INTRODUCTION

Brouwers and Hazel (1978) mentioned that ostracodes, even those from the very fossiliferous Upper Cretaceous sedimentary rocks of the Atlantic and Gulf Coastal Provinces of North America, are relatively poorly known. There has also been little study in Japan. In fact, no hard data have been recorded on Mesozoic ostracodes, to say nothing of Cretaceous ones, in contrast to the fact that there are several published reports on Paleozoic faunas (e.g., Ishizaki, 1964; Adachi and Igo, 1980). This situation might be responsible for Babinton and Colín (1988), undertaking a paleobiogeographic synthesis of the ostracodes of the Tethyan margins during the Cretaceous. They attempted to extend their investigations to the outer limits of the eastern Tethys, but despaired of continuing their investigations beyond Australia. In the meantime, the distinctive contributions of Herrig (1988), who found three new forms belonging to the Puncididae from the Upper Cretaceous of Rügen Island on the southern margin of the Baltic Sea, have stimulated global interest in Cretaceous ostracodes. Under the circumstances, it may be quite pertinent to present information regarding the Japanese Upper Cretaceous ostracode fauna, despite the systematics is still open.

SYSTEMATIC NOTE

Family Cytherellidae Sars, 1866
Genus Cytherella Jones, 1849
Cytherella cf. fragilis Neale, 1962

Compared with: Cytherella fragilis Neale, 1962, p. 429, pl. 1, figs. 5-7.
Dimensions.—Carapace, IGPS coll. cat. no. 101213, Loc. SNS-7, fig. 6-4, 0.77 mm long, 0.47 mm high; carapace, IGPS coll. cat. no. 101214, Loc. SNS-7, fig. 6-5, 0.76 mm long, 0.45 mm high.
Remarks.—This species was described by Neale (1962) from the lower Hauterivian Speeton clay, giving three line drawings. The specimen illustrated as Cytherella cf. fragilis by Babinot et al. (1985) from the French basal Hauterivian is morphologically close to the Japanese specimens.

Occurrence.—66 individuals; abundant at both Locs. SNS-2 and SNS-7.
Genus Cytherelloidea Alexander, 1929

?Cytherelloidea zoogeneugendensis Dingle, 1969
Figs. 6-8—9

Compared with: Cytherelloidea zoogeneugendensis Dingle, 1969, p. 148, figs. 8a-c
Dimensions.—Carapace, IGPS coll. cat. no. 101217, Loc. SNS-7, fig. 6-8a—b, 0.72 mm long, 0.42 mm high; carapace, IGPS coll. cat. no. 101218, Loc. SNS-7, fig. 6-9, 0.73 mm long, 0.42 mm high.
Remarks.—This form, represented by two badly squashed valves, shows no sign of ridges, and so even its generic assignment is doubtful. In the meantime, its surface ornamentation consisting entirely of fine reticulation closely resembles that of specimens reported by Brenner and Oertli (1976) as Cytherelloidea zoogeneugendensis from the Lower Cretaceous in the Algoa Basin of South Africa. However, the former does not show any sign of ridges. In this regard, the Japanese form is similar to Cytherelloidea sp. A reported by Oertli (1974) from the Albion, west of Perth, Australia (DSDP, Leg 27, site 259), but differs in that the DSDP form has laterally distinct carinate muri, showing different patterns of reticulation.

Occurrence.—5 individuals; rare at both Locs. SNS-2 and SNS-7.

Cytherelloidea sp.

Figs. 6-6—7

Dimensions.—Broken carapace, IGPS coll. cat. no. 101215, Loc. SNS-7, fig. 6-6, 0.60 mm long, 0.41 mm high; carapace, IGPS coll. cat. no. 101216, Loc. SNS-7, fig. 6-7, 0.66 mm long, 0.41 mm high.
Remarks.—This form is somewhat similar to Cytherelloidea griesbacki described by Dingle (1980) from borehole BH-9 (uppermost Santonian—Campanian) in Zululand, South Africa, but differs in patterns of carinae.
Fig. 5.
The former has a more continuous carina along the inside of the anterior and ventral margins, and an isolated carina lying obliquely in the mid-dorsal to dorsomedian area.

**Occurrence.**—2 individuals; very rare only at Loc. SNS-2.

Family Progonocystheridae Sylvester-Bradley, 1948

**Genus Acrocythere** Neale, 1960

*Acrocythere*? sp.

