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Late Mesozoic bivalves of the Tetori Group, Japan

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Abstract

The Tetori Group of Japan is one of the most important late Mesozoic deposits showing shallow marine to fluvio-lacustrine environments in East Asia. Rich bivalve fossil faunas indicating marine through brackish to fresh-water water environments are recognized in the group. Additionally, three intercalated marine transgressions, from Bathonian to Oxfordian in age, from Tithonian to Berriasian in age, and from Hauterivian to Barremian in age, have been identified in the Tetori Group, based on ammonite indices. These transgressions are also reflected in bivalve faunal assemblage development.

To establish the above observations, we summarized the present status of the classification of bivalve fossils hitherto described from the Tetori Group, and revised and updated generic and specific names. Previously, 49 species of marine and nonmarine bivalves have been described from the group. In this paper, we have added 24 species to this total, including two new species from both the Kiritani and Magawa formations, and 8 species including three new species and three new genera from other formations of the group. Thus, a total of 81 species of bivalves is now recognized from the Tetori Group. Among these 65 species belong to 30 genera of marine bivalves, and 16 species belong to 13 genera of nonmarine bivalves. Almost all of the bivalve species are regarded as endemic species, the known distribution of which is restricted to Japan and its adjacent area. The biostratigraphic distributions of the species are almost always of short temporal duration, as constrained by well-dated, marine transgressions and regressions within the Tetori Group succession.

Keywords: Late Mesozoic, Tetori Group, marine bivalves, nonmarine bivalves

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Introduction

Late Mesozoic nonmarine deposits, consisting mainly of terrestrial and fluvio-lacustrine strata, are distributed widely across the Asian continent. Marine intercalations in those nonmarine deposits can be recognized only in Jurassic and Cretaceous deposits in Far East China and the Tetori area of the inner zone of southwest Japan. Considering the

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distribution of both marine and non-marine facies allows reconstruction of the late Mesozoic paleogeography and paleoenvironments of the eastern part of Asia, as well as their changes through time.

In late Mesozoic time, the Japanese Islands had not yet rifted from the East Asian margin and the basin of the Tetori Group was located in the most eastern extremity of the Asian continent. Thus, the Tetori basin is one of the most important late Mesozoic deposits showing shallow marine to fluvio-lacustrine environments of East Asia (Fig. 1). Since bivalve fossil faunas indicating marine through brackish water to fresh-water environments are found in the Tetori Group, we can reconstruct paleoenvironments of the group using those molluscan faunas.

Previous studies of the systematic paleontology of bivalve fossils from the Tetori Group include those of Kobayashi and Suzuki (1937), Kobayashi (1956, 1957), Hayami (1959a, b, 1960a), Maeda (1962a, b, c, d, 1963), Maeda and Kawabe (1963, 1966), Ota (1973) , Isaji (1993), Komatsu et al. (2003) and Matsukawa and Fukui (2009). Since those studies new discoveries and changes in classification criterion have taken place and a re-assessment of the paleontological systematics of bivalves from the Tetori Group has thus become necessary. In this paper, we describe bivalve species from the Tetori Group systematically.

I. Geological setting, and bivalve fossil localities and stratigraphic levels

The Tetori Group is distributed in two principal regions of southwest Japan, referred to here as the Hakusan and Jinzu sections. Maeda (1961) proposed many different formation names for the stratigraphic units preserved in each of these two regions and Matsukawa et al. (2003a, 2006, 2007, 2014a, b) subsequently redefined the lithostratigraphic units of the Tetori Group and proposed unified definitions and nomenclature for the diverse strata in both of the regions. These latter workers also produced a geological map based on a coherent stratigraphic sequence throughout the Tetori Group outcrop region. In this paper, we follow the stratigraphic scheme of Matsukawa et al. (2003a, 2006, 2007, 2014a, b) in the full area of the Tetori Group (Table 1).

