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Ecologic and taxonomic diversification in the Mesozoic brackish-water bivalve faunas in Japan, with emphasis on infaunalization of heterodonts

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Abstract

Mesozoic brackish-water bivalve faunas in Japan diversified in three steps: at the beginning of the Early Jurassic, Early and Late Cretaceous. The Hettangian Niranohama Fauna in northeastern Honshu represents the establishment of a heterodont-dominated brackish-water fauna that persisted until the early Late Cretaceous. No similar composition is known from the Triassic. The infauna consists mostly of non-siphonate and some short-siphonate heterodonts, while the epifauna is represented by diverse pteriomorphian families. In the Early Cretaceous Tetori Group in central Honshu, the long-siphonate heterodonts *Tetoria* (Corbiculidae) and the semi-infaunal soft-bottom oyster *Crassostrea* appeared. The evolutionary diversification of the latter, known as the most important element of modern brackish-water faunas, may thus originate at that time. In the early Late Cretaceous (Cenomanian) of the Goshoura and Mifune Groups in west Kyushu, several euryhaline deep-burrowing heterodont families, such as Veneridae and Tellinidae, further diversified in the brackish and marine environments. The Late Cretaceous is characterized by massive shell biolithic beds in which large *Crassostrea* species are common, a feature common for Cenozoic brackish-water faunas. The long-term changes in the composition of the brackish-water faunas in Japan represents thus an evolutionary record, irrespective of the severe physiological and environmental conditions imposed on the highly conservative nature of the fauna.

Keywords: Brackish fauna; Heterodont bivalve; Mesozoic; Infaunalization; Japan

1. Introduction

Palaeoecology of Mesozoic brackish-water faunas has been studied mainly in Europe (e.g., Hudson, 1963; Hudson et al., 1995; Fürsich, 1981; Fürsich and Werner, 1984; Fürsich et al., 1995), with additional investigations in North America (Fürsich and Kauffman, 1984; Fürsich and Kirkland, 1986) and China (Yin, 1989; Yin and Fürsich, 1991). Information from East Asia has been limited, except for taxonomic studies (Hayami, 1958; Ohta, 1972, 1973, 1975, 1981; Tashiro, 1985a, 1987; Kozai, 1986, 1987, 1989). However, encouraged by the progress in the study in Europe (e.g., Fürsich, 1994), information on the paleoecology of brackish-water benthic associations has accumulated for Japanese Jurassic and Cretaceous sediments in recent years (e.g., Hirose and Kondo, 1998; Komatsu, 2004; Sugawara and Kondo, 2004). In addition to these, the earlier studies inferring the existence of brackish faunas more or less empirically (e.g., Kobayashi and Suzuki, 1937, 1939; Kobayashi, 1983; Tamura, 1976, 1977, 1979, 1981; Tashiro, 1993, 1994a) remain useful from a paleoecologic and environmental point of view.

Brackish-water facies in Japan are diverse and cover all the epochs of the Jurassic and Cretaceous, with exception of the Late Jurassic. Although limited records do occur in China (Yin, 1989; Yin and Fürsich, 1991), the fossil record in Japan, as an integral part of Asia, is therefore most representative. Moreover, the wide stratigraphical range of the fossil record in Japan is the most advantageous in comparison to those in Europe, where Early Jurassic and Cretaceous examples are poorly represented. Also, Japanese brackish faunal occurrences are suited for evolutionary paleoecological analysis, being biostratigraphically well constrained, intercalating well dated marine faunas (e.g., Kozai et al., 2005). Taking advantage of these, this paper

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analyzes the ecologic and taxonomic structures of Mesozoic diversification of brackish-water faunas in Japan.

2. Methods

Fürsich (1994) succeeded in establishing the most reliable method of identifying the salinity regime of ancient communities, by combining sedimentological and community structural analysis. Some of the data compiled in this study employ a similar method (Hirose and Kondo, 1998; Sugawara and Kondo, 2004).

Brackish-water faunas are scattered in many horizons in the Jurassic and Cretaceous in Japan, but the distributions are often limited, and the outcrop conditions and fossil preservation are generally poor. In this study, we, therefore, tried to incorporate as much information as possible both geographically and chronologically in order to cover many brackish-water faunas of Jurassic and Cretaceous age in Japan. We renounced reconstructing detailed salinity zonations within the fauna, such as oligohaline, mesohaline and brachyhaline regimes. We compiled paleoecologic and taxonomic information mainly at faunal level, along with the analysis at community (association) level. The localities of the brackish-water bivalves mentioned or figured in this paper are shown in Fig. 1.

