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Did a cooling event in the middle to late Jomon periods induced change in the use of plant resources in Japan?

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ABSTRACT

In Japan management and use of plant resources around settlements can be detected since the early Jomon period starting at ca. 7300 cal BP. At least two arboreal species, *Castanea crenata* (chestnut) and *Toxicodendron vernicifluum* (lacquer tree), show clear records of management by the Jomon people. After the early Jomon period corresponding to the Holocene Climate Optimum, the sea level lowered and the climate cooled, and these changes must have affected geomorphology and vegetation around settlements. However, it is not known if the management and use of plant resources by the Jomon people changed with such changes in environment. From the middle to late Jomon periods corresponding to this phase, pollen records indicated change in dominant plants around settlements from *Castanea crenata* to *Aesculus turbinata* (horse chestnut). This change in vegetation was attributed to a cooling event at the beginning of the late Jomon period at ca. 4400 cal BP or to human management. To examine the influence of environmental changes on vegetation and plant use from the early to final Jomon periods, plant records at four previously studied sites in the Kanto plain, central Japan, were compared. The results revealed that plant use centered on *Castanea crenata* and *Toxicodendron vernicifluum* did not change through the periods, but became more multi-faceted after the late Jomon period with additions of such plants as *Aesculus turbinata* and *Quercus (Cyclobalanopsis)*.

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1. Introduction

The Jomon period is a Neolithic period in Japan that existed from 16,000–2500 cal BP, primarily characterized by manufacture of pottery, formation of pit dwellings, and lack of agriculture. Thus, the Jomon people has often been described as affluent hunter-gatherers or foragers (Habu, 2004; DK, 2016), and their subsistence system has been variously discussed from hunter-gatherer perspective to agriculturist perspective (Matsui and Kanehara, 2006; Crawford, 2008; Morgan et al., 2017). Various excavated animal and plant remains show that the Jomon people were proficient hunter-gatherers since the incipient to early Jomon periods (e.g., Sakazume, 1961; Tsuji et al., 2006; Toizumi, 2006). However, recent reviews on plant remains showed that the Jomon people managed and used plant resources around settlements at least since the early Jomon period (Noshiro and Sasaki, 2013, 2014). By reviewing his archaeobotanical studies in Hokkaido and studies on the Ainu subsistence system, Crawford (2008) placed the Jomon subsistence system in the middle ground between hunting and gathering and intensive agriculture and likened it to the "low-level food production" system proposed by Smith (2001). By comparing the use of plant resources around a Jomon site with that around a modern local village near the site, Nishida (1981, 1983) indicated existence of various levels in the management and use of plant resources that conceptually form concentric circles around settlements both in the Jomon and modern periods. Based on the study of weed associations from carbonized plant remains in Kameda peninsula of Hokkaido (Crawford, 1983), Crawford (1997) concluded that plant domestication and cultivation started by the end of the late Jomon period in northeastern Japan and that they were supported by anthropogenetic impact on environment. Crawford (2011) further argued, by citing occurrences of cultigens and putative ones such as *Echinochloa*, *Cannabis sativa, Lagenaria siceraria, Arctium lappa*, *Glycine*, *Vigna*, and *Toxicodendron vernicifluum* at Jomon sites, that the Jomon people produced not only food, but also various other resources and that "resource

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production" describes the Jomon subsistence better than "low-level food production". Thus, the Jomon people occupied a middle ground between hunter-gatherers and farmers and presents an interesting theme to the study of the historical development of subsistence systems.

In central to northeastern Japan intensive management and use of plant resources can be detected since ca. 7300 cal BP of the early Jomon period and continued to the final Jomon period (Noshiro and Sasaki, 2013, 2014). At least two arboreal species, *Castanea crenata* (chestnut) and *Toxicodendron vernicifluum* (lacquer tree), show clear records of management and use of plant resources by the Jomon people, and this trends continued till the end of the Jomon period at ca. 2500 cal BP (Noshiro, 2016). From the middle to late Jomon periods, however, palynologists detected increase of *Aesculus* pollen over *Castanea* pollen at several sites and argued that a climatic cooling in this period induced the replacement of *Castanea crenata* stands by *Aesculus turbinata* (horse chestnut) stands around settlements and a change in plant use from *Castanea crenata* to *Aesculus turbinata* (Kitagawa and Yasuda, 2004; Yoshikawa, 2008). In view of the resilienc theory, Habu (2015) argued that the cooling event in this period induced a decline in population and reliance on plant food at the Sannai-maruyama site in northern Japan and corresponded this decline to the release phae of the adaptive cycle. However, studies of plant macrofossils and wood remains used by the Jomon people did not indicate such change in plant use, and use of *Aesculus turbinata* apparently came to be added to that of *Castanea crenata* in the late to final Jomon periods (Sasaki et al., 2007). Fruits of *Aesculus turbinata* including saponin besides tannin require a complex processing before being used as food, and its fruit remains show that the Jomon people developed the processing technique in the middle to late Jomon periods. At the same time, the Jomon people began to construct wooden frames for various water uses in the lowland to be used for bleaching of *Aesculus turbinata* and other acrid fruits, processing of fiber materials, and manufacture of wooden tools (Figs. 3 and 16; Sasaki, 2007; Noshiro and Sasaki, 2013, 2014). Thus, to clarify such discrepancies in understanding plant use from the middle to late Jomon periods, we will review plant records at four previously studied sites in the Kanto plain, central Japan, and estimate the effect of environmental changes on vegetation and use of plant resources that occurred in these periods.

