

# **The Beginning of Agriculture in the Ryukyu Archipelago**

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## **Abstract**

The transition from hunting and gathering to agriculture has been one of the major concerns in archaeology, anthropology, and other related fields, since this transition in subsistence economy is almost invariably associated with tremendous cultural and societal changes. For example, in the case of mainland Japan, the introduction of wet rice agriculture during the 9<sup>th</sup> century BC (MIYAMOTO 2018, 2019) brought fundamental changes in every aspect of culture and society. This resulted in, for example, the beginning of hierarchical societies for the first time in Japan, eventually leading to the evolution of state societies.

Archaeologists, anthropologists, and other researchers such as ethnographers and botanists have also paid considerable attention to the transition from hunting, gathering, and fishing to agriculture in the Ryukyu archipelago, located in the southernmost region of Japan. Three distinctive prehistoric cultures appeared in the archipelago during the Holocene epoch: Northern, Central, and Southern Ryukyu cultures. In Northern Ryukyu, written documents state that rice agriculture was practiced during the 7<sup>th</sup> century AD. In the Central and Southern Ryukyus, archaeological data recovered in the 1960s indicated that agriculture, involving rice, wheat, and barley, was practiced during the Gusuku period. While archaeological data suggest that agriculture began during the Gusuku period, various hypotheses proposed that it began before the Gusuku period. Recent applications of flotation and impression replica analyses have been used as evidence to estimate the timeframes when agriculture began on the archipelago. Based on the latest data, this paper discusses the beginning of agriculture in these three

cultural regions.

**Key words:** agriculture, flotation, impression replica analysis, the Ryukyu archipelago

## Introduction

A well-known archaeologist, the late BAR-YOSEF, once stated that “the Neolithic Revolution, or the Agriculture Revolution, was a major ‘point of no return’ in human evolution” (BAR-YOSEF 2011: S175). Because this “Revolution” transformed many aspects of global cultures and societies around the world, when, why, and how the transition from hunting and gathering to agriculture took place has been one of the most important themes in archaeology and anthropology, as well as in related fields such as botany. For example, the world witnessed the emergence of ancient civilizations in Egypt, Mesopotamia, India, China, Mesoamerica, and the Andes. The foundations of these civilizations were agriculture. In other words, without agriculture, these civilizations probably never would have evolved.

Furthermore, since “the Revolution” brought such significant changes in various aspects of culture and society in the world, not only Western scholars but also Eastern scholars have paid a lot of attention to this theme. This has also been true of Japan. For example, as early as 1886, KAMADA (in TOZAWA 1982) analyzed Jomon chipped stone axes and speculated that these artifacts might have been used as digging tools for land tilling purposes. The possibilities of Jomon agriculture and the nature of Yayoi rice agriculture have been the center of major debates among scholars (e. g., MIYAMOTO 2019, NAKAYAMA 2010, OBATA 2016). Thanks to the introduction and development of new technologies and approaches over the last two decades, the nature of the Jomon “agriculture (or cultivation)” and the timing of the introduction of Yayoi agriculture have been much more clearly understood. For example, while some scholars speculated that rice may have been grown during the Jomon period, it is now understood that rice was not cultivated during this period. Interestingly, new findings suggest that soya bean and adzuki bean are cultivated (NAKAYAMA 2010, OBATA 2016). In addition, as will be discussed, the nature of the Initial Yayoi agriculture was unraveled by recent archaeobotanical analysis.

Archaeologists, anthropologists, and scholars from related fields have also paid great attention to the beginning of agriculture in the southernmost region of the Japanese archipelago, the Ryukyu archipelago. The archipelago is located between the Kyushu and Taiwan islands, stretching approximately 1,200 km. By the middle Holocene epoch, three prehistoric cultural regions emerged in the archipelago: Northern, Central, and Southern Ryukyu cultural regions (Fig. 1). Historical documents confirm that rice agriculture was introduced to the Northern Ryukyu cultural region during the 7<sup>th</sup> century AD. Archaeological data collected in the 1960s showed that the subsistence economy of the Gusuku period (ca. late 11<sup>th</sup> to 15<sup>th</sup> centuries)—characterized by the use of iron; the practice of long-distance trade with Japan, Korea, China, and Southeast Asian countries; and the emergence of chiefdoms—was based on crops such as rice, wheat, and barley. However, some hypotheses proposed between the 1950s and the 1990s suggested that agriculture emerged before the

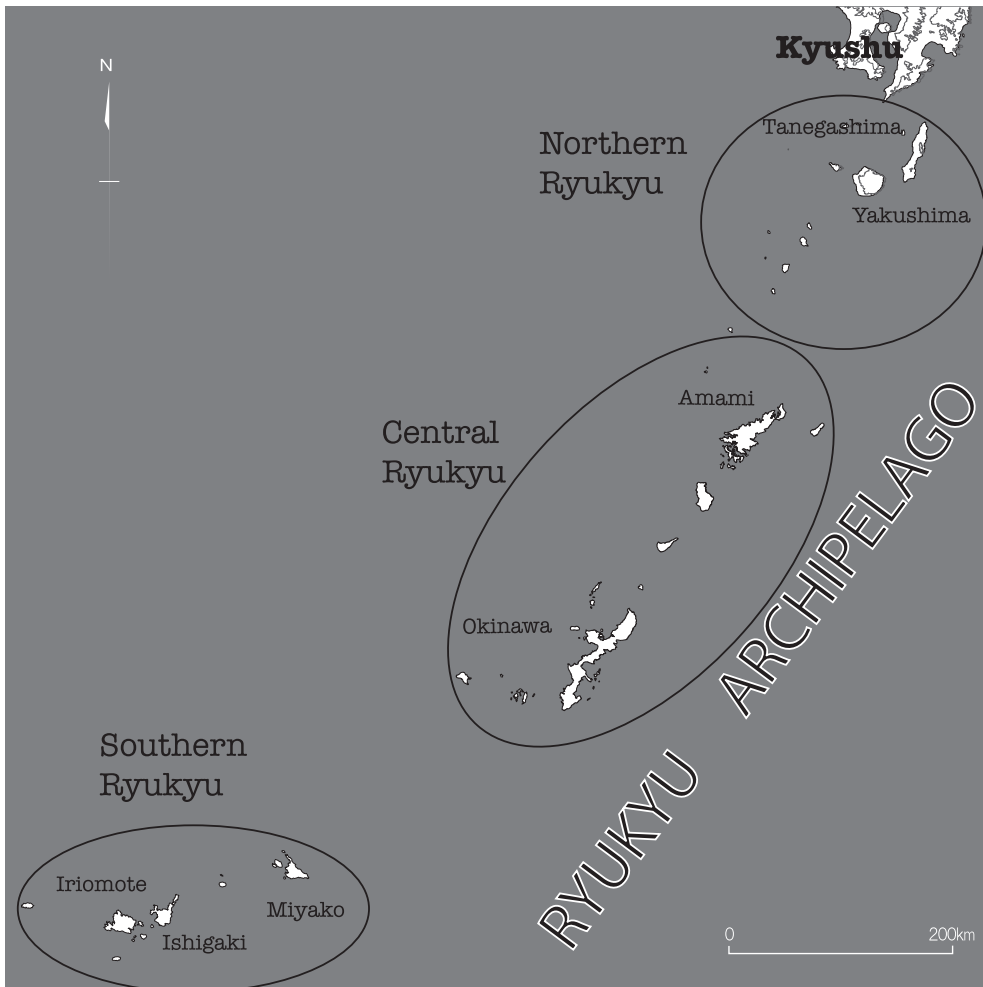


Fig. 1: Map of the Ryukyu archipelago with three cultural regions: Northern, Central, and Southern cultural regions.

Gusuku period in all three Ryukyu cultural regions.

When did the transition to agriculture take place in the Ryukyu archipelago? The purpose of this paper is to use the latest archaeobotanical data obtained by flotation and impression replica methods to examine the agricultural origin hypotheses proposed in the late 20<sup>th</sup> century. The results of the application of these methods to prehistoric sites in the archipelago have shed light on the timing of the introduction of agriculture in this region.

To present archaeobotanical data and evaluate the hypotheses, this paper consists of four sections. The first section deals with the explanations of flotation and impression replica methods because most readers of the *South Pacific Studies* are not familiar with these methodologies. The second section presents the background section. In this section, the agricultural origins of northern Kyushu, where Yayoi agriculture was first introduced, is described. From here, the Yayoi agriculture spread to the rest of Japan. To understand

the origins of agriculture in the Ryukyu archipelago, it is necessary to understand when it reached southern Kyushu, Kagoshima, and Miyazaki prefectures. The section summarizes the agricultural origins in southern Kyushu. In this section, the cultural history of the Ryukyu archipelago is briefly provided.

The background section is followed by hypotheses about prehistoric agriculture, which were proposed during the late 20<sup>th</sup> century (the third section). Since the hypotheses were proposed for three Ryukyu cultural regions, they will be explained separately. It should be noted that these hypotheses were proposed on the basis of secondary data, such as the introduction of foreign pottery and site locations, which to some suggested suitable localities to conduct agriculture. At this time, some hypotheses appear to have been based merely on speculation or subjective opinion.

The fourth section examines the proposed hypotheses. For the last three decades, flotation and impression replica methods have been introduced in the archipelago. The main purpose of flotation is to elucidate prehistoric plant consumption, based on the analysis of carbonized seeds collected by this method. The purpose of the latter has been to verify the beginning of agriculture in the Japanese archipelago. As will be presented in the methodology section, the most crucial advantage of the impression replica method is that, since pottery chronology has been firmly established in Japan (including the Ryukyu archipelago), the relative date of the impressed materials (such as rice) in the potsherd can be estimated. Carbonized plant remains recovered by flotation, on the other hand, should be carbon 14 dated even in small quantities (such as just one rice grain) in order to obtain an accurate date. In other words, with <sup>14</sup>C dating, the dates of plant remains can be precisely determined. These two approaches will provide a better understanding of the origins of agriculture in the Ryukyu archipelago. The combined applications of these two methods successfully evaluated the prehistoric agricultural hypotheses proposed. In addition, applications of these methodologies have more or less pinpointed when agriculture was introduced to the Ryukyu archipelago. Agriculture was introduced to the Northern Ryukyu cultural region by the Middle Yayoi period. It spread into the Central Ryukyu region between the 8<sup>th</sup> and 12<sup>th</sup> centuries AD. In the Southern Ryukyu cultural region, agriculture was accepted between the 12<sup>th</sup> and 13<sup>th</sup> centuries AD.

## Methodology

The methodologies applied in this study were flotation and impression replica analysis. Since most of the readers of *South Pacific Studies* are not familiar with these methodologies, in the following sections, we will briefly introduce their history, usefulness, and procedures.

### Flotation

Because animal bones and shellfish remains are sturdy and relatively large in size, they are visible during the course of excavation. Faunal remains are thus often picked up as the excavation progresses; however, reconstruction of prehistoric animal consumption based on hand picking itself provides a skewed view (GRAYSON 1984, O'CONNOR 2008).



Unlike faunal remains, collecting plant remains, such as wheat and barley seeds, during the excavation period is nearly impossible because of their small size and fragility. Researchers may get lucky enough to encounter extraordinary sites, such as wet sites or dry caves, which may present opportunities to recover plant remains during the course of excavation.

To extract carbonized plant remains (mainly seeds), flotation was introduced into archaeology and popularized by STRUEVER (1968) in North America. According to WATSON (1976), the introduction of this method into archaeology revolutionized this discipline. For example, Hokkaido, located in the northernmost region of Japan, is the home of the indigenous Ainu people. The Ainu people were documented as hunter-gatherers by Japanese scholars and visitors to the island during early historic times (after the Meiji Era, ca. 1860s). Consequently, both in Japan and in the West, the Ainu are usually described as hunter-gatherers of Japan (WATANABE 1968). Furthermore because of this widespread image of the Ainu as hunter-gatherers, Hokkaido had (and has) been thought to have been occupied by hunter-gatherers for thousands of years. Hokkaido is one of the regions where flotation was introduced for the first time in Japan. It has been conducted intensively since the 1970s (CRAWFORD 1983, YAMADA and TSUBAKISAKA 2005). Two important findings are described below.

CRAWFORD (1983) collected soil samples from archaeological sites for flotation dating back to the Initial Jomon to Middle Jomon. Meticulous analysis of carbonized seeds recovered from flotation revealed two interesting trends. First, during the earlier phases, nut remains were identified abundantly but decreased in the later phases. Nut remains were replaced by grass seeds such as *Chenopodium*. Second, the average size of barnyard grass caryopses increased by approximately 20% from the Early Jomon to the Middle Jomon period. CRAWFORD (1983) suggests that at the beginning, nuts were important but were later replaced by grasses. Furthermore, he hypothesizes that among grass species, barnyard grass might have been an important source of plant food and that the Jomon people were on the verge of cultivating barnyard grass.

