Proboscidean fossils from the Japanese Archipelago and Taiwan Islands and their relationship with the Chinese mainland

K. Takahashi[1], C.H. Chang[2], Y.N. Cheng[2]

[1] *Lake Biwa Museum, Shiga, Japan* - Takahasi@lbm.go.jp

[2] *National Museum of Natural Science, Taichung, Taiwan*
cch@nmnss.nmns.edu.tw, joe@nmnsl.nmns.edu.tw

SUMMARY: The colonization, evolutionary processes and the relationship between the faunas of the Japanese Islands and Taiwan Island have been summarised, based on a comparison of their fossil proboscidean taxa with those of the Chinese mainland. The comparison indicates that *Mammuthus protomammonteus* and *Stegodon aurorae* evolved in the Japanese Islands and Taiwan respectively, and that *S. shinshuensis, S. orientalis* and *Palaeoloxodon naumanni* migrated to Japan from the mainland of China. Although *P. huaihoensis* migrated to Taiwan, *P. naumanni* did not migrate there.

1. Introduction

The Japanese Archipelago and Taiwan are located along the east margin of the Asian Continent, with Japan in the north and Taiwan in the south, ranging from 45° ~ till about 24° morthern latitude. Between the Japanese island of Kyushu in the north and Taiwan are situated the Ryukyu Islands, a series of small islands belonging to Japan.

For convenience Hokkaido, Honshu, Shikoku and Kyushu, the main Japanese islands, are herein referred to as the 'Japanese Islands'.

The faunas of all these islands were strongly influenced by local tectonic movements and climate changes, resulting in changes in the sea level in the Plio-Pleistocene. During periods of low sea level, the Strait of Korea immediately northwest of the southernmost Japanese islands, the Strait of Taiwan and the East China Sea, opposite the Ryukyu islands, were exposed as dry land, and these areas then played a central role in the migration of animals. When sea levels rose, islands were again formed, and endemic species sometimes evolved on those islands.

There are two main factors influencing the faunas in these islands. Firstly, the depth of the strait between the islands and the Asian mainland. The maximum depth of the Strait of Korea between the continent and the Japanese islands is about 130 m. Most of the depth of the Strait of Taiwan between the continent and Taiwan is less than 100 m depth. These differences suggest that Taiwan has been connected longer or more frequently to the continent than the Japanese Islands, and such a difference has greatly affected the faunal composition of these two island groups.

A second factor is latitude. The Japanese Islands are located further north than Taiwan. Nowadays, the Japanese Islands are situated in the temeprate zone, while Taiwan is situated in the subtropical zone. These difference in latitude must have resulted also in a difference in climate during the Plio-Pleistocene, which resulted in different faunas. It would have turned up as the movement of the boundary line between the Palaearctic and the Oriental that is presently located on the Ryukyu Islands.

The colonisation, evolutionary processes and the relationship between the faunas of these islands are summarized, and a comparison is

made of the fossil proboscidean taxa of these islands with those of the Chinese mainland (Takahashi and Namatsu 2000).

2. Japanese Proboscidean fossils

In recent years Japanese Plio-Pleistocene strata have been well studied by teprochronology, palaeomagnetic stratigraphy and other dating methods, and recent studies of widespread volcanic ash deposits have allowed for the correlation of event horizons at geographically distant areas (Oda 1977; Machida *et al.* 1980; Yoshikawa *et al.* 1996; Satoguchi *et al.* 1999, etc.). Therefore, the geological horizon and the age of proboscidean fossils are known accurately.

The earliest proboscidean fossils from the Japanese Islands are found in Miocene deposits of Gifu prefecture, Honshu (Matsumoto 1926; Kamei *et al.* 1977). After the Pliocene the number of specimens increases and proboscidean fossil taxa appear in the following chronological sequence: *Shinomastodon sendaicus, Stegodon shinshuensis, S. aurorae, Mammuthus protomammonteus, S. orientalis, Palaeoloxodon naumanni* and *M. primigenius.* These fossil sites number are over 350 (Kamei 1991).

However, only two proboscidean molars have been found from the Ryukyu Islands (Tokunaga 1940; Nohara and Hasegawa 1973). Otsuka (1997) identified one of these specimens as be similar to *Mammuthus paramammonteus shigensis*, and estimated the age as the Late Pleistocene. There are too few proboscidean fossils recovered from the Ryukyu Islands to include this area in the present discussion.

3. Taiwanese Proboscidean fossils

The horizon and the age of proboscidean fossils of Taiwan are not yet known accurately. Recently, the layers of the area in which *Stegodon* and *Mammuthus* occurred were studied. The nannofossil biostratigraphy (Shieh and Shieh, personal communication) suggests that the area involved must be placed in NN19. The boundary of NN19/NN20 is approximately 0,9 to 0,4 Ma.

We began our study in 1999 with a reexamination of 232 proboscidean molar fossils from the sea bottom around the Penghu Island and Tsiliao area near Tainan, including much new material. Our comprehensive study confirmed the presence of two species of *Stegodon*, two species of *Mammuthus* from the Early to Middle Pleistocene, and one *Palaeoloxodon* from the Late Pleistocene. There are no fossils before the Pleistocene.

4. Comparison of Japanese and Taiwanese Proboscidean fossils

A comparison of Japanese and Taiwanese proboscideans by Shikama *et al.* (1975) shows two mammalian faunas in Taiwan. One was named the Cho-chen fauna, being represented by *Mammuthus armeniacus taiwanicus, S. aurorae* and *S. sinensis*.