Figs. 5a–7

**Dimensions.**—Carapace, IGPS coll. cat. no. 101204, Loc. SNS-2, fig. 5-4, 0.65 mm long, 0.34 mm high; carapace, IGPS coll. cat. no. 101205, Loc. SNS-2, fig. 5-5, 0.80 mm long, 0.44 mm high; carapace, IGPS coll. cat. no. 101206, Loc. SNS-2, fig. 5-6, 0.86 mm long, 0.38 mm wide; right valve, IGPS coll. cat. no. 101207, Loc. SNS-2, fig. 5-7a–c, 0.70 mm long, 0.41 mm high.

**Remarks.**—This form, occurring in abundance at two localities, has a hemiserendipitous hinge structure in its immature specimens, and so it can possibly be assigned to the Protocytherinae. This form resembles *Acrocythere haueteriviana* (Bartenstein, 1956), but lacks well-developed eye tubercles that are very prominent in illustrations given by Neale (1962, 1978), and also in specimens deposited at the Forschungs-Institut Senckenberg, Frankfurt am Main.

**Occurrence.**—84 individuals; abundant both at Locs. SNS-2 and SNS-7.

**Genus Arculicythere** Grekoff, 1963

*Arculicythere*? sp.

Figs. 6a–10

**Dimensions.**—Carapace, IGPS coll. cat. no. 101219, Loc. SNS-7, fig. 6-10, 0.38 mm long, 0.23 mm high; carapace, IGPS coll. cat. no. 101220, Loc. SNS-7, fig. 6-11, 0.38 mm long, 0.24 mm high.

**Remarks.**—This form is somewhat similar to *Arculicythere tumida* reported by Dingle (1984) from the Albion on the Agulhas Bank, southern Africa, and on the Falkland Plateau (DSDP site 330), but differs in having narrow but distinct ridges that run laterally or obliquely.

**Occurrence.**—2 individuals; very rare at Loc. SNS-7.

Family Trachyleberididae Sylvester-Bradley, 1948

**Genus Acanthocythere** Howe, 1963

*Acanthocythere*? sp.

Figs. 5a–7

**Dimensions.**—Carapace, IGPS coll. cat. no. 101208, Loc. SNS-2, fig. 5-9, 1.08 mm long, 0.58 mm high; carapace, IGPS coll. cat. no. 101209, Loc. SNS-2, figs. 5-10a–b, 1.00 mm long, 0.55 mm high.

**Remarks.**—This form resembles *Acanthocythere multispinosa* described by Al-Furah (1984) from the Maastrichtian Aruma Formation of Saudi Arabia, but has an outline which less strongly tapers posterior, and has tubercles arranged along the anterior margin at close and regular intervals, and no prominent eye tubercles, all of which cast doubt on its generic assignment to *Acanthocythere*. Dingle (1981) reported indeterminate species 7 from borehole JC-1 (Maastrichtian) of south-east Africa. This species considerably resembles the Japanese form, but differs in that the former species has more distinct pustules in the anteromedian area in contrast to a lack of narrow irregular ridges connecting pustules which are very clear in the Japanese specimens (Fig. 5a).

**Occurrence.**—6 individuals; common at Loc. SNS-2 only.

**Genus Scepticocythereis** Bate, 1972

*Scepticocythereis*? sp.

Figs. 5a–8; 6a–12–14

**Dimensions.**—Carapace, IGPS coll. cat. no. 101221, Loc. SNS-7, figs. 5-8, 6-12, 0.90 mm long, 0.50 mm high; carapace, IGPS coll. cat. no. 101222, Loc. SNS-7, fig. 6-13, 0.92 mm long, 0.53 mm high; Carapace, IGPS coll. cat. no. 101223, Loc. SNS-7, fig. 6-14, 0.98 mm long, 0.48 mm wide.

**Remarks.**—This form superficially resembles *Scepticocythereis ornata* described by Bate (1972) from the Santonian in the Carnarvon Basin, Western Australia and subsequently reported by Neale (1975) from the Santonian Chalk at Goring, Western Australia, but differs in having a slightly stronger subcentral swelling and a more smoothly rounded posterior margin.