CRAWFORD and YOSHIZAKI (1987) applied flotation to the Satsumon period (ca. the 7<sup>th</sup> to 13<sup>th</sup> centuries AD) sites. The Satsumon culture and people were direct ancestors of the Ainu. The application of flotation to many Satsumon sites has revealed that the Satsumon people practiced agriculture and consumed cultivated plants, such as barley, wheat, foxtail millet, and broomcorn millet. The series of applications of flotation demonstrated that the ancestors of the Ainu adopted food production. What about the Ainu? Recent studies have demonstrated that the Ainu had succeeded in Satsumon agriculture (YAMADA and TSUBAKISAKA 2005). Thus, the introduction of flotation to reconstruct the prehistoric subsistence economy in Hokkaido has changed our understanding in the last half century.

The application of the flotation method to an Initial Yayoi site revealed the nature of the subsistence economy of this period. TAKAMIYA's personal question regarding the earliest rice-related sites (i.e., the Initial Yayoi period sites) concerned whether the reconstructed rice-centered Yayoi agriculture might have been biased, since flotation had not been applied to the Initial Yayoi sites. Without flotation, it is almost impossible to recover small-sized seeds, such as foxtail millet and broomcorn millet. What is the nature of Initial Yayoi

agriculture? Was rice a major crop grown and consumed during the Initial Yayoi period, as many scholars feel? Or did small-sized crops, such as foxtail millet and broomcorn millet, also play an important role in the Initial Yayoi?

For the last three years, TAKAMIYA (in press) had the opportunity to analyze plant remains recovered by flotation from the Ukikunden site, located in Saga prefecture. During the 1980s, the site was excavated by Kyushu University and the Karatsu Board of Education, and at least 89 soil samples were collected. Between 2016 and 2018, 89 soil samples were processed by flotation. The plant remains collected were analyzed by TAKAMIYA (in press). Out of approximately 1700 plant remains, the analyzed samples were found to contain more than 1000 grains of rice. Thus, approximately 60% of the plant remains were identified as rice. On the other hand, only 18 and 6 specimens were identified as foxtail millet and broomcorn millet, respectively. In addition, almost all the samples yielded rice remains. More precisely, rice remains were found among at least 75 out of 89 samples. The results of the plant remain analysis suggest that the Initial Yayoi agriculture probably consisted mainly of rice cultivation. Interestingly enough, they did not yield barley and wheat, suggesting that these cultigens might not have been grown and consumed during the Initial Yayoi period (TAKAMIYA in press).

#### **Analytical method: Flotation**

The principle behind flotation is simple. Carbonized plant remains, such as seeds, float, when soil samples collected from archaeological sites are immersed in water. To collect carbonized plant remains,

- 1) Soil samples are collected from archaeological sites (Fig. 2-1).
- 2) The soil samples were dried considerably (but not completely) (Fig. 2-2).
- 3) The volume (or weight) of the soil samples is recorded.
- 4) Several flotation methods are known (CRAWFORD 1983, Watson 1976). Among them, we adopted one shown in Fig. 2-3. This apparatus consists of outer (①) and inner tanks (②), which are placed on a stand. Water was supplied from a rubber hose. The bottom of the inner tank is a 1 mm sieve that enables the collection of heavy materials including small artifacts, bones, and shells (we call these collected from a 1 mm sieve



Fig. 2-1: Soil samples collected from an archaeological site.



Fig. 2-2: Soil sample being dried.

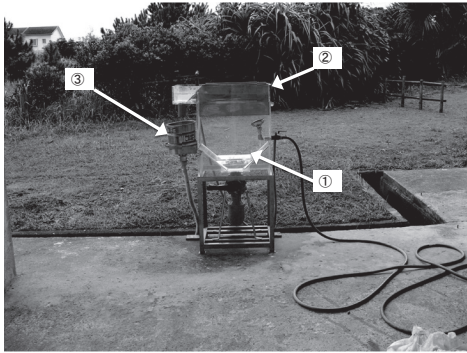


Fig. 2-3: Flotation apparatus used in this study.



Fig. 2-4: Soil samples removed into flotation.



Fig. 2-5: Light fraction.



Fig. 2-6: Collecting light fraction.

as the heavy fractions). Water is filled in the outer tank up to approximately 5 cm from the lip. The soil sample was then dumped into the inner tank (Fig. 2-4). Light materials such as carbonized seeds float from the soil matrix (Fig. 2-5).

- 5) The floated materials were then collected by coarse (2 mm) and fine (0.42 mm) sieves (Fig. 2-6).
- 6) The floated materials (referred to as the light fraction) are then dried.
- 7) The heavy fractions are sorted. Artifacts and ecofacts are collected and identified.
- 8) The light fraction is usually examined under a microscope. From the light fraction, carbonized plant remains were collected and identified.

### Impression Replication Analysis

Using the following procedure, the impression replica method attempts to identify the substance that created a cavity (impression) left on the surface of an artifact. First, the model (replica) of the cavity is made by impression material, and then the replica is identified under a Scanning Electric Microscope. The impression replica method was introduced to archaeology in Europe and Japan as early as the beginning of the twentieth century. In Japan, YAMANOUCHI (1967), using clay and plaster as the impression material, attempted to identify rice husks on potsherds. The present-day impression replica method adopted by Japanese archaeology was developed from the research conducted by USHINO and TAGAWA

(1991). They applied this method to identify impressions left on potsherds, use-wear patterns on lithics, and markings on the perforation in beads.

NAKAZAWA (2005) investigated the beginning of agriculture in Japan by applying this method to identify rice husk impressions of Jomon and Initial Yayoi potsherds. In 2005, YAMASAKI (2005) conducted the impression replica method on every potsherd collected from a site. YAMASAKI (2005) successfully identified rice and rice weevils from Jomon potsherds (however, it should be noted that recent reanalysis of the “Jomon rice impressions” have demonstrated that all of them are inconclusive). Consequently, their work has encouraged and attracted many archaeologists to investigate the presence/absence of cultigens and cultigen-related insects, and other organic materials such as shells, which generally cannot preserve well in archaeological sites. Furthermore, because the impressions were produced when pottery was wet and fired, and because precise pottery chronology has been established in Japan, a more precise relative date of the replica can be grasped.

One major purpose of the impression replica method during the early stage is to understand the beginning of rice agriculture. This method has been applied to not only the Yayoi period but also to other periods and is used not only in Japan but also in other countries as well. For example, OBATA et al. (2007) and NAKAYAMA and KAIMON (2009) attempted to apply this method to examine cultivation during the Jomon period. Consequently, OBATA et al. (2007) recognized cultivated soya bean among the Jomon potsherds; NAKAYAMA and KAIMON (2009) have indicated that soya bean and adzuki bean were utilized and cultivated as early as the Middle Jomon period in central Japan. Furthermore, OBATA et al. (2011a) identified the earliest rice weevil impression on pottery in the world from Tanegashima Island, Japan. It was dated to be more than 10,500 years ago. In addition, OBATA et al. (2011b) elucidated the presence of foxtail millet and broomcorn millet in potsherds, which pre-date the C<sup>14</sup> dates of the carbonized foxtail millet and broomcorn millets in Korea. Thus, this method has been established as one of the major approaches for our understanding of the beginning and spread of agriculture in Japan and other countries.

Recently, distinctions have been suggested between exposed and unexposed impressions. The former describes cavities on the pottery surface and is usually recognized by the naked eye; the latter are those located inside the pottery. The latter are not recognizable with the naked eye. In order to extract and identify unexposed impressions, X-rays, CT, and soft X-rays have been applied (MANABE and OBATA 2011, NAKAYAMA 2010, OBATA 2016). Examination of unexposed impressions demonstrated that more unexposed impressions were found than exposed ones. Furthermore, it is said that the analysis of unexposed impressions sheds light on the process through which seeds and insects could become entangled inside potsherds, the environment where pottery was fired, and whether or not these materials entered the pottery on purpose or accidentally.

#### **Analytical method: Impression Replica Analysis**

The following are procedures for exposed impression analysis (Cf. HISA and KATATA 2005).

- 1) Impressions on the surface and cross section of the potsherd are examined.



Fig. 3-1: Silicon material: Blue Mix.



Fig. 3-2: Injecting silicon into the impression.



Fig. 3-3: Detaching a replica.



Fig. 3-4: An example of a replica (rice). The replica will be identified using a Scanning Electric Microscope.

- 2) While cleaning the potsherd, the impressions are examined by the naked eye and/or under a microscope.
- 3) The areas in and around the impressions are coated by a release agent (such as paraloid solvent melted by acetone) so that silicon is easily peeled off from the potsherd.
- 4) Silicon (Fig. 3-1) is injected into the impressions to make replicas (Fig. 3-2).
- 5) The replica is detached (Fig. 3-3), and the mold release agent is removed from the replica.
- 6) The replicas (Fig. 3-4) are examined and identified using a Scanning Electron Microscope.

When this method is applied, we record basic data, such as the number of potsherds examined, the date of the potsherds based on pottery chronology, and the location of the impression. We also photograph the potsherd prior to examination and the location of the impressions. By doing so, we not only photographically record the necessary data, but we also double check the possibility of contamination and/or damage before and/or after the examination. Drawings of potsherds are conducted when an impression is located on the mouth or decorated area of pottery that provides the date of pottery.



## Background

### Northern Kyushu: Beginning of Yayoi Agriculture

The northern region of Kyushu, mainly Saga and Fukuoka prefectures, is thought to be the cradle of rice agriculture (*Oryza sativa japonica*) in Japan, which had been introduced from the Korean peninsula during the Initial Yayoi period (ca. 9<sup>th</sup> century BC, MIYAMOTO 2018, 2019). For example, the Itatsuke site in Fukuoka city yielded not only numerous rice remains but also agriculture-related tools such as wooden hoes and plows. Ultimately, rice paddy fields were also unearthed at the site. Similar findings have been reported from the Nabatake and Ukikunden sites located in Saga prefecture.

Yayoi agriculture then spread to the east and south of northern Kyushu. When did it reach southern Kyushu, Kagoshima, and Miyazaki? To understand when food production spread into the Ryukyu archipelago, it is crucial to know the situation in southern Kyushu. We will discuss the situation in southern Kyushu below. While flotation has not been applied to Yayoi sites in this region, we have obtained the following information.

### Agriculture origin in southern Kyushu: Kagoshima and Miyazaki prefectures

(See Fig. 4 for site locations)

As early as 1962 and 1963, an archaeological excavation at the Takahashi shellmidden in Kimpo town (now, Kimpo Town, Minami Satsuma city) in Kagoshima prefecture unearthed Early Yayoi pottery, a polished stone sword, stone sickles, and stone knives. This has been argued to indicate that wet rice agriculture reached the western part of Kagoshima during the Early Yayoi period (KAWAGUCHI 2002:38). Moreover, in 1986, the Shimohara site, which is also located in Kimpo town, yielded Early Yayoi pottery, stone knives, and rice husks (KAWAGUCHI 2002:38). The excavation revealed that rice agriculture reached Kagoshima within three hundred years after it appeared in northern Kyushu.

However, a question arises from the above findings. That is, while one can speculate on the presence of rice agriculture based on these findings, it is difficult to determine whether it was wet or dry rice agriculture. Which was it? The Kagoshima University Campus site at the Korimoto Housing Complex sheds light on this question. The layer dated to the Early Yayoi period yielded paddy fields with numerous human footprints (KAWAGUCHI 2002:39). This piece of evidence demonstrates that wet rice agriculture spread to this area by the Early Yayoi period.

Rice agriculture also diffused into Miyazaki prefecture at about the same time. The Kurotsuchi site, the Hijiana site, and the Sakamoto A site, all of which are located in Miyakonojo city, provided archaeological data on rice agriculture. The Kurotsuchi site yielded stone knives, rice-tempered potsherds, and a large amount of rice phytoliths (KAWAGUCHI 2002:39, KUWAHATA and YOKOYAMA 2000:7, NAKAMURA et al. 2013:17). Interestingly, FUJIWARA (in KUWAHATA and YOKOYAMA 2000:7) who examined rice phytoliths from the site thought that the rice cultivated at or near the site was dry field rice agriculture. The Hijiana site also produced stone knives and chipped stone axes, which were probably used for digging, and large amounts of rice phytoliths (KUWAHATA and YOKOYAMA



Fig. 4: Site locations mentioned in the text (in Kagoshima and Miyazaki prefectures).

2000:7). KUWAHATA and YOKOYAMA (2000) thought that wet rice agriculture was practiced at or near the site. These two sites also yielded Paniceae phytoliths, suggesting that foxtail millet, broomcorn millet, and/or barnyard millet might have been cultivated. Finally, a wet rice paddy field was recovered from the Sakamoto A site. These pieces of evidence demonstrate that both wet and dry rice agriculture was practiced in Miyakonojo city, Miyazaki prefecture, during the Early Yayoi period.

