

***Rotaia* (Rhynchonellida, Brachiopoda) from the Lower Carboniferous of northeast Japan and its palaeobiogeographical significance**

by

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Abstract

The rhynchonellid brachiopod genus *Rotaia* is first recorded from the Lower Carboniferous in Japan. The specimen of *Rotaia* sp. is described from the Hikoroichi Formation (Member HK2; lower Visean) of the Hikoroichi district, southern Kitakami Mountains, northeast Japan. The occurrence of *Rotaia* together with two brachiopod genera *Marginatia* and *Syringothyris*, from the Tournaisian to lower Visean of the southern Kitakami Mountains, suggests that this region was biogeographically connected with the Tienshan-Inner Mongolia-Jilin region of northern China in Tournaisian to early Visean time.

Key words : *Rotaia*, Lower Carboniferous, southern Kitakami Mountains, palaeobiogeography

Introduction

Rotaia Rzhonsnitskaja is a large Carboniferous rhynchonellid genus belonging to the family Tetracameridae Likharew. This genus was established by Rzhonsnitskaja in 1959, with *Rhynchonella subtrigona* Meek and Worthen, 1860 from the Keokuk Limestone of Illinois as the type species. Until now 12 species of *Rotaia* have been known from the Tournaisian to Bashkirian, or from the Kinderhookian and Osagean, of the U.S.A., Russia, Kazakhstan, Mongolia, Kashmir, China and Australia.

Recently a pedicle valve specimen of *Rotaia* was discovered by myself from the Lower Carboniferous of the southern Kitakami Mountains, northeast Japan. This is the first record of *Rotaia* in Japan. The single specimen described here as *Rotaia* sp. was collected from the upper part of the Lower Hikoroichi Formation (Member HK2; lower Visean, after Tazawa, 1985) at the Onimaru

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quarry in the Hikoroichi district, southern Kitakami Mountains (Figs. 1, 2). In this locality many brachiopods occur from the same horizon, and several of them, such as *Buxtonia* sp., *Marginatia* sp., *Linoprotonia* sp., *Unispirifer* sp. and *Lamellosathyris lamellosa* (Léveillé) have been described by Tazawa (1985, 1989).

The purpose of this paper is to describe the specimen of *Rotaia* sp. from the Lower Carboniferous of the southern Kitakami Mountains and to discuss its palaeobiogeographical significance.

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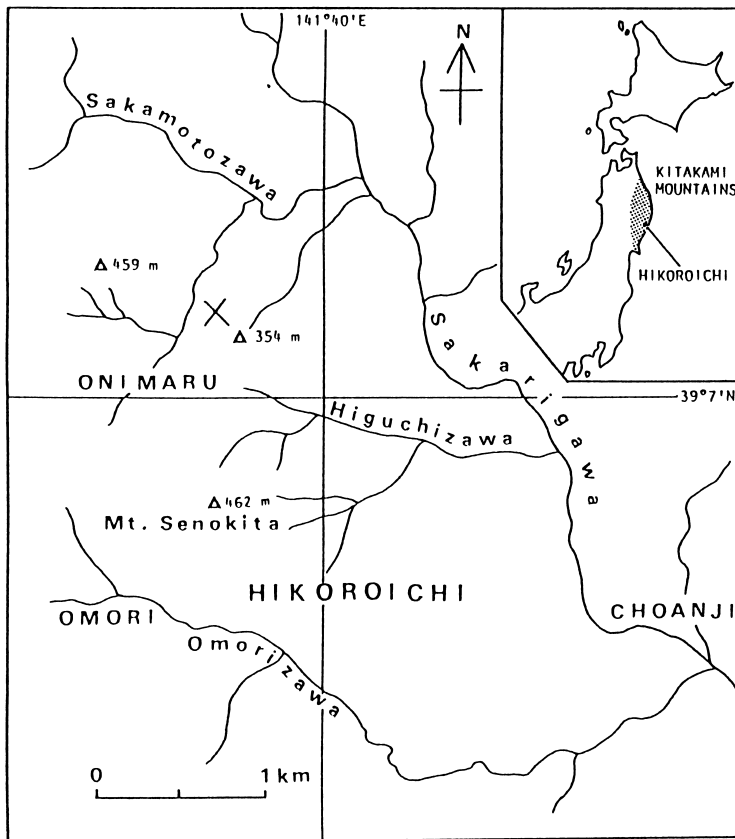


Fig. 1. Map showing the fossil locality (X).