**Occurrence.**—11 individuals; common at Loc. SNS-7 only.

**Genus Rehacythereis** Gründel, 1973

*Rehacythereis* cf. *matronae* (Damotte and Grosdidier, 1963)

Figs. 5a–1–3

Compared with: *Cythereis matronae* Damotte and Grosdidier, 1963, p. 57, pl. 3, figs. 7a–f

**Dimensions.**—Carapace, IGPS coll. cat. no. 101201, Loc. SNS-2, fig. 5-1, 0.86 mm long, 0.43 mm high; carapace, IGPS coll. cat. no. 101202, Loc. SNS-2, fig. 5-2, 0.86 mm long, 0.47 mm high; carapace, IGPS coll. cat. no. 101203, Loc. SNS-2, fig. 5-3, 0.85 mm long, 0.38 mm wide.

**Remarks.**—This form, represented by more than 27 specimens, is comparable with the micrographs of *Matronella matronae* given by Babinot et al. (1985) from the French Albion. In contrast to this, the Irish
Fig. 6.
Genus *Nigeria* Reymont, 1963

*Nigeria* sp.

**Dimensions.**—Carapace, IGPS coll. cat. no. 101210, Loc. SNS-7, fig. 6-1, 1.15 mm long, 0.59 mm high; carapace, IGPS coll. cat. no. 101211, Loc. SNS-7, fig. 6-2, 1.05 mm long, 0.63 mm high; carapace, IGPS coll. cat. no. 101212, Loc. SNS-7, fig. 6-3, 1.10 mm long, 0.51 mm wide.

**Remarks.**—This form is morphologically close to "*Limburgina*" sp. reported by Reymont (1982) from a borehole (Cenomanian-Turonian) in the coastal zone of southwestern Morocco, but has more laterally distinct carinate muri, particularly along the ventral margin.

**Occurrence.**—9 individuals; common at Loc. SNS-7, very rare at Loc. SNS-2.

**Discussion and Concluding Remarks**

Cretaceous ostracodes have been extensively studied, particularly in connection with such paleogeographic histories as the opening of the Proto-Atlantic (e.g., Neale, 1977; Tambareau, 1982) and varying geographic configurations of Tethys (among many, McKenzie, 1982, 1987; Reymont, 1987; Babinot and Colin, 1988). These studies have made clear the waxing and waning of ostracode faunas in time and space on a global scale.

First of all, it is noteworthy that the ostracode faunas are distinct between the Early and Late Cretaceous (Babinot and Colin, 1988) across the Cenomanian and Turonian, particularly in South Africa (Dingle, 1982). They made rapid dispersal, beginning in the Coniacian in the southern Tethys (Reymont, 1987), and attained their maximum diversity during Maastrichtian time in the Cretaceous (Whatley, 1986, 1988). Such faunal changes have been ascribed to vast epicontinental transgressions and regressions accompanying the paleogeographic changes mentioned above. Among these are a striking extension of the shallow shelf seas in the Albian which covered the eastern and southern United States beyond the preceding deposition confined to the eastern side of the Atlantic (Neale, 1977), a rapid expansion of the Tethyan ocean and an invasion of water from the nascent South Atlantic that established a trans-Saharan seaway in Cenomanian-Turonian time (Reymont, 1987), wide distributions of chalk facies in the Northern Hemisphere with the continuing Cretaceous transgression and widening Atlantic Rift (Neale, 1977), which typify deposition under stable shallow to offshore shelf conditions (McKenzie, 1982), and so forth.

The faunal province in the Early Cretaceous, epitomized by the South Gondwanan province, is widespread throughout Argentina-Madagascar-Tanzania-Katch-Western Australia, in which the genus *Arculicythere* is among its important elements (Dingle, 1982). In addition, in a sublatitudinal direction, the western Tethys to Proto-Indian Ocean is characterized by *Arculicythere* and *Majunga*, in contrast to the eastern Tethys where *Protocythere* s. 1. is widely distributed (Babinot and Colin, 1988).

After the Turonian, *Brachycythere* was widely distributed as a key species, although it does not occur in Australia (Babinot and Colin, 1988) or Argentina (Dingle, 1982). In addition, the influx of *Brachycythere*, *Cythereis*, and trachyleberidids replaced the former faunas in Tanzania where details have been investigated along well-exposed sections (Dingle, 1982). In South Africa, there was also an expansion of trachyleberidids, along with that of the Brachycytheridae and Schizocytheridae.