Recently, NAKAMURA et al. (2013) conducted an impression replica study at the Kurotsuchi site and the Sakamoto B site, both of which are located near the Sakamoto A site. Based on pottery chronology, these two sites are dated to the Early Yayoi. From the former, they identified foxtail millet or green foxtail, rice, *shiso* (*Perilla* sp.), and unknown species. NAKAMURA et al. (2013:17) agree with FUJIWARA's remark on dry rice agriculture being practiced at or near the site. From the Sakamoto B site, they identified rice and possible foxtail millet (NAKAMURA et al. 2013:16). Based on this study, NAKAMURA et al. (2013:17) concluded that rice and foxtail millet were cultivated during the Early Yayoi in Miyazaki. They also suggest that foxtail millet might have been cultivated during the Final Jomon period.

Thus, it appears that, during the Early Yayoi period, both wet and dry rice agriculture may have been practiced in Kagoshima and Miyazaki prefectures. In addition, it is likely that millets were cultivated. While sufficient archaeological data have not yet been accumulated, available data suggest that food production was continuously practiced. In Miyazaki, for example, at the Sakamoto A site, rice paddy fields have been identified in the late Early Yayoi period, late Middle Yayoi period, Final Yayoi period, and the Medieval period layers (KAWAGUCHI 2002:42). NAKAMURA et al. (2013) identified rice impressions from the Early Yayoi period pottery and the Middle Yayoi period pottery at the Sakamoto B site (NAKAMURA et al. 2013:16). In addition, foxtail millet impressions from the Early and Middle Yayoi pottery recovered from the Kurotsuchi site (NAKAMURA et al. 2013:16). They reported foxtail millet and broomcorn millet impressions from the late Late to Final Yayoi potsherds from the Hoshihara site. The site also yielded rice, broomcorn millet, and foxtail millet impressions on the Middle Kofun period pottery as well as potsherds dating to the 9<sup>th</sup> to 10<sup>th</sup> centuries AD. A rice-impressed potsherd was reported from the Tsuruhami site, dating to the Late Kofun period.

In Kagoshima prefecture, the Kagoshima University Campus site at the Korimoto Housing Complex yielded wet rice paddy fields dating to the Middle Yayoi period (OHNISHI et al. 2012:99). The Kyoden site in Satsumasendai city, which corresponds with the Middle Yayoi period, produced wet rice paddy fields and numerous rice phytoliths. The Kusumoto site near the Kyoden site, which dates to the final Yayoi period, also yielded numerous rice phytoliths. Furthermore, both the Kyoden and Kusumoto sites produced various wooden tools used for agriculture, such as wooden hoes (KAWAGUCHI 2002:40-41). According to HONDA (in KAWAGUCHI 2002:43), the number of stone knives tends to increase during the Late Yayoi period in southern Kyushu. This suggests that rice agriculture had become more important in the subsistence economy toward the end of the Yayoi period.

Corresponding to the Kofun period, the Kagoshima University Campus site at



the Korimoto Housing Complex yielded a large amount of rice phytoliths. Rice grains were recovered from pit No. 71 (OHNISHI et al. 2012:99, SHIMOYAMA 1995:184). At the Hashimuregawa site in Ibusuki city, hoe marks, Paniceae, and rice phytoliths were found. At the site, archaeologists have recovered ridge marks dating to the Heian period. The Mizumoto site, dating from the Medieval to the early Modern period, yielded rice, wheat, and possible millets. Thus, in the southern Kyushu area, agriculture was practiced during the Early Yayoi period and has been continuously practiced since. Then, when did agriculture begin in the Ryukyu archipelago? Before discussing this topic, it is necessary to present the chronology and cultural history of the archipelago.

### **Chronology and cultural histories**

The Ryukyu archipelago was occupied by *Homo sapiens* during the Paleolithic period (10,000-36,000 BP). For example, sites dating to ca. 30,000-35,000 years ago have been reported from Tanegashima Island. Sites dating approximately 30,000 years ago have been reported from the Amami-oshima and Tokunoshima Islands. Several sites were found from the Okinawa archipelago dating between 14,000 and 36,000 years ago. Miyako and Ishigaki Islands yielded sites dating from 14,000 to 25,000 years ago. While only a handful of islands in the world were occupied by *Homo sapiens* during the Paleolithic period (or prior to 10,000 years ago), it is astonishing to recognize that at least eight islands in the Ryukyu archipelago witnessed the presence of *Homo sapiens* during the Paleolithic period (TAKAMIYA et al. 2019).

During the beginning and mid-Holocene, three prehistoric cultures emerged in the Ryukyu archipelago. They are called the Northern, Central, and Southern Ryukyu cultural regions (Fig. 1). The Northern Ryukyu cultural region, consisting of Tanegashima and Yakushima Islands, was strongly influenced by Kyushu Island during most of the prehistoric period because of its proximity to Kyushu Island. It should be remembered, however, that cultural contact between mainland Kyushu and the Northern Ryukyu region appears to have been minimal or none (at least based on archaeological data) from the late Late Yayoi to Kofun periods. Written history began in the Northern Ryukyu culture around the 7<sup>th</sup> century AD. The late Late Yayoi and Kofun periods in the Northern Ryukyu exhibited different cultural features in the Kagoshima and Miyazaki regions. Japanese archaeologists often call this period the Yayoi/Kofun Parallel. However, native speakers of English informed one of the current paper's authors that "parallel" is not an accurate terminology for use in academic writings. Therefore, the concerned periods will be called Yayoi and Kofun in this paper (Table 1).

The Amami and Okinawa archipelagos constitute the Central Ryukyu cultural region. During the early Holocene, this region was first impacted by Kyushu Island culture, like the Northern Ryukyu. However, because of the considerable distance between Kyushu and Central Ryukyu, a distinctive culture emerged in the latter region. The chronology here consists of the Paleolithic, Shellmidden, and Gusuku periods. The Shellmidden period is further subdivided into Early and Late periods (Table 1). The former is further subdivided into five periods, and the latter into two periods.

Table 1: Chronology of the Northern, Central, and Southern Ryukyu Cultural Regions.

B.P.	Mainland Japan (except Hokkaido)	Osumi Archipelago	Amami•Okinawa	Miyako•Yaeyama	
ca.11/12-15 AD	Kamakura	Kamakura	Medieval	Gusuku	
1400	Asuka to Heian	Asuka to Heian	Ancient	Late 2	
1800-1400	Kofun	Kofun	Kofun	Late 1	
2800-1700	Yayoi	Yayoi	Yayoi	Hiatus?	
3300-2800	Jomon	Final Jomon	Final Jomon	Early 5	
4500-3300		Late Jomon	Late Jomon	Early 4	
5500-4500		Middle Jomon	Middle Jomon	Early 3	
7000-5500		Early Jomon	Early Jomon	Early 2	
		12000-7000	Initial Jomon	Initial Jomon	Early 1
16000			Incipient Jomon	Incipient Jomon	Beginning of pottery culture?
35000		Paleolithic	Paleolithic	Paleolithic	Paleolithic

Note: The mainland chronology is provided as a rough guide. Periodization between the Amami/Okinawa archipelagos and mainland Japan does not always correspond exactly.

The Southern Ryukyu cultural region (consisting of the Miyako and Yaeyama archipelagos) was independent of the Northern and Central Ryukyu cultural regions during most of the prehistoric period. No prehistoric cultural contact has been identified between the Central and Southern Ryukyu cultures prior to the 12<sup>th</sup> century AD. Both the Miyako and Yaeyama archipelagos witnessed presence of *Homo sapience* prior to 10,000 years ago (the Paleolithic period). It is said that they probably migrated from the south. The Holocene prehistoric culture here begins with the Shimotabaru period, which was followed by several hundred years of hiatus in the Yaeyama archipelago. While the Miyako archipelago was thought to have undergone this hiatus, archaeological data from the Nagabaka site indicate remnants of this hiatus (HUDSON 2014). The non-pottery period followed this hiatus period (Table 1). The Central and Southern Ryukyu cultural regions were unified at about the 12<sup>th</sup> century AD for the first time. These cultural regions have distinctive chronologies, as shown in Table 1 (ISHIDO 2014, OKINAWA KOKO GAKKAI ED. 2018, SHINZATO 2014).

### Prehistoric Agricultural Hypotheses

Prehistoric agricultural hypotheses in the Northern, Central, and Southern Ryukyu cultural regions will be briefly introduced here.

### Northern Ryukyu Cultural Region

Prehistoric culture in this region was strongly influenced by the neighboring southern Kyushu region from the Paleolithic to Historic period. The only period during which the region was culturally independent from southern Kyushu was between the late Yayoi and Kofun periods (ca. AD 2<sup>nd</sup> to AD 7<sup>th</sup> centuries). Based on historical written documents such as the *Nihonshoki*, TORAO (2006 in NAKAMURA 2015) and NAKAMURA (2006 in NAKAMURA 2015) wrote that, by the late 7<sup>th</sup> century AD, rice agriculture was practiced in this region. *Nihonshoki* is the earliest historical record produced during the Nara period. This historical document indicates that rice was growing abundantly during the late 7<sup>th</sup> century AD. Thus, according to the written documents, at least by this time, agriculture was practiced in the Northern Ryukyu cultural region (However, we need to examine the presence or absence of rice agriculture after the 7<sup>th</sup> century based on a scientific approach—namely, archaeologically). As described above, in Kagoshima, rice remains and rice paddy fields have been recovered from the Early Yayoi, Kofun, and Medieval sites. Did people in the Northern Ryukyu cultural region adopt agriculture prior to the late 7<sup>th</sup> century AD? In Tanegashima Island, as early as the 1950s, an interpretation of the so-called Yayoi “stone sickles” hinted at the presence of rice agriculture on the island. In addition, in 1955, KOKUBU and MORIZONO (KOKUBU and MORIZONO 1955 in ISHIDO 2014) reported rice-impressed potsherds dating to the Kofun period. Since 2000, some sites have yielded agriculture-related features, rice-impressed potsherds, and agriculture-related tools. However, these findings are indecisive. Some potsherds were found with rice impressions, but they did not provide precise dates. Some stone tools look like stone knives, but it is difficult to make final determinations because their morphologies are not exactly like those used in mainland Japan.

ISHIDO (2014) examined several lines of archaeological evidence and concluded that food production was practiced before the 7<sup>th</sup> century AD. The following two lines of evidence have been suggested by ISHIDO (2014) to argue that agriculture was introduced prior to the 7<sup>th</sup> century AD. First, ISHIDO (2014) analyzed stone tools recovered from Tanegashima Island and noticed that, during the Jomon period, grinding stones and stone dishes (metate) were prevalent among stone tool assemblages. He interprets that these stone tools were used for processing nuts. During the Yayoi period to the Kofun period, these two types of stone tools almost disappear in the stone tool assemblage. He argues that this change in stone tool assemblage is similar to that of southern Kyushu. In addition, the isotopic values from human bones from the Hirota site were similar to those of rice agriculturists in Kyushu (ISHIDO 2014). Accordingly, ISHIDO (2014) feels that agriculture was practiced on Tanegashima Island during the Yayoi to Kofun periods. HASHIMOTO (2012:22) believes that since Yayoi pottery diffused to Tanegashima Island, agriculture was likely accepted there. However, he also suggests that people on the island quit farming and became hunter-gatherers again during the Kofun period since only little influence can be detected from the mainland Kofun culture to Tanegashima Island.

Since few archaeological excavations have been conducted on the other islands in this region, it is not yet understood when food production was introduced other than in

Tanegashima Island. From a study of stone assemblages, ISHIDO (2014) found that the stone tool assemblage on Yakushima Island was mostly dominated by grinding stones and stone dishes. Since these types of stone tools were frequently recovered from Jomon sites, he suggests that Yakushima Island was occupied by hunter-gatherers—at least through the Kofun period.

While ISHIDO (2014) has intensively reviewed all available archaeological and historical data, as of 2014, no hard evidence of rice grains and/or rice paddy fields has been found in this region. Thus, it was not possible to suggest exactly when food production was introduced into the Northern Ryukyu cultural region.

### **Central Ryukyu Cultural Region**

Because the intensity of excavation has been substantial in this region compared with the Northern and Southern Ryukyu cultural regions, extremely large amounts of archaeological data have been collected. Based on these archaeological data, at least six Shellmidden agriculture hypotheses have been proposed (ITO, K. 2007).

#### *The Late 1 agriculture hypothesis*

This hypothesis was proposed by HIROE TAKAMIYA in 1985. During the Late 1 period, a spectacular cultural phenomenon known as the Shell Road emerged in the Okinawa archipelago. The Shell Road is a long-distance exchange system conducted between the Okinawa archipelago and mainland Japan via the Amami archipelago. Mainland Yayoi was eager to obtain large gastropod shells (*Strombus latissimus* and cone shells), which are available in Amami and further south in Japan. The Yayoi people produced bracelets from them, and the Yayoi chiefs used them as status objects. In addition, since Yayoi pottery and other Yayoi cultural elements were recovered from Amami-oshima Island, it was interpreted that Yayoi culture diffused to this island. Based on these findings, HIROE TAKAMIYA (1985) thought that wet rice agriculture might have reached the Amami and Okinawa archipelagos by the Late 1 period (see Table 1 for chronology).

