Original Article

Holocene Vegetation History around Lake Hamana on the Pacific Coast of Central Japan¹⁾

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Holocene vegetation around Lake Hamana was reconstructed from fossil pollen assemblages in three boring core sediments obtained from the bottom of the lake (the deepest point of the main lake and its satellite, Lake Shonai) and the lakeshore (near the Town of Yuto-cho).

Three forest stages were recognized at each site, namely, warm-temperate broad-leaved deciduous forest, lucidophyllous forest, and *Pinus* forest stages.

The development pattern of the lucidophyllous forest in the northern area was different from that in the southern area. In the northern area, which includes the catchment of the Miyakoda River, the major supply source for the main lake, lucidophyllous forest composed of *Castanopsis* and *Quercus* (*Cyclobalanopsis*) developed, and flourished from about 5,000 y.B.P. On the other hand, in the southern area around the Town of Yuto-cho and Lake Shonai, *Castanopsis* forest formed about 7,500 y.B.P. and *Quercus* (*Cyclobalanopsis*) began to expand from about 6,000 y.B.P.

These facts indicate that the southern area of Lake Hamana facing the Pacific Ocean must have been influenced by the ocean, especially the warm Kuroshio current, during the Holocene.

INTRODUCTION

The vegetation history around Lake Hamana has been influenced by the rise of sea level and the warm Kuroshio current since the last glacial age.

In the present study, the history of Holocene vegetation was investigated by pollen analysis of core samples obtained from the bottom of the lake and around the lakeshore. The relationship between the development of lucidophyllous forest and marine conditions was discussed.

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SAMPLES and METHODS

Core samples

Three boring core samples were taken from the eastern lakeshore near the Town of Yuto-cho (H9), and the bottom of Lake Hamana (86H-4 and 85H-1) (Fig. 1). These were part of 19 cores which were sampled in the course of a study on the geohistory of Lake Hamana. Stratigraphical, lithological and chronological studies on the cores were reported by IKEYA *et al.* (1985, 1987).

(1) **H 9 core** : The core was 18 m in length, and consisted of sand, dark-gray silt containing shell fragments, and blackish brown

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Fig. 1 Map of the sampling sites around Lake Hamana.

undecomposed peat in ascending order. The volcanic ash detected in the marine silt layer was identified to be K-Ah (Kikai-Akahoya ash) from the refraction ratio and EDX analysis of the glass. The falling age of the ash has been dated as about 6,300 y.B.P. (MACHIDA and ARAI, 1983). Two tephtras found in the peat layer were identified to be Kg (Kawagodaira pamice) and F-Os (Fuji-Osawa scoria). The falling ages of these tephtras were about at 3,000 and 2,800 y.B.P., respectively (MACHIDA *et al.*, 1984). The ^{14}C date of the lowest part of the peat layer was $5,330 \pm 390$ y.B.P. (KSU-847).

(2) **86H-4 core** : The core was 24 m in length, and consisted of sand, silt and clay layers. Three tephtras of K-Ah, Kg and F-Os were also detected.

(3) **85H-1 core** : The core was 17 m in length, and consisted of gravel and clay containing plant remains. The same tephtras

mentioned above were also observed. The ^{14}C dates were $3,080 \pm 180$ y.B.P. at 5.99 m and $7,140 \pm 140$ y.B.P. at 16.15 m in depth.

Pollen analysis

After boiling with 5 % KOH to remove humic acid, the sediments were centrifuged in a ZnCl_2 solution with a specific gravity of 2.0 g/cm^3 . Then, pollen grains were collected from the top of the supernatant. After acetolysis, they were embedded in glycerine jelly and sorted out under a microscope. A pollen diagram was drawn using the frequencies of individual arboreal pollen based on their total number. Pollen fossil assemblage zones were determined by the stratigraphic occurrence of the main arboreal pollen.

RESULTS

The fossil pollen assemblage zones

(1) **H9** (the Town of Yuto-cho, Fig. 2 : HLS-local assemblage zone)

HLS-I : *Castanea-Quercus* (*Lepidobalanus*)–*Fagus-Abies* zone, below 16.09 m in depth.

Castanea and *Quercus* (*Lepidobalanus*) pollen were obtained at high frequencies of 8.4–37.4 % and 11.8–28.5 %, respectively. *Fagus* and *Abies* were also found at relatively high frequencies of 5.2–6.2 % and 3.7–18.5 %, respectively, when compared to other zones. The frequencies of *Quercus* (*Lepidobalanus*) and *Pinus* were about 20 % and 10–25 %, respectively, throughout zones.

HLS-II : *Castanopsis* zone, 15.45–1.85 m in depth.