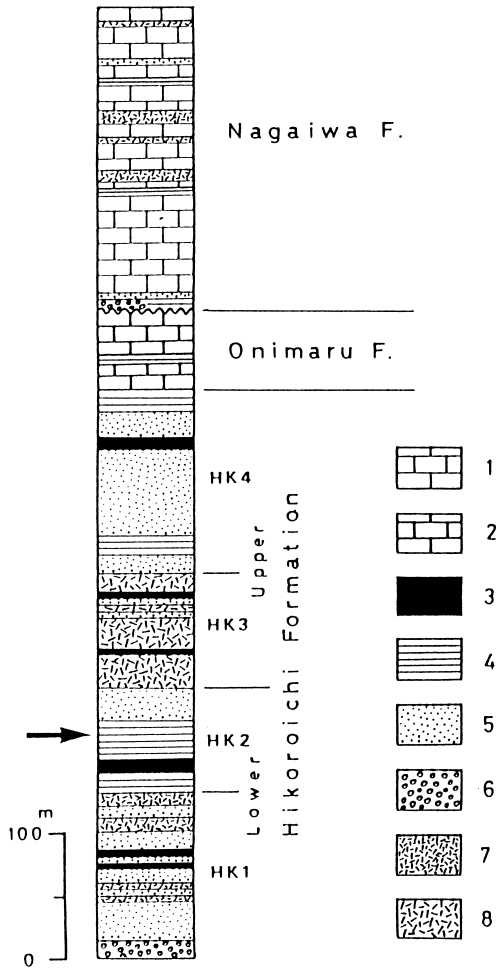


Fig.2. Columnar section of the Carboniferous in the Hikoroichi district, showing the stratigraphical position of the fossil locality (arrow). 1-3: limestone (1: Nagaiwa Formation, 2: Onimaru Formation, 3: Hikoroichi Formation), 4: shale, 5: sandstone, 6: conglomerate, 7, 8:tuff (7: lower Hikoroichi and Nagaiwa Formations, 8: upper Hikoroichi Formation). (Redrawn and adapted from Tazawa, 1984).

Distribution of *Rotaia*

The genus *Rotaia* is distributed in the upper Kinderhookian to upper Osagean (correlative with the lower Tournaisian to lower Viséan) of the U.S.A., and in the middle Tournaisian to upper Bashkirian, mostly in the upper Tournaisian to lower Namurian of Russia, Kazakhstan, Mongolia, China, Japan and Australia (Fig. 3, Table 1). The following 13 species are known at present.

Rotaia subtrigona (Meek and Worthen, 1860), from Osagean (Burlington and Keokuk Limestones) of Missouri, Iowa and Illinois, U.S.A. (Meek and Worthen, 1860, 1866; Hall and Clarke, 1895; Weller, 1910, 1914); middle Tournaisian to upper Viséan (Taidonian, Tersinian and Verkhotomian Horizons) of the Kuznetsk Basin (Rotai, 1941; Sarytcheva *et al.*, 1963); lower

Bashkirian of the central Taimyr Peninsula (Ustritskiy and Tschernjak, 1963); Visean (Kichivayamskaya Formation) of the Chukchi Peninsula, eastern Siberia (Nikolskaya and Stepanov, 1979); upper Tournaisian to lower Visean (Rusakovian and Ishimian Horizons) of northeastern Kazakhstan (Nalivkin, 1937; Simorin, 1956); upper Tournaisian (Bukhtarminskaya Formation) of the northern Altay Mountains (Gretchischnikova, 1966; Bublitschenko, 1976); upper Tournaisian to lower Visean (Tiparinskaya Formation) of the upper Amur River region (Modzalevskaja, 1969); lower Visean (lower and middle Datangian) of north and east Xinjiang, northwest China (Zhang *et al.*, 1983; Lin, 1990).

Rotaia dowhatensis (Diener, 1915), from Visean (Fenestella Shales) of Kashmir (Diener, 1915; Waterhouse and Gupta, 1977, 1979); upper Visean to lower Namurian (Naxing Group) of Mt. Xixabangma in the Himalayas (Yang and Fan, 1983; Sheng *et al.*, 1990).

Rotaia sibirica (Rotai, 1938), from Visean (Verkhotomian Horizon) of the Kuznetsk Basin (Rotai, 1938; Besnossova *et al.*, 1962; Sarytcheva *et al.*, 1963); upper Namurian of the southern Verkhoyanskiy Mountains, Siberia (Abramov, 1970).