1. Hakusan Section

The Hakusan section contains the main "type" stratigraphic sections of the Tetori Group and bears rich phyto- and zoo-fossils, including bivalves. There are three stratigraphic sequences of the Tetori Group in the Hakusan section: the Kuzuryugawa sequence, the Hakusan sequence, and the Hida-Furukawa sequence (Matsukawa et al., 2006, 2007) (Figs. 2, 3-1, 3-2, 4-1, 4-2, 4-3, 5).

1.1 Kuzuryugawa Sequence

In the Kuzuryugawa region, the Tetori Group is composed of conglomerate, sandstone, muddy sandstone and mudstone, and can be divided into eight formations: the Shimoyama, Tochimochiyama, Kaizara, Yambarazaka, Yambara, Ashidani, Izuki, and *Nochino* formations, in ascending order (Matsukawa et al., 2003c, 2006). Based on ammonites, including *Pseudoneuqueniceras yokoyamai*, *Oxycerites* cf. *sulaensis*, and *Kranaosphinctes matsushimai*, the Kaizara Formation is assignable from the Bathonian to the Callovian (Sato, 1962; Sato and Westermann, 1985, 1991), and the Yambarazaka Formation is assignable to the Oxfordian.

Marine bivalve fossils are found in the Kaizara and Yambarazaka formations; *Inoceramus*? *naganoensis* Hayami, *Inoceramus* cf. *nitescens* Hayami, and *Inoceramus hamadae* Hayami were described from the Kaizara Formation by Hayami (1960a). *Myophorella* (*Promyophorella*) *orientalis* Kobayashi and Tamura (Maeda and Kawabe, 1963), *Latitrigonia tetoriensis* Kobayashi (Kobayashi, 1957; Maeda and Kawabe, 1963), *Latitrigonia orbicularis* Kobayashi (Kobayashi, 1957; Maeda and Kawabe, 1963), *Latitrigonia horii* Maeda (Maeda, 1963), *Latitrigonia kasaii* Maeda (Maeda, 1963), *Ibotrigonia tetoriensis* Maeda (Maeda, 1963), *Vaugonia yambaraensis* Kobayashi (Kobayashi, 1957; Yambara conglomeratic sandstone [=Yambara Formation of Matsukawa et al., 2003b]), *Vaugonia fukuiensis* Maeda (Maeda and Kawabe, 1963), and *Vaugonia kuzuryuensis* Maeda (Maeda, 1963) are all recognized from the Yambarazaka Formation. Nonmarine bivalve fossils described in this paper are from the Izuki Formation (Table 2).