The other was the Penghu-Tainan fauna represented by *Palaeoloxodon naumanni*. Shikama *et al.* (1975) placed the first fauna in the Middle Villafranchian and the last in the Late Pleistocene.

In the Japanese Islands, Stegodon and Mammuthus occur in the Early to Middle Pleistocene, the same age as on Taiwan. *S. aurorae* is known from the Late Pliocene to the Early Pleistocene (2.5 Ma – 1.0 Ma), M. protomammonteus from the Early to the Middle Pleistocene (1.0 Ma – 0.7 Ma), and *S. orientalis* from the Middle Pleistocene (0.5 Ma – 0.4 Ma). Using data from tephrostratigraphy and oxygen isotope stratigraphy, Konishi and Yoshikawa (1999) estimated the immigration date of *M. protomammonteus* into the Japanese Islands as 1.15 Ma, and that of *S. orientalis* as 0.62 Ma.

S. sinensis, S. (Parastegodon) akashiensis, S. (Parastegodon) aurorae, Elephas hysudricus and *M. armeniacus taiwanicus* were recorded among the Cho-chen fauna described by Shikama *et al.* (1975). *S. (Parastegodon) akashiensis* has subsequently been synonymised with *S. aurorae* (Taruno 1991), and our studies indicate that the specimens identified as *Elephas hysudricus* by Shikama *et al.* (1975) are identi-

cal to *M. armeniacus taiwanicus*. Furthermore, *S. sinensis* and *S. aurorae* of Shikama *et al.* (1975) are morphologically indistinguishable from *S. orientalis* and *S. aurorae* of the Japanese islands. Although M. armeniacus taiwanicus described by Shikama *et al.* (1975), is slightly different from *M. protomammonteus* of the Japanese Islands in the mumber of lamella and molar size, those general characters are very similar. Therefore, the proboscidean taxa from the Cho-chen fauna can be placed into *S. orientalis, S. aurorae* and *M. a. taiwanicus.*

The fossils from the Cho-chen fauna of Taiwan are considered as resedimentated fossils, and as such the chronological sequence of the proboscidean fossils cannot be decided accurately. However, based upon direct comparison with the Japanese sequence, we posit a sequence of *S. aurorae, M. a. taiwanicus* and *S. orientalis*, with the latter the most recent taxon.

Shikama *et al.* (1975) described *Palaeoloxodon* from Taiwan as *Palaeoloxodon naumanni*. However, our detailed investigations indicate that *Palaeoloxodon* of Taiwan differs markedly from *P. naumanni* of the Japanese Islands in the size and wearing pattern on the occulusal surface of the molars.

We think that three species of *Palaeoloxodon* (*P. namadicus, P. naumanni* and *P. huaihoensis*) are represented in China, and that *Palaeoloxodon* of Taiwan is the same as *P. huaihoensis*, as Qi (1999) describet. *P. naumanni* has been recorded from Japan, but *P. huaihoensis* has not.

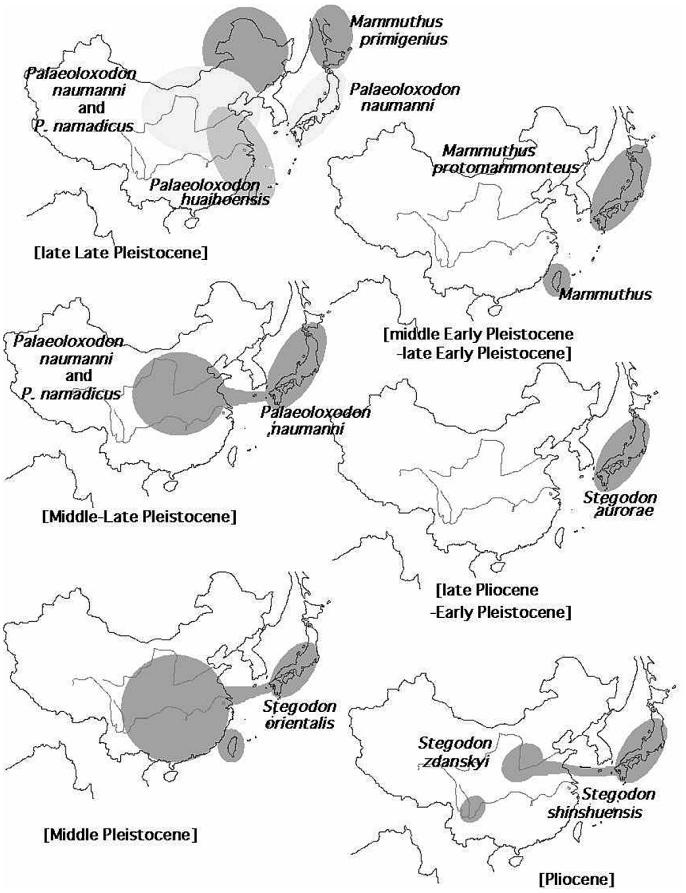

Fig.1 - Distribution maps of proboscidean fossils in eastern Asia during the Plio-Pleistocene.

The migration of *P. naumanni* into the Japanese Islands has been estimated as at 0.43 Ma by Konishi and Yoshikawa (1999). After this age, there exists no evidence that the Japanese Islands were connected with the Asian Continent. Because *Palaeoloxodon* of Taiwan is considered to be of the Late Pleistocene (Hu and Tao 1993), it is understandable that *P. huaihoensis* has not been found in Japan.

Comparison of the research results in the Japanese Islands and Taiwan with data from mainland China indicates that *M. protomammonteus* and *S. aurorae* evolved in the Japanese Islands and Taiwan, and that *S. orientalis, P. naumanni* and *P. huaihoensis* migrated there from the mainland.

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