Geographical Distributions of Fresh and Brackish Water Ostracos around the Circum-Japan Sea and their Significance

Proceedings: International Symposium of the Kanazawa University 21st-Century COE Program Vol. 1 (2003)
Edited by Naoto KAMATA

Geographical Distributions of Fresh and Brackish Water Ostracods around the Circum-Japan Sea and their Significance

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Abstract - The distributions of fresh and brackish water ostracods from around the circum- Japan Sea are discussed. Although the published data are patchy and incomplete, they show that many species are only known from Japan. There is a link of some species in the circum-Japan Sea area and European species despite an apparent disjunct distribution of 7000 km or more.

I. Introduction

The fresh and brackish water faunas of the Japan Sea region are influenced by a number of factors. Warm water currents entering the Japan Sea from the south and cool currents from the north play an important role in shaping the climate of the area and thus fresh and brackish water habitats.

Additionally, the sea level changes that have taken place in the Japan Sea have influenced the distribution of fresh and brackish faunas; high sea levels have produced a barrier to the dispersal of some faunas (but not all), while low sea level has produced the opportunity to spread over exposed land or along new coast lines and colonize new areas [1].

The Japan Sea region was not heavily glaciated during the Pleistocene, unlike much of Europe and North America, which endured subsequent, heavy glaciations that wiped out significant parts of the pre-Pleistocene faunas. Thus the circum-Japan Sea areas could potentially harbor relict faunas, which are extinct elsewhere. Study of living populations of such relict faunas could help in the palaeoecological interpretations around the Japan Sea and even throughout Eurasia.

The human impact on faunal distributions is becoming increasingly important across the Japan Sea area as well as across the globe. Environmental monitoring often relies on distribution data of invertebrates collected in the past, looking for local extinctions or shifts in distributions patterns. In addition to species disappearing from an area, man can also be responsible for introducing them. One commensal ostracod, *Uncinocythere occidentalis*, was imported into Japan by mistake from the USA on its host, the signal crayfish, and it now inhabits Hokkaido [2]. Such introductions may have significant impacts on the local ecosystems. These threats may well increase in the future, but they can only be recognized if the local faunas are well documented.

To study these influences on the fauna of the Japan Sea region non-marine ostracods are ideal. They inhabit both fresh and brackish water environments, are diverse, abundant and have an excellent fossil record due to their calcified carapace. Ostracod faunas in other parts of the