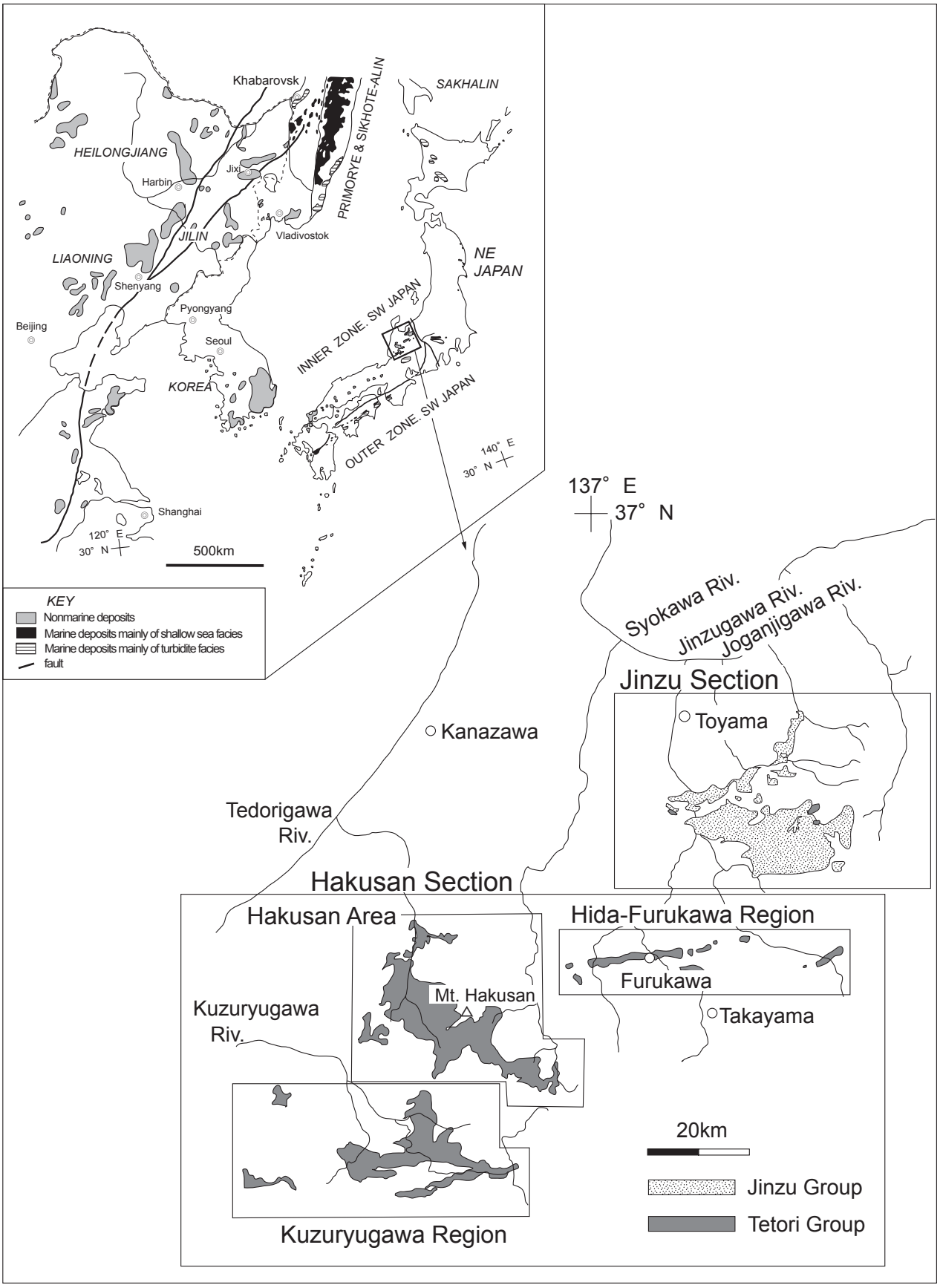

Fig.1. Map showing Jurassic – Lower Cretaceous exposures in East Asia and the main distribution of the Tetori Group in Japan. Riv.: River, Mt.: Mountain. Modified from Matsukawa and Fukui (2009).

Table 1. Summary of locality names used in previous studies of Tetori Group stratigraphy, and consolidated names utilized in this study.