This zone was characterized by high *Castanopsis* frequencies of 22.0–52.9 %. *Myrica* began to appear in this zone. Although one species and a variety, *M. rubra* and *M. gale* var. *tomentosa*, are native to Japan, the former is common within lucidophyllous forests. *Quercus* (*Cyclobalanopsis*) frequencies began to increase from the K-Ah layer and reached 18 % in the upper layer of this zone.

HLS-III : *Quercus* (*Cyclobalanopsis*)–*Cryptomeria* zone, 1.45–1.05 m in depth.

Quercus (*Cyclobalanopsis*) frequencies remained between 12.5 and 20.1 %. *Cryptomeria*

Fig. 2 Pollen diagram of H9.

frequencies increased from 3.6 to 10.2 % and *Castanopsis* abruptly decreased to about 10 %.

(2) **86H-4** (Lake Shonai, Fig. 3: SLB-local assemblage zone)

SLB-I : *Castanea-Quercus (Lepidobalanus)-Alnus* zone, 23.0—19.0 m in depth.

Castanea and *Quercus (Lepidobalanus)* dominated with high frequencies of 9.0—42.2 % and 11.4—33.0 %, respectively. *Castanopsis* frequencies varied from 0.9 to 14.5 %. *Alnus* was detected at relatively high frequencies of 5.7—15.2 %.

SLB-II : *Castanopsis* zone, 18.0—4.9 m in depth.

This zone was characterized by a rapid increase in and dominance of *Castanopsis*. There were three patterns in its appearance. First, its frequency fluctuated greatly between 8.8 and 34.3 % below 13.0 m. Second, in the sediments from 2.0 to 8.0 m, its frequency was constantly high (24.5—32.1 %). Finally, it gradually decreased near the Kg and F-Os layers. *Quercus (Cyclobalanopsis)* with frequencies of 10—20 % continued to increase

and equaled or exceeded the *Castanopsis* frequencies in the uppermost part of the zone. On the other hand, the *Castanea* frequencies that dominated in zone I rapidly decreased. The frequencies of broad-leaved deciduous trees such as *Quercus (Lepidobalanus)* and *Carpinus* were as high as in zone I.

SLB-III : *Quercus (Cyclobalanopsis)-Cryptomeria* zone, 4.0—3.0 m in depth.

The frequencies of *Castanopsis* rapidly decreased to 5.6—5.9 %, whereas *Quercus (Cyclobalanopsis)* dominated with frequencies between 20.7 and 23.8 %. *Cryptomeria* frequencies also increased and reached 10.9 %.

SLB-IV : *Pinus* zone, above 2.0 m in depth.

This zone was characterized by a sharp increase in *Pinus* (21.7—51.2 %) and a marked decrease in *Quercus (Lepidobalanus)* (3.6—8.9 %). The frequency of *Quercus (Cyclobalanopsis)* abruptly declined above 1.0 m, although its highest value appeared in the middle of the zone. In the uppermost layer (0.22 m in depth), *Cryptomeria* had its highest value of 26.4 %.

Fig. 4 Pollen diagram of 85H-1.

are summarized in Fig. 5. The boundary ages of each fossil pollen assemblage zone were determined by the tephra and ^{14}C dates.

Based on similarities of the fossil pollen assemblages and the coincidences of their boundary ages, the HLS-I, II, and III zones correspond to the SLB-I, II, and III zones, respectively. However the boundary age between the HLB-I and II zones is different from those ages between I and II zones of both the HLS and SLB. The former age was about 5,000 y.B.P. and the last two ages were about 7,500 y.B.P. The fossil pollen assemblage of the HLB-II zone is also different from those of II and III zones of both the HLS and SLB. The HLS and SLB II zones were characterized by the dominance of *Castanopsis*. The HLS-III and SLB-III zones were marked by the dominance of *Quercus* (*Cyclobalanopsis*) and *Cryptomeria*, whereas *Castanopsis* became dominant with *Quercus* (*Cyclobalanopsis*) in the HLB-II zone. The SLB-IV and HLB-III zones with boundary ages of about 1,200 to 1,000 years were both dominated by *Pinus*.

DISCUSSION

From the stratigraphical sequence of pollen in the three core sediments, three forest stages were recognized at each site, namely, warm-temperate broad-leaved deciduous forest, lucidophyllous forest and *Pinus* forest stages.

The warm-temperate broad-leaved deciduous forest stage corresponds to the HLS-I, SLB-I, and HLB-I fossil pollen assemblage zones. The dominance of *Quercus* (*Lepidobalanus*), *Carpinus*, and *Ulmus-Zelkovave* etc. was characteristic in this stage. Furthermore, at the H 9 and 86 H-4 sites, *Castanea* dominated eminently.