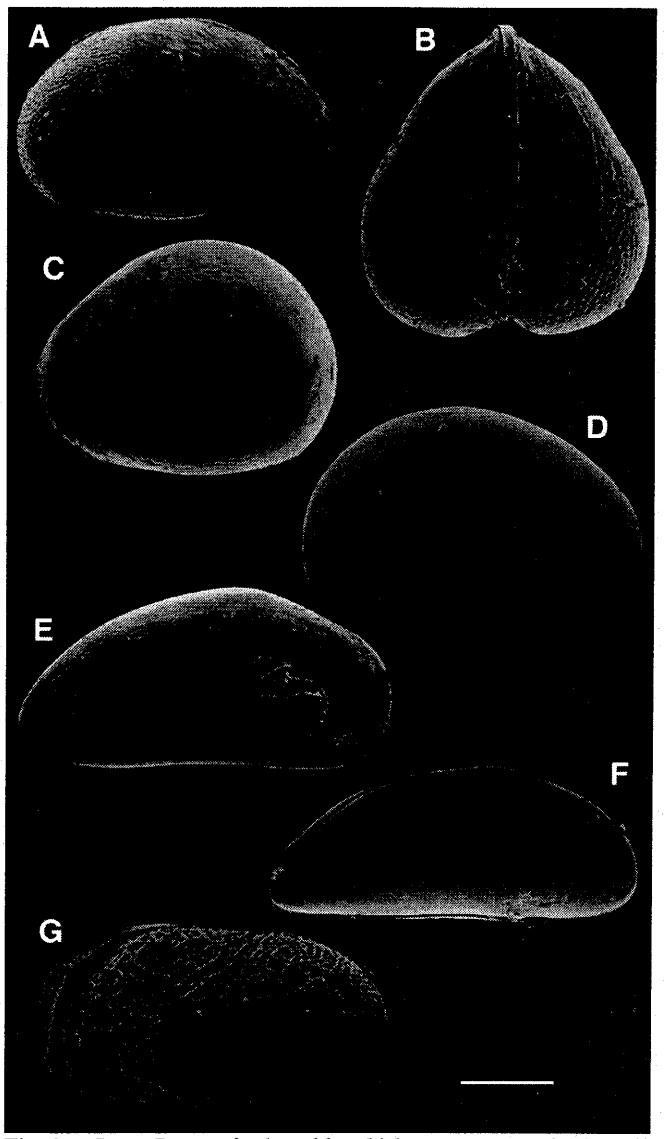

Fig. 1. Some Recent fresh and brackish water ostracods currently known only from Japan. A- *Metacypris digitiformis*, female, right view; B – *M. digitiformis*, female, ventral view; C – *Cyclocypris diebeli*, female, left view; D – *Scottia birigida*, female, right view; E – *Paracypria inujimensis*, female, right view; F – *Dolerocypria mukaishimensis*, female, right view; G – *Ishizakiella supralittoralis*, female, left view. Scale bar = 150 μm for A & B, 145 μm for C & G, 185 μm for D, 195 μm for E and 160 μm for F.

world (especially western Europe) are well studied providing an excellent opportunity to compare species and distributions. At present, the study of fresh and brackish water species around the circum-Japan Sea region is still in its infancy. However, the data currently available is providing some very interesting insights into the geographical distribution of non-marine ostracods around this area.

This preliminary study aims to summarize the current knowledge of fresh and brackish water ostracods around the circum-Japan Sea and look for possible significances in the geographical distribution.

II. Geographical distribution of fresh water ostracods in circum- Japan Sea

Most work concerning freshwater ostracods in the circum-Japan Sea area is from Japan, and much of it by Okubo [e.g. 3, 4, 5, 6]. To date there are around 72 freshwater species from 18 prefectures (38% of the total number of prefectures) recorded from Japan (Figs. 1 & 2). Many of these 18 prefectures have only a few species of ostracods documented from them, and most habitats sampled are rice fields and ponds. Other freshwater habitats, including springs, marshes, mosses, deeper parts of lakes and rivers have mostly been overlooked or not extensively sampled when it comes to ostracods.

Compared with the UK, Japan has a relatively small number of freshwater ostracods reported so far. Japan, with a surface area of approx. 378 000 sq km, is about 33% larger than the UK (surface area of 244 000 sq km). The UK is more restricted in its latitude range (11° latitude range compared with Japan's 22°), and thus covers less climatic zones than Japan. The UK is also much flatter (highest point 1344 m), and therefore with a much more restricted altitude range than Japan (highest point 3776m). However, around 90 species have been reported from the UK [7], which demonstrates that probably many more species than the current 72 are yet to be discovered in Japan.

Despite this patchy study in freshwater ostracods in Japan 17 living species (24 %) (and 1 subspecies) have only ever been reported from Japan (Table 1), 15 of which (21%) are only known from Honshu. Whether such species are endemic to the Japan Sea area, or just have not been found yet in other parts of Asia remains uncertain at present. Such a rate of possible endemism is extremely high compared with the UK, which just has one endemic species (approx. 1%) (*Psychrodromus robertsoni*). Lake Biwa, an 'ancient' lake in Shiga Prefecture, so far only has 4 species identified from it, including one species, *Cypria biwaense*, not found anywhere else, and a further 13 species not yet identified to species level [4, 5, 6]. Other 'ancient' lakes are known for their extremely high levels of endemism of ostracods (e.g. Lake Baikal 90%, Lake Tanganyika 94%, Lake Malawi 50% and Lake Ohrid 66%, [9]). Its therefore highly possible that many species of endemic ostracods are yet to be discovered in Lake Biwa.

Table 1. Species and subspecies of freshwater ostracods currently only known from the circum-Japan Sea area.