Area	Formation	Matsukawa and Ido (1993)	Matsukawa and Nakada (1999)	Matsukawa et al. (1999)	Matsukawa et al. (2000)	Matsukawa et al. (2003c)	Matsukawa et al. (2006)	Matsukawa and Fukui (2009)	Matsukawa and Asahara (2010)	Matsukawa et al. (2014a)	This study (following Matsukawa et al., 2006)
Hida-Furukawa Region	Inagoe Fm.							KT-01			KT-01
								KT-02			KT-02
								MK-02			MK-02
								H-01			H-01
								WT-03			WT-03
								WT-04			WT-04
	Taie Fm.							KR-01			KR-01
								KR-05			KR-05
								NB-02			NB-02
								TE-01			TE-01
								ON-01			ON-01
								Heb-01			Heb-01
								Sz-01			Sz-01
	Sugizaki Fm.							NB-01			NB-01
	Numamachi Fm.							KJ-02			KJ-02
Hakusan Area	Amagodani Fm.								UT-1		UT-1
									UT-3		UT-3
									TY-1		TY-1
	Okurodani Fm.	KT-00					M37				M37
		KT-01					M36				M36
		KT-02					M35				M35
		KT-03					4				4
							50				50
		KT-05					2				2
			OK-11								OK11
			OK-13								OK13
		OT-02	OK-17C								OK17C
		OT-02	OK-17B								OK17B
		OT-02	OK-17A								OK17A
		OK-001		OK-21D		OK21	OK21				OK21
		OK-001		OK-21C		OK21	OK21				OK21
		OK-001		OK-21B		OK21	OK21				OK21
		OK-001		OK-21A		OK21	OK21				OK21
		OK-002		OK-22B		OK22	OK22				OK22B
		OK-002		OK-22A		OK22	OK22				OK22A
		OK-003		OK-23		OK23	OK23				
			OK-24				OK24				OK24
			OK-31				OK31				OK31
			OK-51				OK51				OK51
				OS-14			OS14				OS14
				OS-10A			OS10				OS10A
				OS-10D			OS10				OS10D
				OS-10E1			OS10				OS10E1
				OS-10G			OS10				OS10G
				OS-10H			OS10				OS10H
	Kuwajima Fm.	KWJ-01					M18				M18
		KWJ-02					M19				M19
		KWJ-03					9				9
		KWJ-04					M4				M4
		KWJ-06					M2				M2
		KWJ-10					M6				M6
		KWJ-11					M5				M5
		KWJ-12					44				44
											MK03
							7				7
					HD-01-05		HD01				HD01-05
					HD-01-04		HD01				HD01-04
					HD-01-03		HD01				HD01-03
					HD-01-02.1		HD01				HD01-02-1
					HD-01-02.2		HD01				HD01-02-2
					HD-01		HD01				HD01-01
	Otaniyama Fm.	OT-01	OK-19				OK19				OK19
			OK-52F				OK52				OK52F
			OK-52E				OK52				OK52E
			OK-52D				OK52				OK52D
			OK-52C				OK52				OK52C
			OK-52B				OK52				OK52B
			OK-52A				OK52				OK52A
	Ushimaru Fm.		US-10A				US10				US10A
			US-10D				US10				US10D
			US-10E				US10				US10E
			US-21A				US21				US21A
			US-21B				US21				US21B
			US-21E				US21				US21E
			US-21L				US21				US21L
Kuzuryugawa Region	Izuki Fm.								UT-1		UT-1
									UT-2		UT-2
									UT-3		UT-3
									UT-4		UT-4
									UT-5		UT-5
									YU-1		YU-1
		IZ-13				2 (IZ-013)	51				IZ13
						2 (IZ-011)	51				IZ11
		IZ-10				2 (IZ-010)	51				IZ10
		IZ-09				2 (IZ-009)	51				IZ09
		IZ-03				2 (IZ-003)	51				IZ03
		IZ-05				2 (IZ-005)	51				IZ05
		IZ-06				2 (IZ-006)	51				IZ06
		IZ-04				2 (IZ-004)	51				IZ04
		IZ-02				2 (IZ-002)	51				IZ02
Jinzu Section	Kiritani Fm.										KIK
	Magawa Fm.										Mg07
										Mg-06	Mg06
										Mg-05	Mg05
										Mg-04	Mg04
										Mg-03	Mg03
										Mg-01	Mg01