The lucidophyllous forest stage corresponds to the HLS-II and III, SLB-II and III, and HLB-II zones. This stage is marked by the dominance of *Castanopsis* and *Quercus* (*Cyclobalanopsis*). As discussed below, the results obtained at the 85 H-1 site differ from those at the H 9 and 86 H-4 sites.

The *Pinus* forest corresponds to the SLB-IV and HLB-III zones and is characterized by the predominance of *Pinus*. Interference by

Fig. 5 Comparison of the fossil pollen assemblage zones of H9, 86H-4 and 85H-1.
Numerals in zones show ¹⁴C dates. HLS, SLB and HLB are the designations of the respective local pollen assemblage zone.

man probably occurred, and eventually, secondary *Pinus* forests developed.

Lucidophyllous forests around Lake Hamana began to develop and existed during the Holocene. The pattern of the forest development in the northern area, however, was different from that in the southern area. The lucidophyllous forests reconstructed from the fossil pollen assemblage from the deepest point of the main lake (85 H-1) were composed of *Castanopsis* and *Quercus* (*Cyclobalanopsis*), and flourished from about 5,000 y.B.P. Whereas in the southern areas around the Town of Yuto-cho (H 9) and Lake Shonai (86 H-4), *Castanopsis* forests formed during the early Holocene, about 7,500 y.B.P., and then *Quercus* (*Cyclobalanopsis*) began to expand from about 6,000 y.B.P.

The major constituents of the vegetation covered extensively in the area studied must have been the source of pollen found in the deposits. SANUKIDA and MATSUSHITA (1986) showed that the substances including pollen deposited in the main lake and Lake Shonai were derived from the Miyakoda River catchment, and the Hana River and Isaji River catchments, respectively. Accordingly, the fossil pollen assemblage observed in the core sediments from the deepest point of the main lake may well be reflected the vegetation developed in the northern area around Lake Hamana, since the Miyakoda River catchment was the main source of supply for the main lake. The assemblages obtained at the Town of Yuto-cho and Lake Shonai must show the vegetation developed in the southern area

around the Hana River and Isaji River catchments.

The earlier and notable development of the *Castanopsis* forests observed in the southern area suggests the influence of marine condition at that time. A similar tendency has been observed in a core sample from near Haibara-cho, a town in Shizuoka Prefecture, on the eastern part of Lake Hamana (unpublished). Both of these areas are located within the coastal region facing the Pacific Ocean and, therefore, would have been directly affected by the ocean, especially the warm Kuroshio current.

REFERENCES

- IKEYA, N., AKUTSU, H. and WADA, H. (1985) A report on stratigraphy, lithofacies and geological age of the Holocene sediments along the east coast of Hamana-ko. *Geoscience Reports of Shizuoka University*, No. 11, p. 171-179. (in Japanese)
- IKEYA, N., WADA, H. and OHMORI, M. (1987) On the boring core sediments from Hamana Lake. *Geoscience Reports of Shizuoka University*, No. 13, p. 67-111. (in Japanese)
- MACHIDA, H. and ARAI, F. (1983) Widespread late Quaternary tephra in Japan with special reference to archaeology. *The Quaternary Research* (Tokyo), **22**, p. 133-148. (in Japanese)
- MACHIDA, H., ARAI, F., ODA, S., ENDO, K. and SUGIHARA, S. (1984) Tephra in Japan with special reference to archaeology. *The Editorial Study of Cultural Property*, 984p., Dohosha, p. 865-928. (in Japanese)
- SANUKIDA, S. and MATSUSHITA, M. (1986) Studies on the modern sedimentary environment in Lake Hamana on the Pacific Coast of Central Japan. *The Quaternary Research* (Tokyo), **25**, p. 1-12.

浜名湖周辺の完新世植生史

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浜名湖畔（静岡県浜名郡雄踏町）および浜名湖底（主湖最深部、庄内湖）で得られた完新世堆積物の花粉化石群集にもとづき、浜名湖周辺地域の古植生を復元した。この地域では、暖帯落葉樹林期、照葉樹林期、マツ林期の3つの森林期を設定することができた。

しかしながら照葉樹林の発達様式は北部と南部で異なっていた。主湖最深部への花粉の供給源となる都田川流域の位置する北部では、照葉樹林はシイとカンで形成さ

れ、その繁栄期は約5,000年前以降であった。一方、雄踏町および庄内湖の位置する南部では、約7,500年前にシイ林が成立し、カン類の分布拡大は6,000年前頃にみられた。

こうした事実は、浜名湖南部地域が太平洋に面し、海洋の影響、とくに黒潮による気候緩和作用を受けた結果と考えられる。