#### *The Early 5 agriculture hypothesis*

This hypothesis was proposed by NITTA in 1969. He recognizes three features that characterize the Early 5 period. First, he notes that the Early 5 sites yield larger amounts of stone dishes, compared with Late 1 and Early 4. Second, while archaeological sites in this region usually unearth abundant faunal remains such as wild boar, fish bones, and shells, the Early 5 sites tend to contain much fewer numbers (and species) of animal remains. First and second observations have indicated to NITTA (1969) that plant resources were more important during the Early 5 compared to the Early 4 and Late 1. Third, NITTA (1969) realizes that the Early 5 sites are mostly found at higher elevations and in open areas, such as mountain ridges and hilltops. He believes that agriculture was practiced in such locations.

#### *The Early 4 agriculture hypothesis*

ITO, S. (1993) compared site locations of the Early 4 period and contemporaneous

site locations in mainland Japan (that is, Late Jomon). Accordingly, he notes that the sites in the Okinawa archipelago are found at higher elevations than the Late Jomon period sites. For example, he states that most archaeological sites in Japan are reported at elevations less than 50 m. On the other hand, the Early 4 Okinawan sites are often discovered at higher elevations, usually more than 50 m. Furthermore, he also recognized that many Early 4 sites yielded numerous land snails (*Cyclophorus turgidus turgidus*), which inhabit open areas. These pieces of information suggest that slash and burn agriculture was practiced during this period.

#### *The “Early 4” agriculture hypothesis*

This hypothesis was proposed by HIROTO TAKAMIYA (1993). He investigated when people first successfully colonized the islands of the Okinawa archipelago. To understand the timing of successful colonization, he attempted to reconstruct the palaeodemography. A pattern of population increase was perceived during the Early 4 period, which suggests the timing of successful island colonization. Based on these indicators, TAKAMIYA thought that the islands of Okinawa were successfully colonized for the first time during the late Early 3 and Early 4 periods. He terms this period the “Early 4.” In addition, he learned that most islands in the world were successfully colonized by agriculturalists. The Mediterranean, most Oceania, and the Caribbean islands were settled by farmers. Based on these pieces of information, he proposes that the “Early 4” people were farmers.

These four hypotheses were proposed by archaeologists and anthropologists. The beginning of agriculture in the Amami and Okinawa archipelagos also attracted scholars from different fields. Two influential hypotheses have been proposed: one by a distinctive folklorist and another by a rice geneticist.

#### *The Ocean Road hypothesis*

This hypothesis was proposed by the pioneer of Japanese folklore studies, KUNIO YANAGITA (1961). As a Japanese folklorist, YANAGITA considered the foundation of modern Japanese culture. The conclusion he reached was that wet rice agriculture must have been the foundation. He speculated when and how wet rice agriculture was introduced into Japan. This resulted in the proposition of the well-known Ocean Road hypothesis. He hypothesized that, sometime between the end of the Jomon period and at the beginning of the Yayoi period, wet rice agriculture based on *Oryza sativa japonica* was introduced to mainland Japan from southern China and/or Taiwan via the Ryukyu archipelago.

#### *The New Ocean Road hypothesis*

YOICHIRO SATO (1992), a distinguished rice geneticist, suggested the introduction of rice agriculture during the Jomon period. He paid special attention to the fact that by the Early Yayoi period wet rice agriculture was practiced in Aomori, the northernmost prefecture of Honshu Island. He thought that, for rice to grow in such a region, the rice must have been an early ripening variety. However, rice cultivated during the Yayoi period (*Oryza sativa japonica*) is a late ripening variety. *O. s. javanica*, the other variety of Asian

rice, is also a late ripening variety. Thus, neither variety of Asian rice could have been grown in the northern region of Japan. Experimentally, when he crossed *O. s. japonica* and *O. s. javanica*, he successfully produced an early ripening variety of rice. Based on this experiment, he proposes that *O. s. javanica* was introduced from Southeast Asia, the cradle of *O. s. javanica*, to Japan via the Ryukyu archipelago during the Jomon period, that is, before the Yayoi period. Then, it was crossed with *O. japonica*, which was brought from the Korean peninsula to Kyushu at the beginning of the Yayoi period.

The differences between the Ocean Road and the New Ocean Road hypotheses are that YANAGITA (1961) thought that *O. s. japonica* was introduced sometime at the end of the Jomon and the beginning of the Yayoi period. On the other hand, SATO (1992) felt that *O. s. javanica* was introduced during the Jomon period. SASAKI (2003) supports Sato's hypothesis and believes that either foxtail millet and/or rice was introduced.

### **Southern Ryukyu Culture Region**

Proponents of the Ocean and New Ocean Road hypotheses, such as YANAGITA (1961), SATO (1992), and SASAKI (2003), presume that the Southern Ryukyu islands are the route of entry of agriculture to the Central and Northern Ryukyus and finally to mainland Japan. Therefore, according to these theorists, the Southern Ryukyu culture region must have witnessed agriculture during the Shimotabaru period and/or the non-pottery period.

As early as 1955, KANASEKI (1955) considered prehistoric agriculture in this area. He examined lithics recovered from the Shimotabaru shellmidden and found morphological similarities between the adzes recovered from the site and the so-called *pira* (a traditional iron spatula used for digging). Accordingly, he suggests that stone adzes were used for agriculture during the Shimotabaru period. As has been explained in the background section, prehistoric culture here was not introduced from the Central Ryukyus, but from further south (i.e., Taiwan and/or the Philippines). While we have not been able to identify the source of the Southern Ryukyu culture, it is possible that the colonizers might have brought crops with them to the Southern Ryukyu area.

## **Examination of Hypotheses and the Beginning of Agriculture**

### **Northern Ryukyu Cultural Region**

During the 7<sup>th</sup> century AD, rice agriculture was documented to have been practiced in this region. How much earlier than this date was agriculture introduced? While ISHIDO (2014) strongly feels that agriculture was introduced to the Northern Ryukyu cultural region before the 7<sup>th</sup> century AD, no direct data had been known until 2015. In 2015, NAKAMURA (2015) conducted an impression replica analysis. She has analyzed potsherds recovered from the Izumibaru site, Shimohagimine site, and Kamiyokino site, located in the northern part of Tanegashima Island (Fig. 4). She analyzed 1098 pieces, 1080 pieces, and 3444 pieces of potsherds. The Izumibaru site dates mainly to the Middle Yayoi period. From the site, she successfully identified eight potsherds with impressions. Two of them were rice impressions (Fig. 5). Four of them were unknown seeds, one had a wood chip, and the other had possible



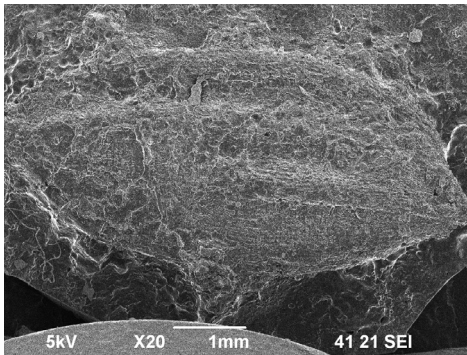


Fig. 5: A rice replica found from the Izumibaru site.

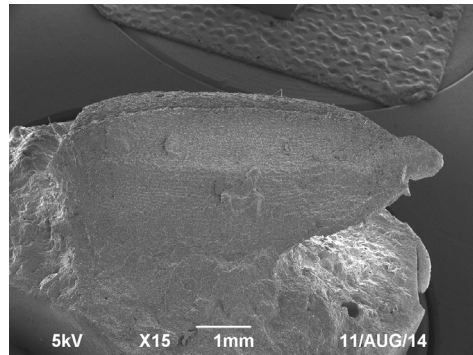


Fig. 6: A rice replica found from the Shimohagimine site.

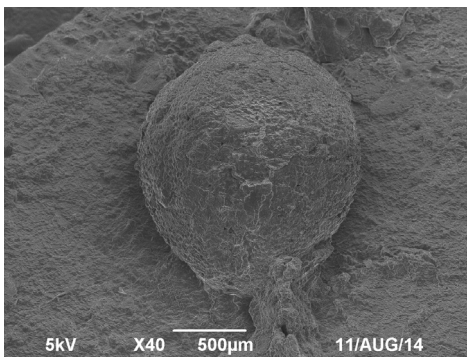


Fig. 7: A foxtail millet replica found from the Shimohagimine site.

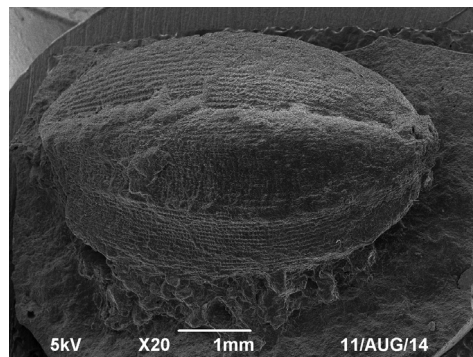


Fig. 8 A rice replica found from the Kamiyokino site.

leaf fragments. The Shimohagimine site dates to the Middle Yayoi period. Three potsherds with impressions were recognized. One was with rice (Fig. 6), the other was with foxtail millet (Fig. 7), and the third was with a possible beetle. The Kamiyokino site is dated to the Middle Yayoi and the late Kofun period. Three potsherds, dating to the late Kofun period, exhibit plant impressions. Two were rice (Fig. 8), and the third could not be identified.

The analysis demonstrates that people on the island knew rice and foxtail millet by the Middle Yayoi to the late Kofun period. The question is whether rice and foxtail millets were cultivated on the island or imported from nearby Kyushu. While NAKAMURA (2015) considers the possibility that this was a result of exchange, she thinks that rice and foxtail millets were cultivated on the island for the following two reasons. First, the fact that rice was more or less constantly recovered from the Middle Yayoi to Kofun period potsherds indicates that rice was likely an important plant food. Second, according to NAKAMURA (2015), among these rice- and foxtail millet-impressed potsherds, only one piece was introduced from Kyushu, and other potsherds were locally manufactured. This also suggests that food production was practiced on the island.

The following pieces of information support NAKAMURA's conclusion: As mentioned above, carbon and nitrogen isotope analysis of human bones from the Hirota site indicated the consumption of agricultural products, likely rice (ISHIDO 2014). Second, the so-called shoe-shaped axe was recovered from the Shimohagimine site. MITOMO et al. (1953 in

NAKAMURA 2015) felt that the shoe-shaped axe was used as a digging tool for dry field rice agriculture. Two other sites, the Atake cave site and the Izumibaru site, also yielded a shoe-shaped axe, which was dated to the Middle Yayoi period. Furthermore, as mentioned in the southern Kyushu section, agriculture diffused into mainland Kagoshima, including the Osumi peninsula, by the Early Yayoi period. The distance between the Osumi Peninsula and Tanegashima Island is approximately 40 km. Thus, it is most likely that food production was accepted on Tanegashima Island by the Middle Yayoi period.

### Central Ryukyu Cultural Region

The hypotheses presented in the earlier section imply that agriculture might have been practiced during prehistoric times. Flotation was conducted more intensively in this region than in the other two regions. Consequently, the timing of the transition from hunting, gathering, and fishing to agriculture has been elucidated. To examine the hypotheses presented above, archaeobotanical remains recovered from each period will be discussed here (TAKAMIYA and CHIDA 2014). See Table 1 for the relevant periods, Fig. 4 and Fig. 9 for site locations and Fig. 10 for major plant remains recovered from the respective sites.

#### *The Late 1 period*

The Takachikuchibaru Shellmidden is located on Okinawajima Island in Yomitan village. The  $^{14}\text{C}$  dates of the nut fragments were 375 -560 cal. AD and 115-425 cal. AD (2 $\sigma$ ) (TAKAMIYA and CHIDA 2014). Thus, the site is dated from Late 1 to early Late 2.