Fm. = Formation

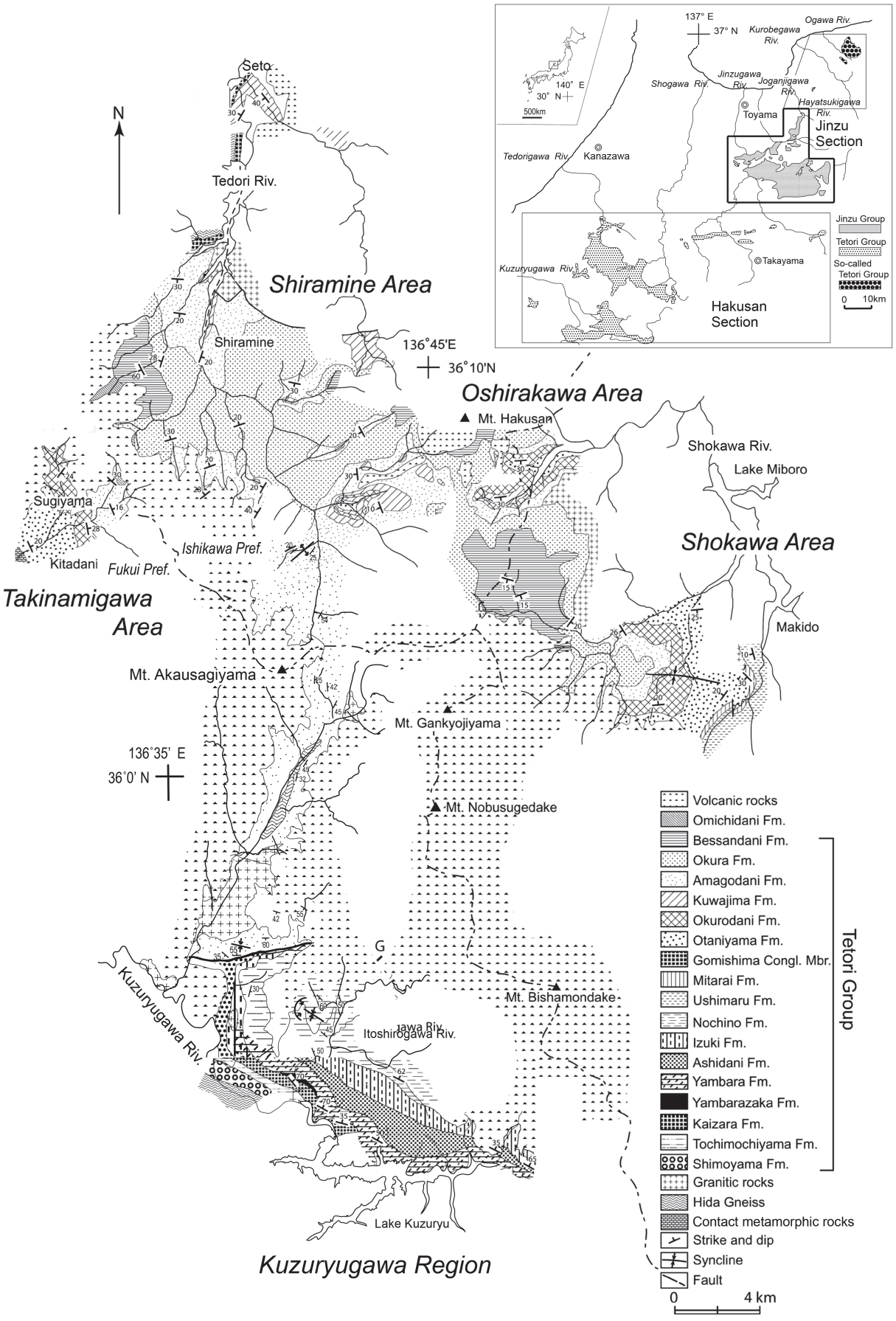

Fig.2. Geological map of the Tetori Group in Hakusan area and Kuzuryugawa region, Hakusan section, central Japan. Fm.: Formation, Mbr.: Member, Riv.: River, Mt.: Mountain, Pref.: Prefecture. After Matsukawa et al. (2008a).