We acknowledge that empirical determination of brackish-water species may become ambiguous and even erroneous. Such problems may arise particularly for the Late Cretaceous examples in which the more or less isolated distribution of brackish-water and marine bivalves became obscured by the diversification of the generally euryhaline siphonate, deep-burrowing bivalves. In such a case, recognition was based on the occurrence of unequivocally brackish-water bivalves, such as Neomiodontidae and Corbiculidae.

All the brackish-water sediments compiled in this paper are of “marginal marine” type, such as estuaries and deltas. The only exception is the Tetori Group of the Hida-Gaien Belt, which was deposited in a huge brackish lake that extended as far as China, as witnessed by the wide distribution of the bivalve *Tetoria* cf. *yokoyamai* in China (Kobayashi, 1983).

Bivalves being dominant in brackish-water shell-faunas, we analyzed the bivalve paleoecology. Bivalve life habit types were defined as: pteriomorphian (PT), non-siphonate paleoheterodont (NSPH), non-siphonate heterodont (NSH), siphonate shallow-burrowing heterodont (SSBH), siphonate, deep-burrowing heterodont (SDBH) and infaunal anomalodesmatan (IA). Pteriomorphians are mostly epifaunal, but includes infauna such as Noetiidae. Because ecological characteristics broadly control taxonomic composition, our ecologic subdivision is combined here with taxonomic classification. For example, most of the anomalodesmatans and siphonate deep-burrowing heterodonts may be grouped in the same life habit, i.e. siphonate deep-burrowers. However, anomalodesmatans being generally sluggish burrowers and most heterodonts more rapid burrowers, even if they have siphons of similar lengths, they are ecologically different. Recognition of siphonate shallow-burrowing bivalve without pallial sinus (SSBH) may be controversial, because there is no direct evidence for the formation of a siphon in extinct bivalves. However, basic life habits in bivalves being relatively uniform

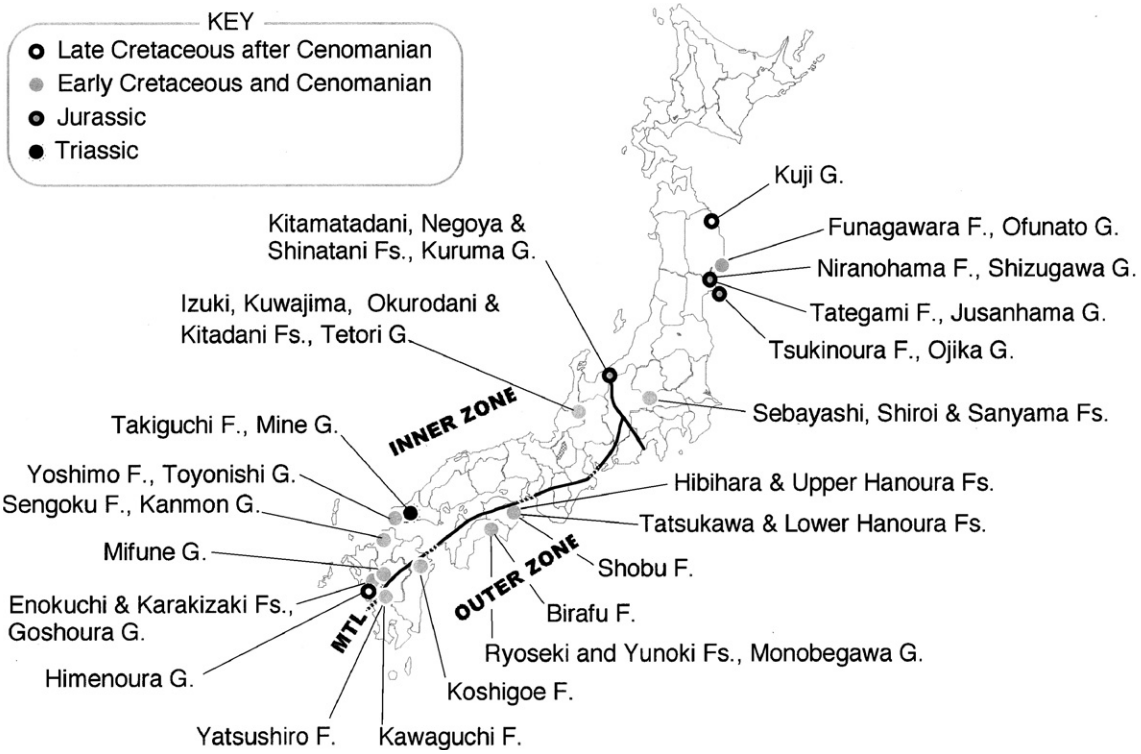

Fig. 1. Localities of the brackish-water bivalves mentioned or figured in this paper.