Rotaia kusbassi (Rotai, 1938), from upper Visean to lower Namurian (Ostrogskaya Formation) of the Kuznetsk Basin (Rotai, 1938; Besnossova *et al.*, 1962; Sarytcheva *et al.*, 1963); Middle Carboniferous (Gutayskaya Formation) of western Zabaykal, Russia (Kotljar and Popeko, 1967).

Rotaia golikovi Abramov and Grigorjeva, 1983, from lower Middle Carboniferous (Natalinskiy Horizon) of the southern Verkhoyanskiy Mountains, Siberia (Abramov and Grigorjeva, 1983).

Rotaia sp. cf. *R. subtrigona* (Meek and Worthen, 1860), from upper Visean (Lower Burindi Group) of Babbinboon, New South Wales, eastern Australia (Campbell, 1957).

Rotaia sp. cf. *R. subtrigona* (Meek and Worthen, 1860), from Visean of the Kolyma River region, Siberia (Mironova, 1963).

Rotaia sp. aff. *R. subtrigona* (Meek and Worthen, 1860), from upper Visean of Qimantagshan, Qinghai-Xinjiang boundary region, northwest China (Wang, 1990).

Rotaia sp. cf. *R. kusbassi* (Rotai, 1938), from upper Visean to lower Namurian of Chen Barag Qi, northeastern Inner Mongolia (Lin, 1990).

Rotaia sp. aff. *R. kusbassi* (Rotai, 1938), from upper Visean of southern Gobi, Mongolia (Ruzhentsev and Badarch, 1988).

Rotaia sp., from upper Kinderhookian to lower Osagean (Chappel Limestone) of central Texas, U.S.A. (Carter, 1967).

Rotaia sp., from upper Visean to lower Namurian (Lueyang Formation) of Shaanxi, northwest China (Wu, 1990).

Rotaia sp., from lower Visean (upper Lower Hikoroichi Formation) of the southern Kitakami Mountains, northeast Japan (this paper).