Species	Location
Candona morimotoi Mckenzie, 1972	Korea
Chrissia vittata Okubo, 1974	Kagoshima, Japan
Cyclocypris diebeli Absolon, 1973	Hokkaido, Japan
Cypria biwaense Okubo, 1990b	Shiga, Japan
Cypridopsis coreana coreana Mckenzie, 1972	Korea
Cypridopsis coreana elongata Mckenzie, 1972	Korea
Cypridopsis japonica Okubo, 1990a	Okayama, Japan
Cypridopsis kurilensis Schornikov, 1974	Kuril Islands
Cypridopsis nigrovittata Okubo, 1990a	Okayama, Japan
Cyprinotus setoensis Okubo, 1990b	Okayama, Japan
Cryptocandona brehmi Klie, 1934	Nagano, Japan
Dolerocypris fasciata nipponensis Okubo, 1972	Okayama, Gumma, Japan
Fabaeformiscandona japonica (Okubo, 1990a)	Okayama, Gumma, Fukuoka, Japan
Hemicypris kibiensis Okubo, 1990b	Okayama, Gumma, Japan
Hemiypris nipponica Okubo, 1990b	Okayama, Gumma, Japan
Hemicypris vulgaris Okubo, 1990b	Japan
Ilyocypris japonica Okubo, 1990a	Gumma, Japan
Metacypris digitiformis Smith & Hiruta in press	Hokkaido, Japan
Physocypria nipponica Okubo, 1990b	Kyshu to Kanto, Japan
Scottia birigida Smith et al., 2002	Ishikawa, Japan
Stenocypris viridis Okubo, 1990a	Okayama, Gumma, Japan

Data from the Korean peninsular is exclusively from South Korea. Only 11 species and subspecies have so far been reported from South Korea [10, 11, 12], eight of which are commonly found else where, including southern Japan. *Candona morimotoi, Cypridopsis coreana coreana* and *Cypridopsis coreana elongata*, however, have only been recorded from Korean subterranean habitats (Table 1).

For the vast region of Russia, most ostracod work has centered on the west of the country. However, four species of freshwater ostracod have been reported from near Vladivostok, close to the coast of the Japan Sea [13]. All four species have a wide distribution in the northern hemisphere.

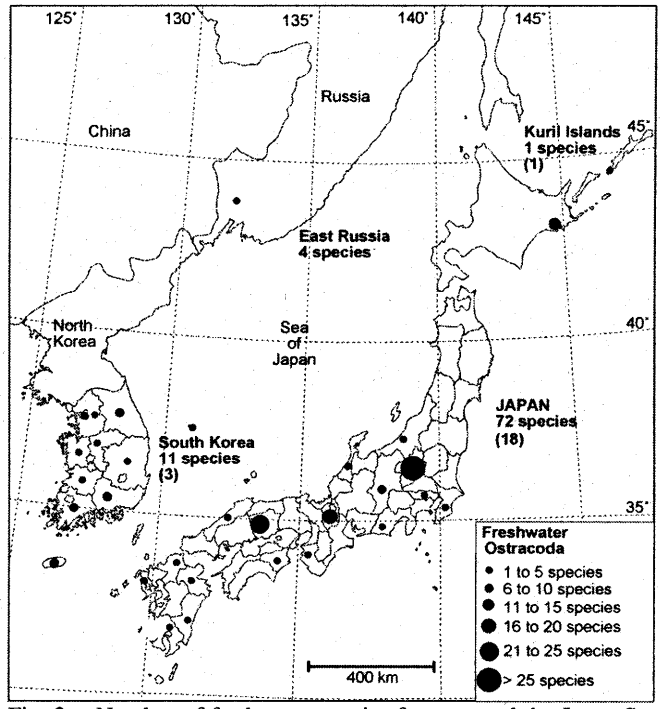

Fig. 2. Number of freshwater species from around the Japan Sea. Numbers in parentheses are species and subspecies that are only known from that region.

A. European Connections

In the circum-Japan Sea area there are some species with a cosmopolitan distribution, found in many other areas worldwide (e.g. *Heterocypris incongruens*, *Cypridopsis vidua*, *Darwinula stevensoni*, *Notodromus monacha* etc). Others are more restricted in their distribution, but common in Asia (e.g. *Ilyocypris dentifera*, *Stenocypris hislopi*, *Ilyodromus smaragdinus* etc). However, there is 1 species, *Cyclocypris diebeli*, that has a disjunct distribution, with fossil populations in Western Europe and living populations in Japan Sea area, separated by at least 7000 km. Additionally there are 2 species in the Japan Sea area whose closest relatives are found only in Western Europe: *Scottia birigida* and *Metacypris digitiformis*.