By comparing environmental events that occurred mostly in Japan and some from other areas during MS 1 of the postglacial, Kudo (2012) recognized five stages, PG Warm-1, PG Warm-2, PG Cold-1, PG Cold-2, and PG Cold-3, in the environmental history of the Kanto district. We will discuss changes in environment, vegetation, and use of plant resources from the early to final Jomon periods in the Kanto plain based on his scheme of environmental changes (Fig. 1).

During PG Warm-1 ranging from ca. 11,500 cal BP to ca. 8400 cal BP and corresponding to a rapid warming at the beginning of the postglacial, deciduous broadleaved forests of *Quercus (Lepidobalanus)* prevailed, but *Castanea crenata* became a major component in the latter half of this stage.

During PG Warm-2 ranging from ca. 8400 cal BP to ca. 5900 cal BP corresponding to the Holocene Climate Optimum, the sea level attained the highest level during the postglacial, called Jomon transgression in Japan, and lucidophyllous forests of *Quercus (Cyclobalanopsis)* expanded in the southern part and around the inner Tokyo bay, but deciduous broadleaved forests of *Quercus (Lepidobalanus)* spread in other areas.

During PG Cold-1 ranging from ca. 5900 cal BP to ca. 4400 cal BP when the sea level lowered after the Jomon transgression, *Castanea crenata* came to dominate in the upland areas, and wetland forests of *Alnus japonica* came to be established with *Aesculus turbinata* stands at their margins and in side valleys.

During PG Cold-2 ranging from ca. 4400 cal BP to ca. 2800 cal BP that started with a short cooling event, wetland forests of *Fraxinus mandshurica* and *Alnus japnoica* covered the lowland with *Aesculus turbinata* stands around them. *Castanea crenata* stands frequently existed on uplands or riverside slopes that were mostly covered by deciduous broadleaved forests of *Quercus (Lepidobalanus)*.

PG Cold-3 started with a cooling event at ca. 2800 cal BP, but vegetation was not affected by this cooling event. Vegetation changed drastically with a later regression dated at ca. 2200 cal BP, called minor Yayoi regression, and wetland forests were replaced by herbaceous marshes of *Carex* in the lowland, and lucidophyllous forests began to spread on the upland in the inner areas.

To interogate environmental effects on changes in vegetation and plant use from the middle to late Jomon periods, we would like to test the following three opposing hypotheses.

1. Change in vegetation induced by the climatic cooling at ca. 4400 cal BP lead to change in plant use from *Castanea crenata* to *Aesculus turbinata.* By comparing pollen records at the Sannai-maruyama and Kamegaoka sites in northeastern Honshu, Kitagawa and Yasuda (2004) suggested that reduction by this cooling event of *Castanea crenata* stands growing in the northern limit of its distribution forced the Jomon people to use *Aesculus turbinata* fruits that need complex processing. We would like to discuss the effect of this cooling event on the geomorphology and vegetation and on the use of plant resources by the Jomon people.

2. Expansion of *Aesculus turbinata* stands detected by pollen records were caused not by a cooling event, but by human management. By comparing pollen records at several sites from the middle to late Jomon periods, Yoshikawa (2008) recognized that *Castanea crenata* stands were not affected by the cooling event, but that *Aesculus turbinata* stands increased in the lowland. Based on distinct increases of *Aesculus turbinata* pollen around settlements, he postulated that the Jomon people increased *Aesculus turbinata* stands around settlements.

3. Change in geomorphology induced the establishment of *Aesculus turbinata* stands in the lowland. Tsuji (1989) showed that, after a minor regression in PG Cold-1, wetland forests of *Alnus japonica* came to be established in the lowland in the middle Jomon period and that they developed into wetland forests of *Fraxinus mandschurica* and *Alnus japonica* in the late to final Jomon periods with *Aesculus turbinata* and *Acer* growing at their margins.

2. Plant records of the Jomon periods at four sites in the Kanto plain

Plant records nearly continuous from the early to final Jomon periods have been obtained at four sites in central Japan with enough radiocarbon dates to follow the changes in plant assemblages through the periods (Fig. 2). The four sites are Shimo-yakebe site in Tokyo (Research Group of the Shimo-yakebe Site, 2006; Kudo et al., 2007), Domeki-yatsu site in Chiba (Archaeology Center of Chiba Educational Promotion Foundation, 2014), Akayamajinya-ato site in Saitama (Archaeology Center of Kawaguchi City, 1987; Tsuji, 1989), and Minami-kounuma site in Saitama (Archaeology Center of Saitama City, 2015). Except for the Shimo-yakebe site located in Sayama hills in the middle of the Musashino upland, the three other sites are located at the edges of uplands around the central lowland of the Kanto plain. At these sites, plant records are obtained by analyses of pollen, plant macrofossils, and wood remains.

2.1. Plant records at the Shimo-yakebe site

The Shimo-yakebe site studied by Research Group of the Shimo-

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