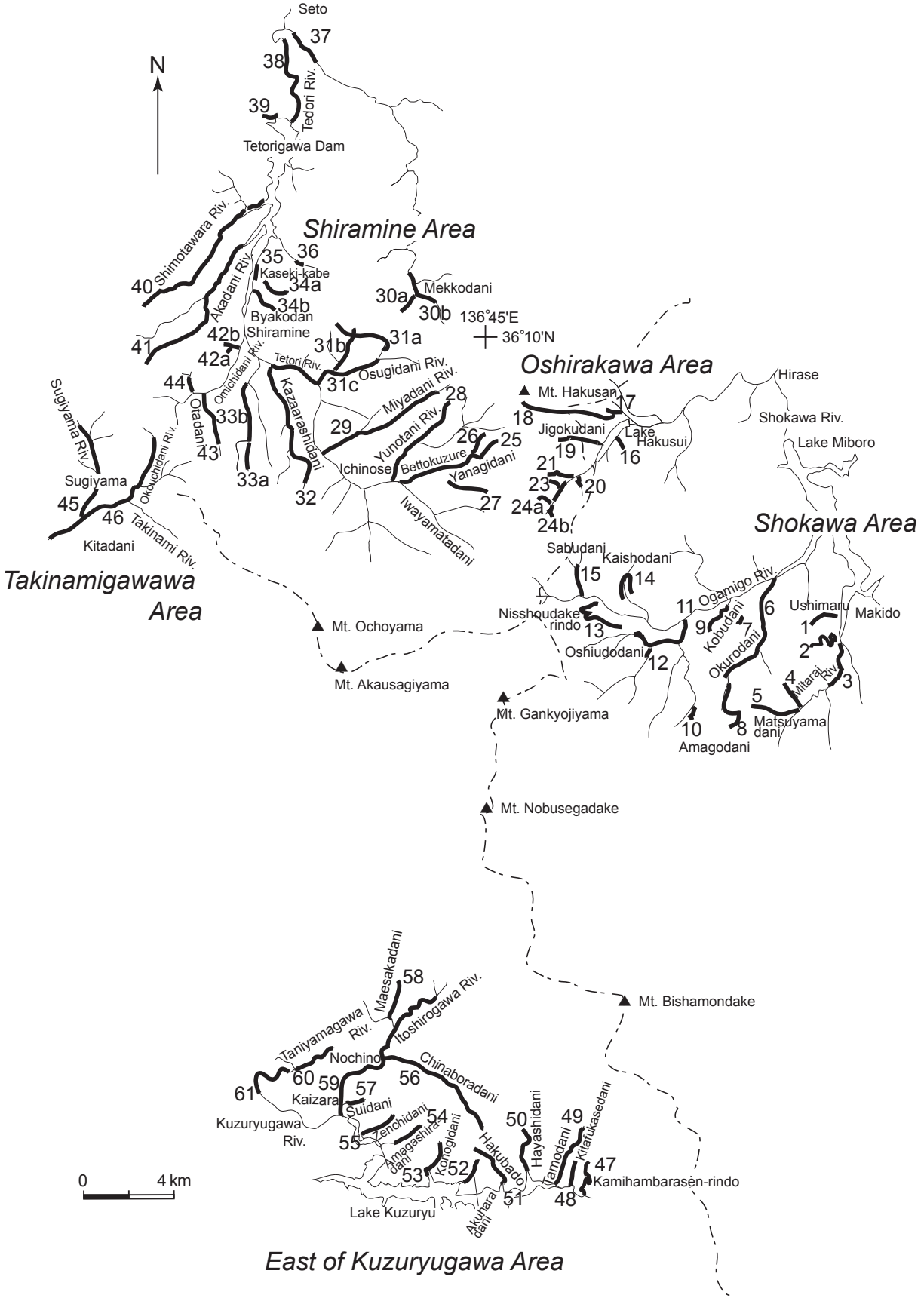

Fig.3-1. Map showing locations of the Hakusan area and Kuzuryugawa region, routes along which columnar sections were measured. Riv.: River, Mt.: Mountain. Compiled from Matsukawa et al. (2006).