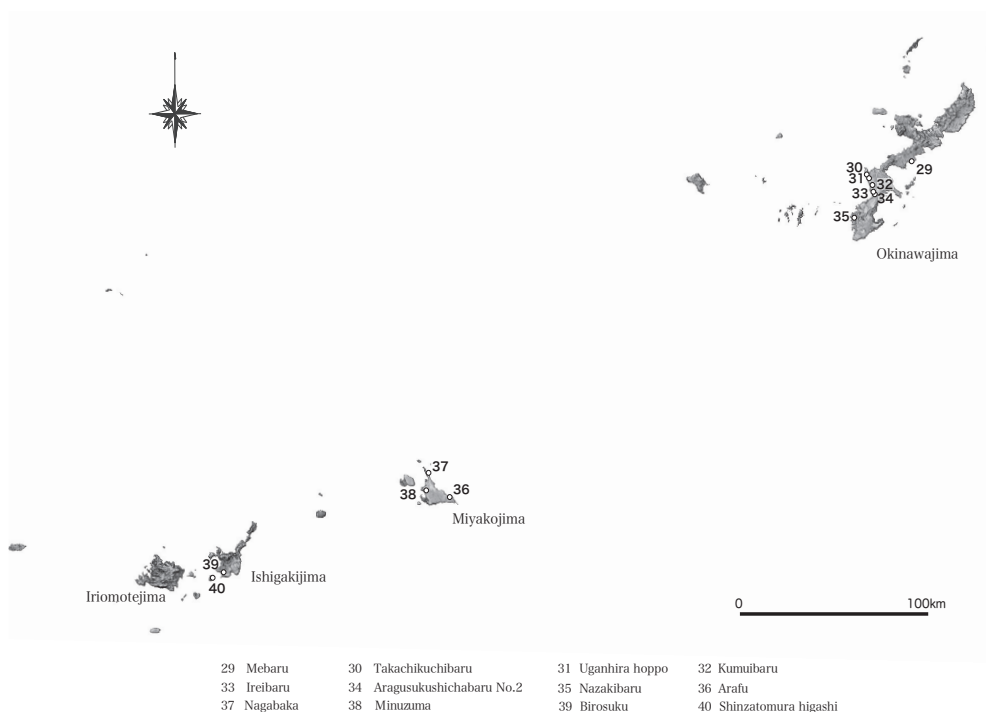


Fig. 9: Site locations mentioned in the text (in Okinawa prefecture).



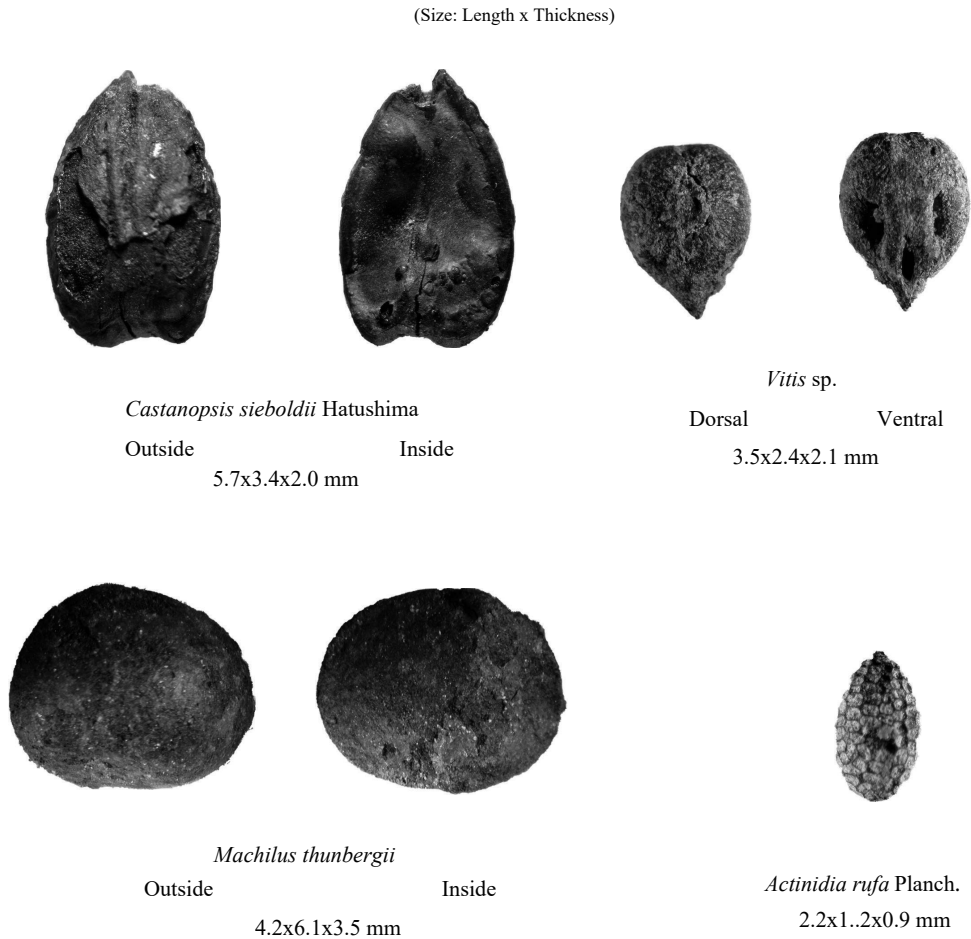


Fig. 10: Major plant remains identified from the Shellmidden sites.

Approximately 2,500 l of soil samples were collected for flotation. The application of flotation at the site resulted in recovery of the following plant remains: *Casatanopsis sieboldii* cotyledons, *Actinidia rufa*, many nut cotyledon fragments plus nut shells, *Machilus thunbergii* cotyledons, and *Vitis* (grape) species. No rice remains or other cultigens were recovered from this site.

#### *The Early 5 period*

The Sumiyoshi shellmidden on Okinoerabu Island ( $^{14}\text{C}$  dates on three nut cotyledons ( $2\sigma$ ): 1536-1435 cal. BC, 1430-1309 cal. BC, 1392-1212 cal. BC, TAKAMIYA and CHIDA 2014), the Tobaru site ( $^{14}\text{C}$  dates on a nut cotyledon ( $2\sigma$ ): 1014 -895 cal. BC, TAKAMIYA 2017), and the Kannate site (no  $^{14}\text{C}$  date, TAKAMIYA 2018a) on Tokunoshima Island are the Early 5 sites. These three sites also have yielded *Casatanopsis sieboldii* cotyledons, *Actinidia rufa*, many nut cotyledon fragments plus nut shells, *Machilus thunbergii* cotyledons, and *Vitis* (grape) species. Only plant remains of wild species have been obtained

from these sites.

#### *The Early 4 period*

The Kuzuri site on Kikaijima Island belongs to this period (TAKAMIYA 2018b). The  $^{14}\text{C}$  date of a possible *Machilus thumbergii* cotyledon is 1701-1625 cal. BC ( $2\sigma$ ). The site has yielded possible nut cotyledons, nut shells, *Machilus thumbergii* cotyledons, possible *Machilus thumbergii* cotyledon fragments, and *Actinidia rufa*. The Mebaru site on Okinawajima Island also belongs to this period (TAKAMIYA and CHIDA 2014). The  $^{14}\text{C}$  dates on wood charcoals are 2120-2080 cal. BC, 2190-1935 cal. BC, 2300-2140 cal. BC, 1305-1045 cal. BC and 1135-980 cal. BC ( $1\sigma$ ). The site is waterlogged, and the preservation of plant remains was excellent. Consequently, a large number of plant remains were obtained. The analysis revealed that more than 30 taxa were identified. The most conspicuous plant remains are nuts, especially *Quercus miyagi*. No cultivated plants were obtained from this site.

#### *The Early 3 period*

At the present time, there is no known site for this analysis, which only corresponds to the Early 3 period. The Omonawa No. 4 site, located on Tokunoshima Island, dates from the Early 3 to Early 4 periods, based on pottery typology (no  $^{14}\text{C}$  date, TAKAMIYA 2016). Only a small amount of soil samples was collected. Accordingly, the plant remains obtained are small in quantity. The identified plant remains are *Castanopsis sieboldii* cotyledons, nut cotyledon fragments, and possible nut shells. The results of the analysis indicate that the Omonawa No. 4 people were gatherers of wild plants. The Kamino site, located on Okinoerabujima Island, is contemporaneous with the Omonawa No. 4 site. Although flotation was not conducted, the site yielded *Machilus thumbergii* cotyledons (KAMIMURA 1984).

#### *The Early 2 period*

The Ireibaru site in Chatan Town on Okinawajima Island is a waterlogged site dating to this period. Several  $^{14}\text{C}$  data were collected. They are 4220-3995 cal. BC ( $1\sigma$ ) on *Pandanus* seed, 3915-3880 cal. BC ( $1\sigma$ ) and 3975-3925 cal. BC ( $1\sigma$ ) on *Castanopsis* cotyledons, 4250-4210 cal. BC ( $1\sigma$ ) and 3960-3915 cal. BC ( $1\sigma$ ) on carbide materials on potsherds, 3936-3877 cal. BC ( $1\sigma$ ) on nut cotyledons and 3945-3770 cal. BC ( $1\sigma$ ) on wild boar bone TSUJI, OHMATSU, and TSUJI (in TAKAMIYA and CHIDA 2014) conducted an archaeobotanical analysis. They identified at least 60 taxa. Numerous nut remains, such as *Quercus miyagi* and *Castanopsis* sp., have been recovered. The only cultigen obtained from the site is *Lagenaria siceraria* (bottle gourd) seeds. While a large amount of plant remains are obtained from the site, no rice or other cultigens are identified, except for *Lagenaria siceraria*.

#### *The Early 1 period*

The Aragusuku Shichabaru No. 2 site is located several kilometers north of the Ireibaru site (TAKAMIYA and CHIDA 2014). The site yielded finger-nailed pottery, which is the type

pottery of this period. Only one  $^{14}\text{C}$  date was obtained from a wild boar bone with a date of 5047-4911 cal. BC ( $1\sigma$ ). The site is a waterlogged site. Thus, plant remains were well preserved. The analysis successfully identified more than 30 taxa. They all belonged to wild species such as *Myrica rubra*.

Recently, archaeological sites older than 7000 years with pottery have been reported from the Central Ryukyus. The Hango site, located on Amami-oshima Island, has yielded potsherds dating back to more than 10,000 years ago. In this study because the site yielded pottery, the site is considered to belong to the Early 1 period (TAKAMIYA 2019). Flotation was conducted at the site, and numerous nut cotyledons, mostly *Castanopsis* sp., were obtained. The  $^{14}\text{C}$  dates of nut cotyledons from the site were 9445-9428 cal. BC ( $2\sigma$ ), 9463-9297 cal. BC ( $2\sigma$ ), 9296-9214 cal. BC ( $2\sigma$ ), and 9296-9218 cal. BC ( $2\sigma$ ). Since food production was not practiced even in Japan at around 9,200 BC, it is expected that the site would contain no cultigens. Indeed, no cultigen was recovered from the site.

#### *Short summary*

Archaeobotanical analysis conducted over the last three decades from sites dating from Early 1 to Late 1 yielded only wild plants, except bottle gourd from the Ireibaru site. The analysis suggested that, from Early 1 to Late 1, nuts were an important source of carbohydrates in this region, where several nut-bearing species are known. Furthermore, the agriculture hypotheses presented above (the New Ocean Road, the Ocean Road, the “Early 4”, Early 4, Early 5, and the Late 1 agriculture hypotheses; see Prehistoric Agricultural Hypotheses section for the difference between the “Early 4” and Early 4.) can be all rejected. Was food production introduced during the Late 2 period?

#### *The Late 2 period*

Plant remains were collected from several sites. The Omonawa No. 1 site is located near the Omonawa No.4 site mentioned above (TAKAMIYA 2016). The  $^{14}\text{C}$  dates on wood charcoal were 710-750 cal. AD and 770-890 cal. AD ( $2\sigma$ ). The site yielded *C. sieboldii* cotyledons and nut shells. Yomisaki, Arago, and Matsunoto on Amami-oshima Island are other Late 2 sites where flotation was conducted. Since many  $^{14}\text{C}$  datings were collected, we will not present each date here—only the collective results (TAKAMIYA and CHIDA 2014). The dates obtained were between the 5<sup>th</sup> and 7<sup>th</sup> centuries AD. *Castanopsis sieboldii*, *Machilus thumbergii*, and nut shells were obtained from the former two sites. No plant remains, including cultigens, were obtained from the Matsunoto site. Furthermore, archaeobotanical analysis was conducted at the Nagarabaru Higashi shellmidden on Iejima Island in the Okinawa archipelago (TAKAMIYA and CHIDA 2014). The site is contemporaneous with the four sites mentioned above. As expected, the shellmidden has yielded similar plant remains, such as *Castanopsis sieboldii* and *Machilus thumbergii* cotyledons. Thus, the series of archaeobotanical studies strongly suggest that people of the Late 2 also consumed wild plant resources. Then, when did agriculture begin in the Central Ryukyu region?

## The Beginning of Agriculture in the Central Ryukyu Region

### *The Amami Archipelago*

(Fig. 4 for site locations and Fig.11 for major cultigens recovered)

In 2002, TAKAMIYA (in TAKAMIYA and CHIDA 2014) had an opportunity to analyze plant remains recovered from flotation at the Akakina Gusuku site. Based on artifacts recovered from the site, the site was dated to the 12<sup>th</sup> to 13<sup>th</sup> centuries AD. The result of flotation was astonishing. While only six l of soil samples were processed by flotation, more than 200 plant remains were recovered. Interestingly, approximately 180 were rice. Other plant remains were barley and millet. The analysis demonstrated for the first time that during the Gusuku period, the subsistence economy in this region was agriculture.