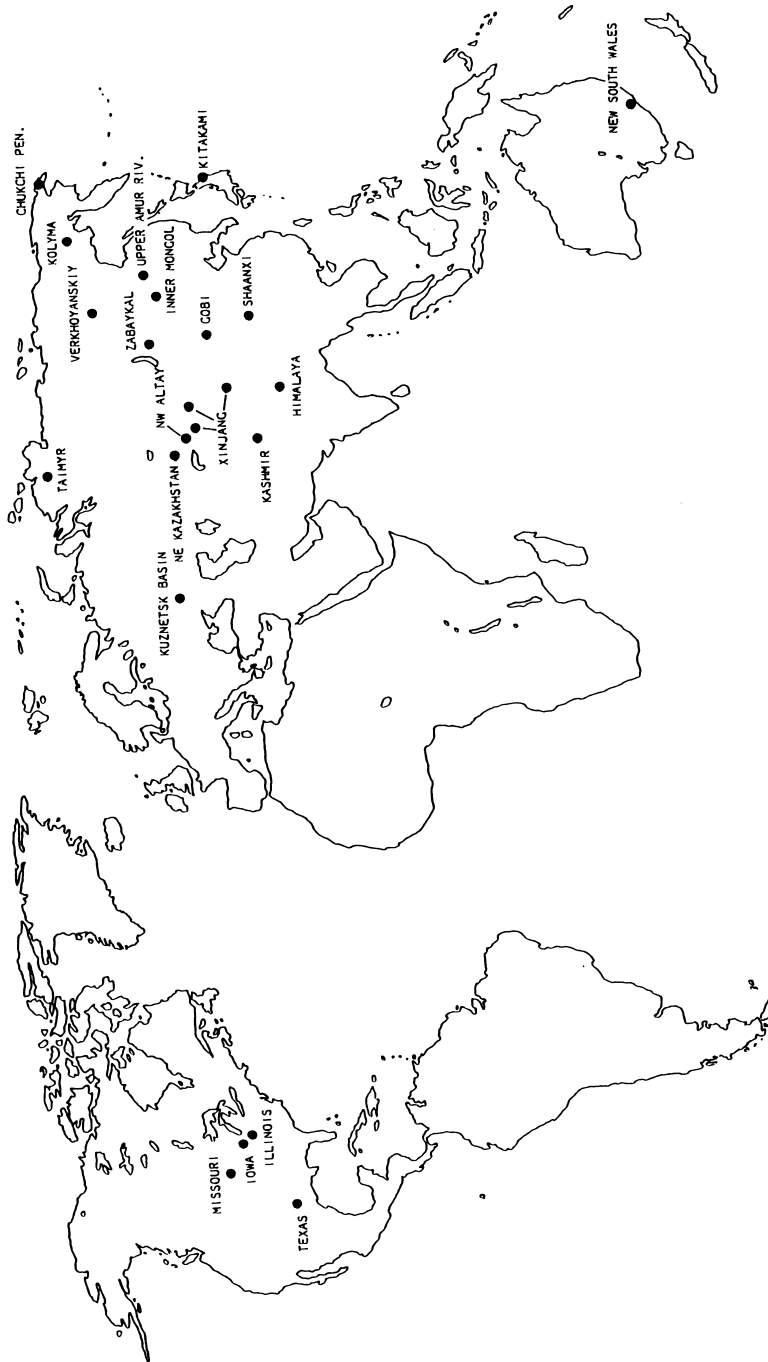


Fig. 3. Geographical distribution of *Rotaia*.

Table 1. Stratigraphical and geographical distributions of *Rotaia*.

Species	Carboniferous								Region	
	Lower				Middle					
	Tournaisian		Viséan		Namurian		Bashkirian			
	L	M	U	L	U	L	U	L		U
<i>R. subtrigona</i>		+	+	+						U.S.A. (Missouri, Iowa, Illinois)
		+	+	+	+					Russia (Kuznetsk Basin)
								+		Russia (Taimyr Peninsula)
					+	+				Russia (Chukchi Peninsula)
		+	+							Russia (Upper Amur River)
				+	+					Kazakhstan (NE Kazakhstan)
					+					Kazakhstan (Altay Mts.)
					+				China (Xinjiang)	
<i>R. dowhatensis</i>				+	+					Kashmir
					+	+				China (Himalayas)
<i>R. sibirica</i>				+	+					Russia (Kuznetsk Basin)
								+		Russia (Verkhoyanskiy Mts.)
<i>R. kusbassi</i>					+	+				Russia (Kuznetsk Basin)
						+	+	+	+	Russia (Zabaykal)
<i>R. golikovi</i>						+	+			Russia (Verkhoyanskiy Mts.)
<i>R. cf. subtrigona</i> (Campbell, 1957)					+					Australia (New South Wales)
<i>R. cf. subtrigona</i> (Mironova, 1963)				+	+					Russia (Kolyma River)
<i>R. aff. subtrigona</i>					+					China (Qinghai-Xinjiang)
<i>R. cf. kusbassi</i>					+	+				China (Inner Mongolia)
<i>R. aff. kusbassi</i>					+					Mongolia (Gobi)
<i>R. sp.</i> (Carter, 1967)	+	+								U.S.A. (Texas)
<i>R. sp.</i> (Wu, 1990)					+	+				China (Shaanxi)
<i>R. sp.</i> (this paper)					+					Japan (Kitakami Mts.)

Palaeobiogeographical significance of *Rotaia*

In the noticeable work on early Carboniferous brachiopod biogeography of China, Yang (1983) treated *Rotaia* as an important element of the early Early Carboniferous (Tournaisian to early Viséan)

brachiopod fauna of the North China Province, which covers the Tienshan-Inner Mongolia-Jilin region, and is characterized by the presence of *Marginatia-Syringothyris-Rotaia* assemblage.

It is noteworthy that the fauna of the Onimaru quarry in the Hikoroichi district, southern Kitakami Mountains contains both *Marginatia* and *Rotaia*. In addition, some *Syringothyris* species have been described by Minato (1951, 1952) and Tachibana (1969) from the Tournaisian beds of the Hikoroichi, Yokota, Shimoarisu and Nagasaka districts in the southern Kitakami Mountains. The above data suggest that the South Kitakami region was biogeographically close to the North China Province of Yang (1983), i.e., the Tienshan-Inner Mongolia-Jilin region of northern China in Tournaisian to early Visean time. This expectation is in harmony with the Middle Permian brachiopod biogeography of east Asia shown and discussed by Tazawa (1991) and Shi *et al.* (1995). According to them, the South Kitakami region was biogeographically and also geographically connected with the southern part of the Inner Mongolia-Northeast China region in the Middle Permian time.