Cyclocypris diebeli was first described in Slovakia in late and postglacial freshwater carbonate sediments (Fig. 1) [14]. Since the description this species has been recorded in central Europe and in Ireland, always as a fossil, mostly in Pleistocene and early Holocene sediments [15]. In Europe this species was most abundant during the early Holocene, but after this time it declined and eventually became extinct around 3000 years ago [16]. However, living specimens of this species in eastern Hokkiado have recently been found, over 8700km east of the most easterly record of fossil *C. diebeli* [15]. The fossil specimens of *C. diebeli* are found only in strongly carbonate sediments. However, the living *C. deibeli* are found in only weakly carbonate or neutral waters. This indicates, that although the morphology of the living and fossil forms are identical, the species' environmental requirements have changed over time in Japan.

The genus *Metacypris* contains only two living species and over 130 fossil species. One living species, *M. cordata*, has been known in Europe for over 130 years, but the second living species, *M. digitformis*, has only recently been discovered in Hokkaido (Fig. 1) [17]. The Japanese species is morphologically very close to the living European species, both of which are distinctively different from any of the fossil forms of *Metacypris* found throughout the world. These two, very similar species are separated by 7400km.

The genus *Scottia* has been known in Europe since 1889, and for 70 years was thought to be living only in Europe, respresented by one species, *S. pseudobrowniana*. However, a report of *Scottia* from America, a new species in Oceania and a new species, *S. birigida* from Japan (Fig. 1) has expanded the known distribution of this genus considerably [18]. The Japanese species is most closely related to the European species, and is found over 7000 km further east than the most easterly record of *S. pseudobrowniana*.

Thus these three freshwater species living in Japan, *Cyclocypris diebeli*, *Scottia birigida* and *Metacypris digitiformis* are most closely related to, or are the same as, European species. This indicates a connection of at least some Japanese species to European species and the disjunct distribution of these closely related species and fossil and living populations today is a puzzling phenomena. Invasions due to man can be ruled out due to the Japanese species being different than the European species in the case of *M. digitformis* and *S. birigida* and the European population being extinct, in the case of *C. diebeli*. Future work across Eurasia will determine if such distributions are really disjunct, or that the faunas are actually present right across Eurasia. Either way, there is a significant link of faunas in the Japan Sea area and Europe. Questions for future research include the directions of migrations of such species; were migrations from Europe, across Eurasia to the Japan Sea area? Or visa versa?

III. Geographical distribution of brackish water ostracods in circum- Japan Sea

As with freshwater species, the majority of work on brackish water species from the circum-Japan Sea area is from Japan. Brackish water ostracods are generally a mixture of species derived from freshwater and marine lineages. Some species are very tolerant to salinity conditions; e.g *Ilyocypris dentifera*, a species mostly found in freshwater habitats can be found in salinities of up to 21 0/00 [19] and many marine forms can be found in brackish water. This provides some confusion when trying to determine if a species is truly brackish, or a marine or freshwater form found in a brackish environment. Previous work on brackish water ostracods have concentrated on species found in water depths of greater than a few meters, generally to help in the reconstructions of paleoenvironments. A few studies have included work in lower saline conditions in shallower environments and are

dominated by just a few species [20]. Nakao and Tsukagoshi provided an excellent study of shallow water, brackish habitats from low to high salinities from the Obitsu River Estuary in central Japan [19]. Of particular note of Nakao & Tsukagoshi's study is that one third of the species they recovered were previously undescribed This highlights that there are many species yet to be discovered in the brackish water habitats of Japan.

A. Distributions of some brackish water species

Ishizakiella is probably the most studied brackish water ostracod genus in the Japan Sea area. Two *Ishizakiella* species, *I. miurensis* and *I. supralittoralis* (Figs. 1 & 3) are distributed at many localities along the coasts of Honshu and Hokkaido and are a result of migrations from the south of a common ancestor [1]. There are genetic differences in the populations of *I. miurensis* in the Japan Sea with that of populations on the Pacific coast and this is most probably due to the Japan Sea populations becoming isolated during the Late Pleistocene low sea levels [1]. This highlights the influence of the development of the Japan Sea on brackish faunal distributions.