Between 2006 and 2016, several late Shellmidden and initial Gusuku period sites were excavated, and soil samples for flotation were collected. These sites are the Gusuku site group on Kikaijima Island (TAKAMIYA and CHIDA 2014) and the Kawaminetsuji site (TAKAMIYA 2010) and the Nakagumi site (TAKAMIYA and CHIDA 2013) on Tokunoshima Island. The latter two sites yielded small amount of cultigens such as barley. The Gusuku site group consisted of eight sites, and soil samples were collected from four of these sites.

(Size: Length x Width x Thickness)

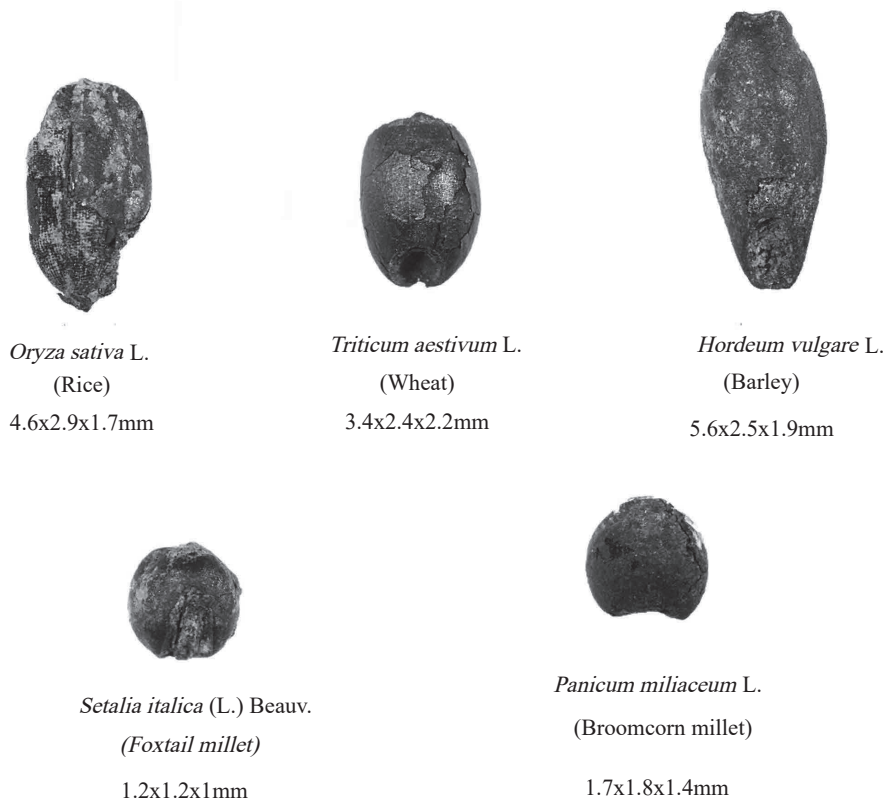


Fig. 11: Major plant remains identified from the Gusuku sites.

All these sites yielded cultigens, such as barley, wheat, rice, foxtail millet, and broomcorn millet. The result suggests that by this time period food production was the major subsistence economy in the Amami archipelago.

Three rice grains from the Akakina Gusuku site were  $^{14}\text{C}$  dated. The dates were between the 11<sup>th</sup> and 12<sup>th</sup> centuries AD. In addition, nine cultigen samples (rice, barley, wheat, and foxtail millet) from the Gusuku site group were also  $^{14}\text{C}$  dated. They belonged to between the 8<sup>th</sup> and 12<sup>th</sup> centuries AD. Thus, in the Amami archipelago, food production began sometime between the 8<sup>th</sup> and 12<sup>th</sup> centuries AD. The Maetari site, on Tokunoshima Island, also belongs to the initial Gusuku period. The site also unearthed cultigens, including foxtail millet, wheat, barley, and rice (TAKAMIYA 2018c). The  $^{14}\text{C}$  dates of cultigens, such as those on rice and barley grains, were from the 10<sup>th</sup> to 11<sup>th</sup> centuries AD.

### *The Okinawa Archipelago*

(See Fig. 9 for site locations)

Thanks to the introduction of flotation in the early the 1990s, the timing of the Okinawa archipelago's transition from hunting, gathering, and fishing to agriculture has been clearly understood. In the Okinawa archipelago and the Amami archipelago, the initial stage of the Gusuku period is characterized by the presence of Chinese white wares, steatite cauldrons, and *kamuiyaki* (gray stone ware). These dates range from the late 11<sup>th</sup> to the 12<sup>th</sup> centuries AD. The sites discussed below have yielded these three types of artifacts. They are all located on Okinawajima Island. The Yabumedabaru shellmidden is thought to belong to the late Shellmidden period to the initial Gusuku period (TAKAMIYA and CHIDA 2014). The site yielded foxtail millet, barley, wheat, and rice. The respective  $^{14}\text{C}$  dates of rice, wheat, and barley were 1018-1155 cal. AD ( $2\sigma$ ), 969-1045 cal. AD ( $2\sigma$ ), and 1024-1115 cal. AD ( $2\sigma$ ). The dates of cultigens were from the 10<sup>th</sup> to the 12<sup>th</sup> centuries AD. The Kumuibaru site is interpreted as the initial Gusuku period. At the site, a large number of soil samples were collected and processed by flotation (TAKAMIYA and CHIDA 2014). The site yielded rice, foxtail millet, wheat, barley, and broomcorn millet. In addition, foxtail millets, barley, and rice were  $^{14}\text{C}$  dated. They dated respectively 1031-1170 cal. AD ( $2\sigma$ ), 967-1040 cal. AD ( $2\sigma$ ), and 1062-1155 cal. AD ( $2\sigma$ ). These dates indicate that the cultigens can be dated to between the 10<sup>th</sup> and 12<sup>th</sup> centuries AD. Finally, the Uganhira-hoppo site, which is also thought to be the initial Gusuku period site, yielded cultigens (TAKAMIYA and CHIDA 2014). The site yielded rice, foxtail millet, wheat, and barley. Among them, rice, wheat, and barley were  $^{14}\text{C}$  dated. The dates obtained are respectively 1022-1155 cal. AD ( $2\sigma$ ), 990-1057 cal. AD ( $2\sigma$ ), 1022-1155 cal. AD ( $2\sigma$ ). Thus, they indicated that agriculture began in the Okinawa archipelago between the 10<sup>th</sup> and 12<sup>th</sup> centuries AD.

### *Short Summary*

A series of archaeobotanical research conducted in the Central Ryukyu has demonstrated that agriculture centered around foxtail millet, wheat, barley, and rice began in this region between the 8<sup>th</sup> and 12<sup>th</sup> centuries AD. As presented in the previous section, no cultigens were found from the Shellmidden period (more precisely, before the 7<sup>th</sup> century

AD), except for bottle gourd. The analysis showed that food production was rather abruptly introduced into the Central Ryukyu region. The fact that the dates of cultigens in the Amami archipelago were the 8<sup>th</sup> to 12<sup>th</sup> centuries AD, and those in the Okinawa archipelago were between the 10<sup>th</sup> and 12<sup>th</sup> centuries AD strongly suggests that food production began in the Amami archipelago and then spread to the Okinawa archipelago 100 to 200 years later. While recovered grains were not directly <sup>14</sup>C dated, the Nazakibaru site (estimated dates of the 9<sup>th</sup> to 10<sup>th</sup> centuries AD), in Okinawajima Island, also yielded foxtail millet, rice, barley, and wheat (TAKAMIYA 1996). This suggests that food production spread almost spontaneously in the Amami and Okinawa archipelagos.

### The Beginning of Agriculture in the Southern Ryukyu Cultural Region

(See Table 1 for Chronology, Fig. 9 for site locations)

Archaeobotanical research has not been conducted as intensively as in the Central Ryukyu cultural region. Flotation has been conducted at only two prehistoric sites. The Arafu site on Miyakojima Island is dated to the non-pottery period (TAKAMIYA 2003). The flotation yielded no cultigens—only small amount of grass seeds. The Nagabaka site is also located on Miyakojima Island. According to HUDSON (2014), who excavated the site, the site dates ca. 4,000 years ago to the non-pottery period. The analysis of plant remains has not been completed yet. However, prehistoric samples examined so far do not contain any plant remains. According to SHIMABUKURO (2011), no cultigens have been unearthed from the Shimotabaru and non-pottery periods in Yaeyama arcipelago.

The non-pottery period ends with the introduction of Chinese white wares, steatite cauldrons, and *kamuiyaki* (gray stone ware) (which date ca. late 11<sup>th</sup> to the early 12<sup>th</sup> centuries in Central Ryukyus). The end of the non-pottery period simultaneously signifies that the Central and Southern Ryukyu cultures united for the first time at the beginning of the new era, the Gusuku period. It should be remembered that, as we have seen, these three sets of artifacts are associated with cultigens in the Central Ryukyus. The initial Gusuku period in the Yaeyama archipelago is called the Shinzato mura period (12<sup>th</sup>-13<sup>th</sup> centuries AD). While no flotation has been carried out, some Shinzato mura period sites, such as the Shinzato mura higashi and Birosuku, have yielded rice and *mugi* (i.e., barley or wheat in Japanese). Rice phytoliths have been reported from the Birosuku site (ISHIGAKI SHI SOMUBU SHISHI HENSHUSHITSU 2009). These pieces of information suggest that agriculture spread to the South Ryukyu cultural region at the beginning of the Shinzato mura period (PEARSON 2013).

Recently, both flotation and impression replica analyses were conducted at the Mizunuma site on Miyakojima Island. The soil samples for flotation were collected from a hearth, and dates were estimated to be between the 11/12<sup>th</sup> and 15<sup>th</sup> centuries AD. The flotation process successfully recovered more than 300 carbonized seeds. They are foxtail millet (109), barley (90), wheat (31), *mugi* (barely or wheat (53)), and Fabaceae (16). Fabaceae possibly belonged to the adzuki group. In addition, a small amount of rice (6) was identified (CHIDA 2015, MANABE et al. 2019). According to MANABE et al. (2019), the <sup>14</sup>C dates are as follows: barley 1272-1309 cal. AD, 1338-1397 cal. AD, wheat 1297-1373 cal.



AD, 1279-1318 cal. AD. The cultigens date between the 13<sup>th</sup> and 14<sup>th</sup> centuries AD.

MANABE et al. (2019) conducted the impression replica method on 1537 potsherds, dating to the 12<sup>th</sup> to 14<sup>th</sup> centuries AD. Among these potsherds, 83 had an impression. The impressions totaled 151. The identification of these impressions revealed that they were mostly foxtail millet (almost 80%), followed by barley, wheat, and *mugi*. In addition, broomcorn millet, adzuki group, and rice were identified. As implied by the flotation analysis, all five important crops (rice, wheat, barley, foxtail millet, and broomcorn millet) were also identified by impression replica analysis. Thus, the people of the Minuzuma site grew these crops at least by the 12<sup>th</sup> to 14<sup>th</sup> centuries AD. While paleoethnobotanical studies have just begun in the South Ryukyu cultural region, the above analysis indicates that agriculture was practiced in this region from the 12<sup>th</sup> to 14<sup>th</sup> centuries AD. Since the three sets of artifacts (Chinese white wares, steatite cauldrons, and *kamuiyaki*) have been reported at several sites in this region, it strongly suggests that food production was the major subsistence economy in the South Ryukyu cultural region at this time.

## Discussion and Conclusions

The origin of agriculture in the Ryukyu archipelago has been vigorously discussed among researchers for more than fifty years. While it can be understood that agricultural origins have been vigorously discussed in this region, it can also be interpreted that this “vigorousness” had emerged as a result of an inadequate amount of archaeobotanical data. Indeed, most hypotheses presented in this paper are based on secondary data. Secondary data in this paper means data, which might imply the presence of agriculture, such as the presence of Yayoi pottery and site locations that might be suitable for agriculture. These pieces of data are not decisive in stating the presence of agriculture, although they might hint at the presence of agriculture. To understand agricultural origins, we need direct data, such as cultigens with precise dating, impression of cultigens in/on potsherds, and/or ancient paddy fields. For the last three decades, direct data have accumulated in this region, mainly owing to the introduction of flotation and impression replica analyses.