Systematic descriptions

Order Rhynchonellida Kühn, 1949

Superfamily Rhynchonellacea Gray, 1848

Family Tetracameridae Likharew *in* Rzhonsnitskaja, 1956

Genus *Rotaia* Rzhonsnitskaja, 1959

Rotaia Rzhonsnitskaja, 1959, p. 30; Rzhonsnitskaja *et al.*, 1960, p. 249; Schmidt and McLaren, 1965, p. H588.

Type species: -*Rhynchonella subtrigona* Meek and Worthen, 1860, from the Keokuk Limestone of Warsaw, Illinois (Meek and Worthen, 1860, p. 451), by original designation of Rzhonsnitskaja *et al.* (1960, p. 249).

Diagnosis: -Medium to large Tetracameridae, with shallow ventral sulcus and low dorsal fold, and ornamented by broad, rounded costae. Spondylium supported by a pair of buttress plates. Septalium partly covered by discrete inner hinge plates.

Remarks: -Meek and Worthen (1860) did not illustrate the type specimens in their original description. Later, they presented some figures of the type specimens (Meek and Worthen, 1866, pl. 18, figs. 7a-c). Subsequently, the internal structures of shell were described and illustrated in detail by

Weller (1910, p. 505, text-fig. 5) on the materials from the Keokuk Limestone of Keokuk, Iowa.

The shell outline of *Rotaia* is commonly transverse, but *R. dowhatensis* (Diener, 1915) from the Fenestella Shales of Kashmir has a variety of shells from transversely elongate to a form of slightly longer than wide (Diener, 1915, p. 45). The present species from the Hikoroichi Formation of the southern Kitakami Mountains may be a species of the elongate form, although the Kitakami species is represented by a single, badly preserved specimen.

Rotaia sp.

Figs. 4a, 4b

Material: -One specimen, fragmentarily preserved external and internal moulds of a pedicle valve, NU-B49, from the upper part of the lower Hikoroichi Formation (Member HK2; lower Visean) at the Onimaru quarry, Onimaru, Hikoroichi-cho, Ofunato City, Iwate Prefecture, i.e., the Hikoroichi district, southern Kitakami Mountains, northeast Japan. The single specimen is stored in the Department of Geology, Faculty of Science, Niigata University.

Descriptive remarks: -Shell of large size for genus, longer than wide and subovate in outline; length about 50 mm, width about 44 mm. Pedicle valve moderately convex near umbo, becoming slightly convex to flat anteriorly. Sulcus very shallow and ill defined. External ornament of pedicle valve consists of broad and rounded costae, numbering 18 on the whole surface of the pedicle valve. Pedicle valve interior with a small, elongate spondylium, extending to one-third length of the valve. External and internal features of brachial valve unknown.

In spite of the ill state of preservation, the specimen from the Onimaru quarry can be assigned to the genus *Rotaia* on account of its large size, external ornament of broad and rounded costae, and possessing a spondylium in the pedicle valve.

This specimen somewhat resembles shells of *R. dowhatensis* (Diener, 1915) from the Fenestella Shales of Kashmir (Diener, 1915, p. 45, pl. 5, figs. 1-4) in outline of shell and having a shallow ventral sulcus. But the Kitakami specimen is larger in size than the Kashmirian shells.

The type species, *R. subtrigona* (Meek and Worthen, 1860) is readily distinguished from the Kitakami species by its smaller, wider, and subtrigonal to subpentagonal shell (see Weller, 1914, pl. 29, figs. 1-13).

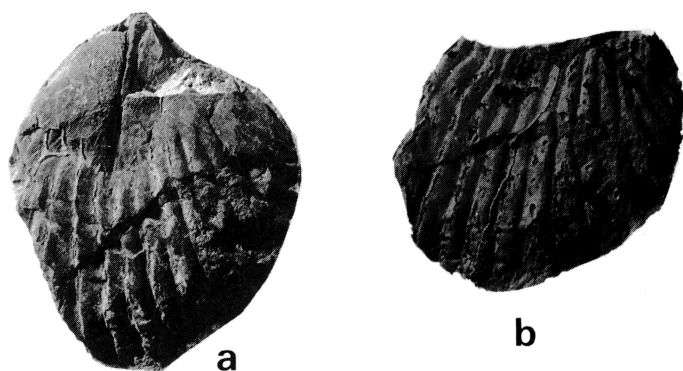


Fig. 4. *Rotaia* sp. from the upper part of the lower Hikoroichi Formation at the Onimaru quarry, Hikoroichi district, southern Kitakami Mountains. Internal mould (a) and external rubber cast (b) of a pedicle valve specimen, NU- B49. (× 1).

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