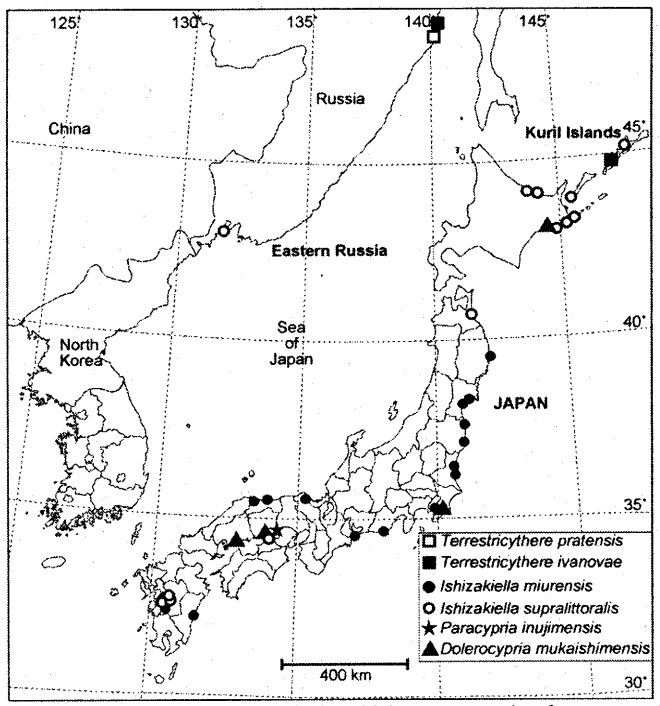

Fig. 3. The distribution of six brackish water species from around the Japan Sea.

Other species of brackish water ostracods found exclusively around Japan include *Dolerocypris mukaishmiensis* and *Pararcypria inujimensis* (Figs. 1 & 3). *D. mukaishimensis* is found from Hiroshima to Hokkaido, and is sometimes found with *I. supralittoralis*. At present, it is not known if this species migrated to the Japanese archipelago at the same time as *I. supralittoralis*, and future work on this species and others will help to form a picture of colonization of brackish faunas. *P. inujimensis* has only been found twice, only in a small area of the Inland Sea of Japan. One of these findings included *P. inujimensis* with both *D. mukaishimensis* and *I. supralittoralis*, [20] which indicates similar habitat requirements of all three species. Why two of these species have a relatively large distribution and one species is very restricted is one of many questions remaining about the brackish water ostracods around the Japan Sea.

B. Terrestrial Ostracods

Terrestricythere is the only genus in the superfamily Terrestricytheriodea, and consists of only 2 described species: *T. pratensis*, and *T. ivanovae* [21, 22]. A third species of this superfamily has been found from the south coast of England and is currently being described. *Terrestricythere* species lives a terrestrial lifestyle in damp leaf litter or damp decaying seaweed along the edges of brackish estuaries. For significant periods of time such environments are above the water level, and are only flooded during some high tides. However, occasional submersion in brackish water appears to be a requirement for these species and hence they are classified as brackish water species in this study. As with some fresh water species there is again a very distinctive disjunct distribution of this genus. The British species closely resembles *T. pratensis*, found on the coast of far eastern Russia, a gap of 8600 km.

The disjunct distribution of this brackish water fauna is unexpected, due to the fact that brackish water faunas can only migrate along coastlines rather than across continents. Migration from the Japan Sea area to Europe, or visa versa would involve an extremely long migration route, through many climatic zones.

IV. Summary

Although the data of fresh and brackish water ostracods from the circum-Japan Sea area is patchy, there are several significant distribution patterns.

There are a high proportion of fresh and brackish water species reported from around the Japan Sea that are currently unknown outside this area. More such species are expected to be found in the future, especially from Lake Biwa.

There appears to be a connection of some species with European species, but the distribution of such species is disjunct, separated by thousands of km. The evolution of the Japan Sea most probably played a significant role in the distribution of these species today and further research will help in clarifying the situation.

Acknowledgements

I thank Professor Kamiya for his help and encouragement of my studies on fresh and brackish water ostracods from Japan. I am also grateful to Dr. David Horne for data from the Non-marine Database of Europe (NODE).

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