The results of the impression replica analysis conducted at three sites dating to the Middle Yayoi and Kofun periods in the Northern Ryukyu cultural region have elucidated that rice and foxtail millets were cultivated by the Middle Yayoi and continuously to the Kofun periods. This analysis revealed that agriculture was practiced in the Northern Ryukyu cultural region prior to the 7<sup>th</sup> century AD, revealing that agriculture was practiced earlier than historically acknowledged. Because more archaeological excavations were conducted in the Central Ryukyu cultural region compared to the Northern and Southern Ryukyu cultural regions, at least six Shellmidden agriculture hypotheses have been proposed. The application of flotation in this region has shed light on the timing of the transition from hunting, gathering, and fishing to agriculture. Agriculture was practiced in the Amami archipelago between the 8<sup>th</sup> and 12<sup>th</sup> centuries AD and in the Okinawa Archipelago between the 10<sup>th</sup> and 12<sup>th</sup> centuries AD. In the South Ryukyu cultural region, paleoethnobotanical research has just been launched. While traditional archaeological approaches in this region

(based on artifacts, i.e., secondary data) have suggested the possible presence of agriculture during the Shimotabaru and/or the non-pottery period, recent applications of flotation and impression replica analyses strongly suggest that agriculture was introduced into this region for the first time around the 12<sup>th</sup> and 14<sup>th</sup> centuries AD. While ISHIDO's (2014) hypothesis has been confirmed, other prehistoric agriculture hypotheses proposed based on secondary data from the Central and Southern Ryukyus have been rejected, including the famous Ocean Road and New Ocean Road hypotheses.

Applications of flotation (and the <sup>14</sup>C dating of cultigens) and impression replica analyses shed light on several important aspects of agricultural origin in the archipelago in addition to the timing of the origin. Firstly, while the hypotheses mentioned in this paper argued for the presence of agriculture, four of them speculate from where agriculture was introduced: the Ocean Road and New Ocean Road hypotheses from the south; the "Early 4" and Late 1 from the north. In contrast to the two "southern" route hypotheses, which predicted that agriculture (wet and dry field rice agriculture) was introduced to mainland Japan from southern China/Taiwan or Southeast Asia via the Ryukyu archipelago, agriculture in the Ryukyu archipelago was diffused from north to south. In that, the "northern" route was correct. However, the timing of the introduction from the north was wrong. Yayoi agriculture began ca. 9<sup>th</sup> BC in northern Kyushu, and then it spread into southern Kyushu by the 7<sup>th</sup> BC. By the Middle Yayoi, it reached the Northern Ryukyu cultural region, and this Middle Yayoi agriculture continued to be practiced there in the succeeding Kofun and historical periods. It then advanced into the Amami archipelago by ca. the 8<sup>th</sup> to 12<sup>th</sup> centuries AD. Immediately after it reached the Amami archipelago, it expanded into the Okinawa archipelago (the 10<sup>th</sup> to 12<sup>th</sup> centuries AD) probably within 100-200 years (or if the Nazakibaru data is acceptable, it spread within 100 years). Finally, within the next 100-200 years, agriculture was established in the Southern Ryukyu cultural region (the 12<sup>th</sup> to 14<sup>th</sup> centuries AD). Thus, recent studies have clearly demonstrated that agriculture spread from north to south in the Ryukyu archipelago.

Applications of flotation and impression replica analyses have revealed that hunters, gatherers, and fishers lived in the Central Ryukyu cultural region at least from ca. 7,000 years ago (or 11,000 years ago, if we include the Hango site) to 1,000 years ago. This is an extremely important finding from this region. Many islands in the world were colonized by agriculturalists, including all the Mediterranean and most Caribbean and Oceanian islands. Only a handful of islands were colonized by hunter-gatherers. These islands are characterized by 1) large islands, 2) being located close to a continent or another large island, 3) availability of sea mammals, 4) translocation of edible plants and animals from the motherland to the island, or 5) a combination of 1)-4) (TAKAMIYA et al. 2016). None of these applies to Central Ryukyu. Furthermore, recent findings of Paleolithic sites in this region suggest the possibility of hunter-gatherer habitation on the islands since ca. 30,000 years ago. This would contribute brand new information to human history and world history.

In the future, at least two issues must be examined. First, the Northern Ryukyu cultural region accepted agriculture almost immediately after the Yayoi culture spread into southern Kyushu. Why did they accept agriculture so fast? It took several centuries until it reached



the Amami and Okinawa archipelagos. While the Amami and Okinawa people knew of the presence of rice agriculture by the Middle Yayoi period, why did they not accept it until ca. the 8<sup>th</sup> to 12<sup>th</sup> centuries AD? Furthermore, agriculture diffused to the Amami and Okinawa archipelago almost simultaneously, and it spread within 100 to 200 later to reach the Southern Ryukyu cultural region. Why did it spread almost concurrently in the Central and Southern Ryukyu cultural regions?

The second issue is the subsistence economy of the Southern Ryukyu cultural region. Based on flotation and impression replica analyses, it is certain that agriculture was introduced into this region by the 12<sup>th</sup> to 14<sup>th</sup> centuries AD. How about the subsistence economy during the prehistoric times (the Shimotabaru and non-pottery periods)? The results of flotation at the two sites (Arafu and Nagabaka sites) imply no evidence of cultigens. Is this true or just a result of insufficient research there? If people consume cultigens, applications of flotation will reveal this economy. Or, have root crops played a significant role there? If so, the starch analysis could indicate the presence or absence of root crop consumption. Similar to the Central Ryukyu cultural region, did hunters, gatherers, and fishers sustain themselves in the small islands? If this is the case, it will shed very important light on the life of *Homo sapiens* on small islands. In any case, the studies on the subsistence economy in the Ryukyu archipelago will greatly contribute to the nature of our species, *Homo sapiens*, in addition to the elucidation of the cultural history of the archipelago.

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### References

- BAR-YOSEF, O. 2011. Climatic Fluctuation and Early Farming in West and East Asia. *Current Anthropology*, 52 Supplement 4: S175-S193.
- CHIDA, H. 2015. *Miyakojima no Gusuku Jidai Noko Shiron* (A Hypothesis on the Miyakojima Island Gusuku Period Agriculture). In: Ima Miyako no Kokogaku ga omoshroi! Mudoki-ki kara Gusukujidai eno Utsuri Kawari Okinawa Koko Gakkai 2015 Nendo Kenkyu Happyou Shiryo (Ed. Okinawa Koko Gakkai), 52-59. Okinawa Koko Gakkai, Nishihara Cho, Okinawa, Japan (in Japanese).
- CRAWFORD, G. W. 1983. Paleoethnobotany of the Kameda Peninsula, Jomon. 200 pp., University of Michigan Press: Ann Arbor, USA.
- CRAWFORD, G. W. and YOSHIZAKI M. 1987. Ainu Ancestors and Prehistoric Asian Agriculture. *Journal of Archaeological Science*, 14: 201-213.
- GRAYSON, K. D. 1984. Quantitative Zooarchaeology: topics in the analysis of archaeological

- faunas. 202 pp., Academic Press, London, UK.
- HASHIMOTO, T. 2012. *Kofun Chikuzo Shuen Chiiki ni okeru Kyokaikeisei-Nangen Shakai to Kokka Keisei* (The Formation of the Boundary in the Peripheral Regions during the Kofun Building Times-the Southern Boundary Society and the State Formation). *Kokogaku Kenkyu*, 58(4) : 17-31 (in Japanese).
- HISA, Y., and KATATA, M. 2005. *Doki Akkon Repurika-ho ni yoru Tensha Sagyo no Tebiki* (A Guide Book for Transcriptions of Pottery Impression Replicas). Fukuoka Shi Maizo Bunkazai Senta, Fukuoka Shi, Japan (in Japanese).
- HUDSON, M. 2014. *Sakishimani okeru Senshijidai no Hito to Seitaishi-Miyakojima Nagabakai Iseki wo Chushin ni* (Prehistoric Human and Ecological History in the Sakishima Archipelago: focusing on the Nagabaka site, Miyakojima Island). In: *Ryukyu Retto Senshi/Genshi Jidai no Kankyo to Bunka no Hensen* (Eds. TAKAMIYA, H. and SHINZATO, T.), 181-194, Rokuichi Shobo, Tokyo, Japan (in Japanese).
- ISHIDO, K. 2014. *Osumishoto no Senshi Bunka ni mirareru Seigyo no Tokucho to Hensen* (Subsistence Economy and its Change in the Prehistoric Cultures in the Osumi Archipelago). In: *Ryukyu Retto Senshi/Genshi Jidai no Kankyo to Bunka no Hensen* (Eds. TAKAMIYA, H. and SHINZATO, T.), 159-170, Rokuichi Shobo, Tokyo, Japan (in Japanese).
- ISHIGAKI SHI SOMUBU SHISHI HENSHUSHITSU 2009. *Mudoki kara Yudoki e* (From Non-Pottery to Pottery). Ishigaki Shi Kokogaku Bijuaru Ban 4. 70 pp., Ishigaki Board of Education, Ishigaki Shi, Japan (in Japanese).
- ITOH, K. 2007. *Kaizuka Jidai ni okeru Nokomondai Kenkyu shi* (History of the Origins of Agricultural Issues during the Shellmidden Period). *Nanto Koko*, 26: 97-120 (in Japanese).
- ITOH, S. 1993. *Ryukyu Jomon Bunka no Wakugumi* (A Framework of the Ryukyu Jomon Culture). *Nanto Koko*, 13: 19-34 (in Japanese).
- KAMIMURA, T. 1984. *Nanseishoto Senshi-jidai ni okeru Kokogaku teki Kiso Kenkyu* (The Fundamental Archaeological Research on Prehistoric Southwest Islands). 132 pp., Kagoshima University, Kagoshima Shi, Japan (in Japanese).
- KANASEKI, T. 1955. *Yaeyama-gunto no Kodai Bunka* (The Ancient Culture of the Yaeyama Archipelago). *Minzokugaku Kenkyu*, 19(2): 107-141 (in Japanese).
- KAWAGUCHI, M. 2002. *Minami Kyushu ni okeru Inasaku bunka to Mokuseihin-saishin no chosa seika kara* (Rice Agriculture and Wooden Tools in the Southern Kyushu-Latest Excavation Results). *Gekkan Bunkazai*, 11: 38-43 (in Japanese).
- KUWAHATA, M. and YOKOYAMA, A. 2000. *Inasaku bunka wa Minami Kyushu ni Dou Hiromattaka- Miyazaki Ken Nairikubu no Isekikara* (How Rice Agriculture Spread into the Southern Kyushu-From Inland Sites in Miyazaki Prefecture), *Rekishu Kyushu*, 11: 2-10 (in Japanese).
- MANABE, A., and OBATA, H. 2011. *X sen CT ni yoru Senzai Akkon no Kenshutsu* (Detection of Unexposed Impressions by X Ray CT). *Nihon Shokuseishi Gakkai Dai 26 Kai Taikai Koen Yoshi-shu*, 82-82 (in Japanese).
- MANABE, A., CHIDA, H., KUGAI, M., and OBATA, H. 2019. *Miyako shi Minuzuma Iseki*

- Shutsudo Gusuku Doki no Akkon Seika* (Results of the Survey of the Impressions on the Gusuku Pottery Found in Minuzuma Site in Miyako City). Nanto Koko, 38: 51-66 (in Japanese).
- MIYAMOTO, K. 2018. *Yayoijidai Kaishiki no Jisunendai Sairon* (Reconsideration of the Actual Dates of the Beginning of the Yayoi Period). Kokogaku Zasshi, 100(2): 1-27 (in Japanese).
- MIYAMOTO, K. 2019. *Soron Yayoi Jidai no Hajimari* (General Remarks on Several Issues about the Beginning of the Yayoi Period). Kokogaku Janaru 729: 3-4 (in Japanese).
- NAKAMURA, N. 2015. *Tanegashima Doki Akkon Chosa kara mita Yayoi/Kofun Jidai Heikouki no Shokuyo Shokubutsu* (The Food Plants during the Yayoi and the Kofun Parallel Periods as Seen from Tanegashima Island Potsherds Impression Analysis). In: Archaeology from the South 3 HONDA MICHITERU Sensei Taishoku Kinen Ronbunshu (Ed. by HONDA MICHITERU Sensei Taishoku Kinen Jigyokai), 161-168, HONDA MICHITERU Sensei Taishoku Kinen Jigyokai, Kagoshima, Japan (in Japanese).
- NAKAMURA, N., MANABE, A., OHNISHI, T., SANGAWA, T., FUKUI, T., and KUWAHATA, M. 2013. *Miyakonojo shi ni okeru Doki Akkon no Chosa-Saibai Shokubutsu no Donyu ni kanrenshite-* (Potsherds Impression Analysis in Miyakonojo City-The Introduction of Cultivated Plants). Miyazaki Koko, 24 (bottom):15-29 (in Japanese).
- NAKAYAMA, S. 2010. *Shokubutsu Koko Gaku to Nihon no Noko no Kigen* (Archaeobotany and the Origins of Agriculture in Japan). Doseisha, Tokyo, Japan (in Japanese).
- NAKAYAMA, S. and KAIMON, T. 2009. *Yamanashiken Meotoishi Iseki no Jomon Jidai Chuki no Mame Akkon* (Bean Impressions Observed in the Middle Jomon Meotoishi Site, Yamanashi Prefecture). Yamanashi Koko Gaku Ronshu, 4: 43-61 (in Japanese).
- NAKAZAWA, M. 2005. *Sanin Chiho ni okeru Jomon Jidai no Shokubutsushitsu Shokuryo ni tsuite: Saibai Shokubutu no Mondai wo Chushin ni* (On Plant Food Consumed during the Jomon Period in the Sanin Region, Mainly Focusing on Cultigens). In: Dai 16 Kai Chugoku/Shikoku Jomon Kenkyukai Happyo Shiryoushu Jomon Banki no Sanin Chiho (Ed. Chu/Shi Jomon Kenkyukai), pp. 119-130. Chu/Shi Jomon Kenkyukai, Yonego, Japan (in Japanese).
- NITTA, J. 1969. *Saikin no Okinawa ni okeru Koko Gakkai no Doko* (Recent Trends in the Archaeology of Okinawa). Ryukyu Shigaku, 1: 61-70 (in Japanese).
- OBATA, H. 2016. *Tane wo Maku Jomon-jin* (The Jomon People who Sowed Seeds). 217 pp., Yoshikawa kobunkan, Tokyo, Japan (in Japanese).
- OBATA, H., MANABE, A., NAKAMURA, N., ONISHI, T., and SENBA, Y. 2011a. A New Light on the Evolution and Propagation of Prehistoric Grain Pests: the world's oldest maize weevils found in Jomon potteries, Japan. PLoS ONE (<http://www.plosone.org>).
- OBATA, H., HA, I-S., and MANABE, A., 2011b. *Tosando Kaizuka Hakken no Kankoku Saiko no Kibi Akkon* (The Oldest Millet Impressions Found from the Dongsam-dong Shell-Midden). Nihon Shokuseishi Gakkai Dai 26 Kai Taikai Koen Yoshi Shu, 39-40 (in Japanese).
- OBATA, H., SASAKI, Y., and SENBA, Y. 2007. *Doki Akkon karamita Jomonjidai Ko/Banki niokeru Kyushu no Daizu Saibai* (Cultivation of Soya Bean as Seen from the Late and

