of Livestock Carcasses in Japanese History, An Archaeological Perspective' "*Coexistence and Cultural Transmission in East Asia*" Left Coast Press. California, pp.127-139
- Matsui, A. 1997 'Faunal remains recovered from Gushibaru shell midden. In The site report of Gushibaru shell midden' "*Archaeological report of the Okinawa Prefecture 50*", pp. 49-70 (In Japanese). The Board of Education, Okinawa Prefecture Government .
- Matsui, A., N. Ishiguro, H. Hongo and M. Minagawa, 2005 'Wild pig? Or domesticated boar? An archaeological view on the domestication of *Sus scrofa* in Japan' *The First Steps of Animal Domestication*, eds J.-D. Vigne, J. Peters and D. Helmer, Oxbow Books, pp.148-159,.
- Minagawa, M., A. Matsui and N. Ishiguro 2005 'Patterns of prehistoric boar *Sus scrofa* domestication, and inter-islands pig trading across the East China Sea, as determined by carbon and nitrogen isotope analysis' *Chemical Geology* 218 pp.91-102,.
- Morii, Y., Ishiguro, N., Watanobe. T., Nakano, M., Hongo, H., Matsui, A. and Nishimoto. T. (2002) Ancient DNA reveals genetic lineage of *Sus scrofa* among archaeological sites in Japan. *Anthropological Science* 110.3.313-328.
- Nishimoto, T. 1991 'Pigs in Yayoi Period' *National Museum of Japanese History, Research Report* 36, pp. 175-189.
- Ozawa. T. 2004 'Raise domestic pigs in Jomon and Yayoi Periods?' *Archaeological Quarterly* 73, pp.17-22 (in Japanese).
- Watanabe, M. 2000 'New current of the Jomon studies' *Archaeological Quarterly*, 73 pp.14-16 (in Japanese).