In Coniacian-Maastrichtian time, two provinces can be discriminated: one extending from Brazil to West Africa, and the other stretching from South Africa to Australia via Tanzania.

Throughout the Late Cretaceous, the West-North Africa Province, in which bunionite commonly occurred, was consistently separated from the Southern Province, in which bunionite was absent (McKenzie, 1982; Bate and Bayliss, 1969). Such faunas include the Cytherideidae and Brachycytheridae along with c therel lacid and trachyleberidids (McKenzie, 1982).

The fauna in Western Australia is more or less unique, comprising both endemic and cosmopolitan elements, which Neale (1976) called an Australian Upper Cretaceous paradox and attributed to elaborate Senonian ocean currents. This fauna contains the Gondwana genera of *Majunga* and its related genera, several endemic genera, and such cosmopolitan elements as c therel lacin, cytherideids, trachyleberidids, cytherurids, and bythocytherids (Neale, 1975, 1976). It is also important that this fauna is characterized by the local development of a rich pectocytherid fauna (Dingle, 1982) in contrast to the lack of cytherettids which are common in Europe (McKenzie, 1982).

The Japanese Campanian ostracode fauna comprises
nine species belonging to eight genera which fall under three families, namely, the Cytherellidae, Progonocytheridae, and Trachyleberididae. The Japanese fauna is characterized by the dominance of the Trachyleberididae, including four species (44%), which is concordant with the overall features of the Late Cretaceous faunas quoted above. In addition, the Cytherellidae, including the genus Cytherelloidea, also occurs in abundance (33%). Nevertheless, a comparison discloses a considerable degree of conservative natures of the Japanese fauna: Neither the Brachycytheridae nor the Schizocytheridae occurs in the Japanese fauna which instead contains two species of the Progonocytheridae. This feature may be comparable with older faunas.

At the generic level, it is noticed that the Japanese fauna includes two species of the genus Cytherelloidea (22%). This genus is considered to be or to have been an element of shallow and warm waters (Morkhoven, 1963; Neale, 1977). Another noteworthy aspect is the occurrence of abundant specimens of Acrocythere? sp. The genus Acrocythere is well known from the Valanginian-Albian interval (Neale, 1978; Tambareau, 1982; Hart and Chrittenden, 1985) and the Oxfordian (Rosenfeld et al., 1987) of the Atlantic-Mediterranean region. Therefore, if my generic assignment is proper, the Japanese occurrence may be of great importance which merits going into detail about the distribution and evolutionary processes of this genus. Along with this, the occurrence of Scepticocythereis? sp. may be of great significance, should its generic assignment be acceptable, because it has been considered to be an endemic Australian taxon.

At the specific level, although the systematics remains open, two species of the Cytherellidae are compared in this study with those reported from the Irish and French Hauterivian, and South African Lower Cretaceous (refer to systematic note for references). The occurrence of Arculicythere? sp. suggests some communication with the Proto-Indian Ocean and the eastern Tethys in the South Gondwana Province, although its characteristic occurrence there was confined to a time interval prior to the Cenomanian. In addition, the occurrence of Rehacythereis cf. matronae implies a connection with the French Albian rather than the Irish Cenomanian (references in systematic note). Such occurrences indicate that those forms, occurring before the Albian elsewhere and in the Santonian in Western Australia, still lingered on in Japan.

The Podocopida includes essentially benthic organisms incapable of sustained swimming, and so land masses or ocean depths would prove to be insuperable barriers (Neale, 1976). Therefore, the presence of the cosmopolitan family Cytherellidae implies the absence of a physical barrier between the eastern margin of the Tethys and Japan. This may indicate that the cold Arctic waters, which are of primary concern, hardly affected the Japanese Islands during that time. In addition, Marinovich et al. (1983) suggested on the basis of paleontological evidence that the Arctic Ocean was geographically isolated during the Paleogene. Matsumoto (1973) also expressed a similar view regarding Late Cretaceous time, postulating a circum-North Pacific orogenic mountain system, on the basis of ammonite distributions.

The information provided by this study is significant in that it shows that Japan was under the influence of Tethyan rather than cold Arctic waters in Campanian time.

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