- Final Jomon Potsherd Impressions). *Shokuseishi Kenkyu*, 15(2): 97-114 (in Japanese).
- O'CONNOR, T. 2008. *The Archaeology of Animal Bones*. 206 pp., Texas A&M Press Sutton Publishing, College Station, USA.
- OKINAWA KOKO GAKKAI (Ed.) 2018. *Nanto Koko Nyumon* (An Introduction to the Archaeology of the Southern Islands). Bodainku, Naha, Japan.
- OHNISHI, T., MANABE, A., SANGAWA, T., KANEGAE, K. and NAKAMURA, N. 2012. *Bisho-shoibutsu/bisho-kon-ato no Bunsekini motozuku Shokuyo Shokubutu no Chosa-tokuni SLW deno torikumi wo chushin ni* (A Study on Edible Plants Based on the Analyses of Micro-Artifacts and Micro-Imprints). *Kagoshima Koko*, 42: 99-108 (in Japanese).
- PEARSON, R. 2013. *Ancient Ryukyu*. 396 pp., University of Hawaii Press, Manoa, USA.
- SASAKI, K. 2003. *Minami karano Nihon Bunka* (Japanese Cultural Elements That were Introduced from the South). 296 pp., NHK books, Tokyo, Japan (in Japanese).
- SATO, Y. 1992. *Ine no Kita Michi* (Tracing the Route of Rice). 166 pp., Shokabo, Tokyo, Japan (in Japanese).
- SHIMABUKURO, A. 2011. *Sakishima Shoto no Senshijidai-Yaeyama Shoto wo Chushin ni* (Prehistory of the Sakishima Archipelago, Mainly Focusing on the Yaeyama Archipelago) In: *Senshi/Genshi Jidai no Ryukyu Retto-hito to keikan* (Eds. TAKAMIYA H. and ITOH, S.), 267-289. Rokuichi Shobo, Tokyo, Japan (in Japanese).
- SHIMOYAMA, S. 1995. *Kokogaku kara mita Hayato no Seikatsu-'Hayato' Mondai to Tembo* (The Life Ways of the Hayato as seen from Archaeology-Questions and Prospects on the Hayato). In: *Saikai to Nanto no Seikatsu/Bunka* (Ed. SHINKAWA, T.), 169-199, Meicho Shuppan, Osaka, Japan (in Japanese).
- SHINZATO, T. 2014. *Ryukyu Retto no Senshijidai Meisho to Jidai kubun* (Period Names and Period Divisions in the Prehistoric Ryukyu Archipelago). In: *Ryukyu Retto Senshi/Genshi Jidai no Kankyo to Bunka no Hensen* (Eds. SHINZATO, T. and TAKAMIYA, H.), viii-xii, Rokuichi Shobo, Tokyo, Japan (in Japanese).
- STRUEVER, S. 1968. Flotation Techniques for the Recovery of Small-Scale Archaeobotanical Remains. *American Antiquity*, 33(3): 353-362.
- TAKAMIYA, HIROE 1985. *Okinawa no Iwayuru Koki Iseki ni tsuite-Yayoi Bunka tonon Kanren ni oite* (So called the Late Period Sites in Okinawa-Relation with Yayoi Culture). In: *Nihonshi no Reimei* (Ed. YAWATA, I.), 311-333, Rokko Shuppan, Tokyo, Japan (in Japanese).
- TAKAMIYA, HIROTO 1993. *Senshi Jidai no Okinawa honto ni okeru Hito no Tekio Katei* (Adaptation Processes of *Homo sapiens* to Prehistoric Okinawajima Island). *Kobunka Danso*, 30: 1089-1107 (in Japanese).
- TAKAMIYA, HIROTO 1996. *Kodai-minzokushokubutsu gaku teki apurochi ni yoru Nazakibaru Iseki no Seigyō* (The Subsistence Economy of the Nazakibaru Site, based on Paleoethnobotanical Approach). In: *Nazakibaru Iseki* (Ed. The Naha City Board of Education), 83-100, The Naha City Board of Education, Naha Shi, Japan (in Japanese).
- TAKAMIYA, HIROTO 2003. *Arafu Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Arafu Site). In: *Arafu Iseki Chosa Kenkyu I* (Ed. Arafu Iseki Hakkutsu Chosadan), 105-106, Arafu Iseki Chosadan, Ginowan shi, Japan (in Japanese).

- TAKAMIYA, HIROTO 2010. *Kawaminetsuji Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Kawaminetsuji Site). In: Kawaminetsuji Hakkutsu Chosa Hokokusho (Ed. The Isen Town Board of Education), 77-79, The Isen Town Board of Education, Isen Cho, Japan (in Japanese).
- TAKAMIYA, HIROTO 2016. *Omonawa Dai 1 Kaizuka, Omonawa Dai 4 Kaizuka Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Omonawa No.1 Shellmidden and the Omonawa No. 4 Shellmidden). In: Omonawa Kaizuka Sokatsu Hokokusho (Ed. The Isen Town Board of Education), 140-141, The Isen Town Board of Education, Isen Cho, Japan (in Japanese).
- TAKAMIYA, HIROTO 2017. *Tobaru Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Tobaru Site). In: Tobaru Iseki (4) (Ed. The Amagi Town Board of Education), 77-86, The Amagi Town Board of Education, Amagi Cho, Japan (in Japanese).
- TAKAMIYA, HIROTO 2018a. *Kannate Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Kantena Site). In: Maeatari Iseki/Kannate Iseki (Ed. The Isen Town Board of Education), 117-119, The Isen Town Board of Education, Isen Cho, Japan (in Japanese).
- TAKAMIYA, HIROTO 2018b. *Kuzuri Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Kuzuri Site). In: Kuzuri Iseki (Ed. The Kikai Town Board of Education), 122-132, The Kikai Town Board of Education, Kikai Cho, Japan (in Japanese).
- TAKAMIYA, HIROTO 2018c. *Maeatari Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Maeatari Site). In: Maeatari Iseki/Kannate Iseki (Ed. The Isen Town Board of Education), 61-70, The Isen Town Board of Education, Isen Cho, Japan (in Japanese).
- TAKAMIYA, HIROTO 2019. *Hango Iseki (dai 2 ji chosa) Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Hango <the second investigation> Site). In: NAKAYAMA KIYOMI to Amami-gaku NAKAYAMA KIYOMI-shi Tsuito Ronbun shu (Ed. Amami Koko Gakkai), 485-492, Amami Koko Gakkai, Kagoshima Shi, Japan (in Japanese).
- TAKAMIYA, HIROTO In Press. *Ukikunden Iseki Shutsudo no Shokubutu Itai* (Plant Remains Recovered from the Ukikunden Site). In: Ukikunden Iseki (Ed. MIYAMOTO, K.), Kyushu University, Fukuoka Shi, Japan (in Japanese).
- TAKAMIYA, H. and CHIDA, H. 2013. *Nakagumi Iseki kara Kenshutsu sareta Shokubutsu Itai* (Plant Remains Recovered from the Nakagumi Site). In Nakagumi Iseki: (Ed. The Amagi Town Board of Education), 46-50, The Amagi Town Board of Education, Amagi Cho, Japan (in Japanese).
- TAKAMIYA, H. and CHIDA, H. 2014. *Ryukyu Retto Senshi/Genshi Jidai ni okeru Shokubutsu Shoku Riyo-Amami Okinawa Shoto wo Chushin ni* (Plant Foods during the Prehistoric and Protohistoric periods in the Ryukyu Archipelago, Focusing on the Amami and Okinawa Archipelagos). In: Ryukyu Retto Senshi/Genshi Jidai no Kankyo to Bunka no Hensen (Eds. TAKAMIYA, H. and SHINZATO, T.), 127-142, Rokuichi Shobo, Tokyo, Japan (in Japanese).

- TAKAMIYA, H., KATAGIRI, C., YAMASAKI, S. and FUJITA M. 2019. Human Colonization of the Central Ryukyus (Amami and Okinawa Archipelagos), Japan. *The Journal of Island and Coastal Archaeology*, 14(3): 375-393.
- TAKAMIYA, H., HUDSON M., YONENOBU H., KUROZUMI T. and TOIZUMI T. 2016. An Extraordinary Case in Human History: prehistoric hunter-gatherer adaptation to the islands of the Central Ryukyus (Amami and Okinawa archipelagos), Japan. *The Holocene*, 26(3)408-422.
- TOZAWA, M. 1982. *Jomon Noko Ron* (An Essay on Jomon Agriculture). In: *Nihon no Kokogaku wo Manabu* (2) Genshi • Kodai no Seisan to Seikatsu (Eds. OHTSUKA, H., TOZAWA, M. and SAHARA, M.), 173-191. Yuhikaku Sensho, Tokyo, Japan (in Japanese).
- USHINO, T. and TAGAWA H. 1991. *Repurika-ho niyoru Doki Akkon no Kansatsu* (An Examination of Pottery Impression by the Replica Method). *Kokogaku to Shizen Kagaku*, 24: 13-36 (in Japanese).
- WATANABE, H. 1968. Subsistence and Ecology of Northern Food Gatherers with Special Reference to the Ainu. In: *the Man the Hunter* (Eds. LEE R. and Devore, I.), 69-77, Aldine publishing Co., Chicago, USA.
- WATSON, P. J. 1976. In Pursuit of Prehistoric Subsistence: A Comparative Account of Some Contemporary Flotation Techniques. *Midcontinental Journal of Archaeology*, 1(1): 77-100.
- YAMADA, G. and TSUBAKISAKA, Y. 2005. *Kita no Noko* (Agriculture in the North), In: *Yurashia no Noko-shi* (Eds. SATO, Y. and KIMURA, E.), 48-85, Rinsenshoten, Kyoto, Japan (in Japanese).
- YAMANOUCHI, S. 1967. *Sekkijidai Doki Teihenmen ni okeru Inamomi no Akkon* (Rice Impression Observed at the Bottom of Prehistoric Pottery). (originally 1925, but not published until 1967), In: YAMANOUCHI SUGAO: *Senshi/Kokogaku Ronbunshu*, 4: 207-208, Senshi Koko Gakkai, Tokyo, Japan (in Japanese).
- YAMASAKI, S. 2005. *Nishi Nihon Jomon Noko Ron* (Jomon Agriculture Hypotheses in Western Japan). In: *Keinan Bunkazai Kenkyuin/Kan/Nichi Shin Sekki Jidai to Noko Mondai* (Eds. Kankoku Shinsekki Gakkai/Kyushu Jomon Kenkyu Kai), 38-41, Keinan Bunkazai Kenkyuin/Kan/Nichi Shin Sekki Jidai to Noko Mondai, Hakata, Japan (in Korean and Japanese).
- YANAGITA, K. 1961. *Kaijo no Michi* (The Ocean Road). 328 pp., Iwanami Bunko, Tokyo, Japan (in Japanese).