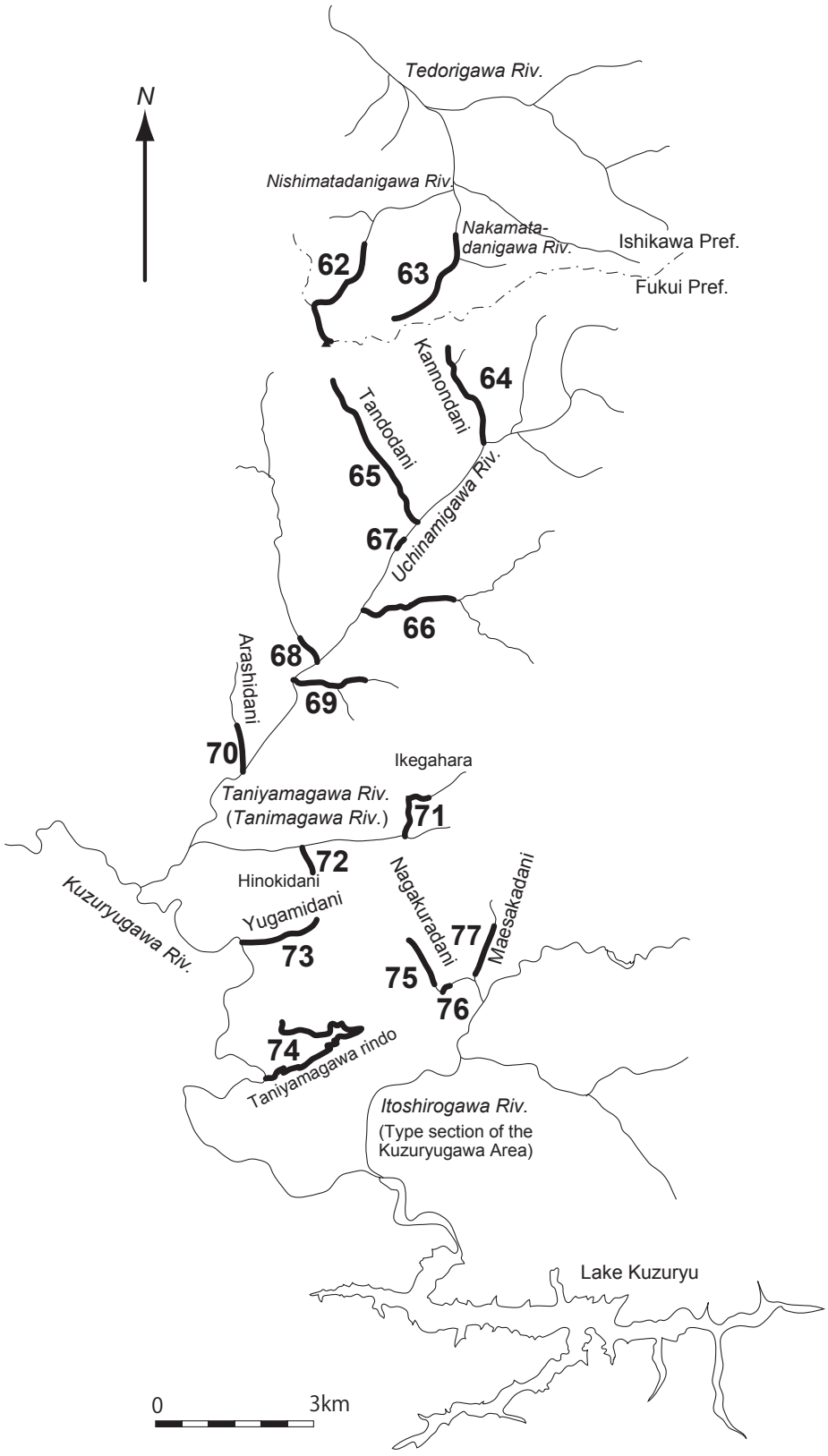

Fig.3-2. Map showing locations of the Takinamigawa area, routes along which columnar sections were measured. Riv.:River, Pref.: Prefecture. Modified from Matsukawa and Asahara (2010).

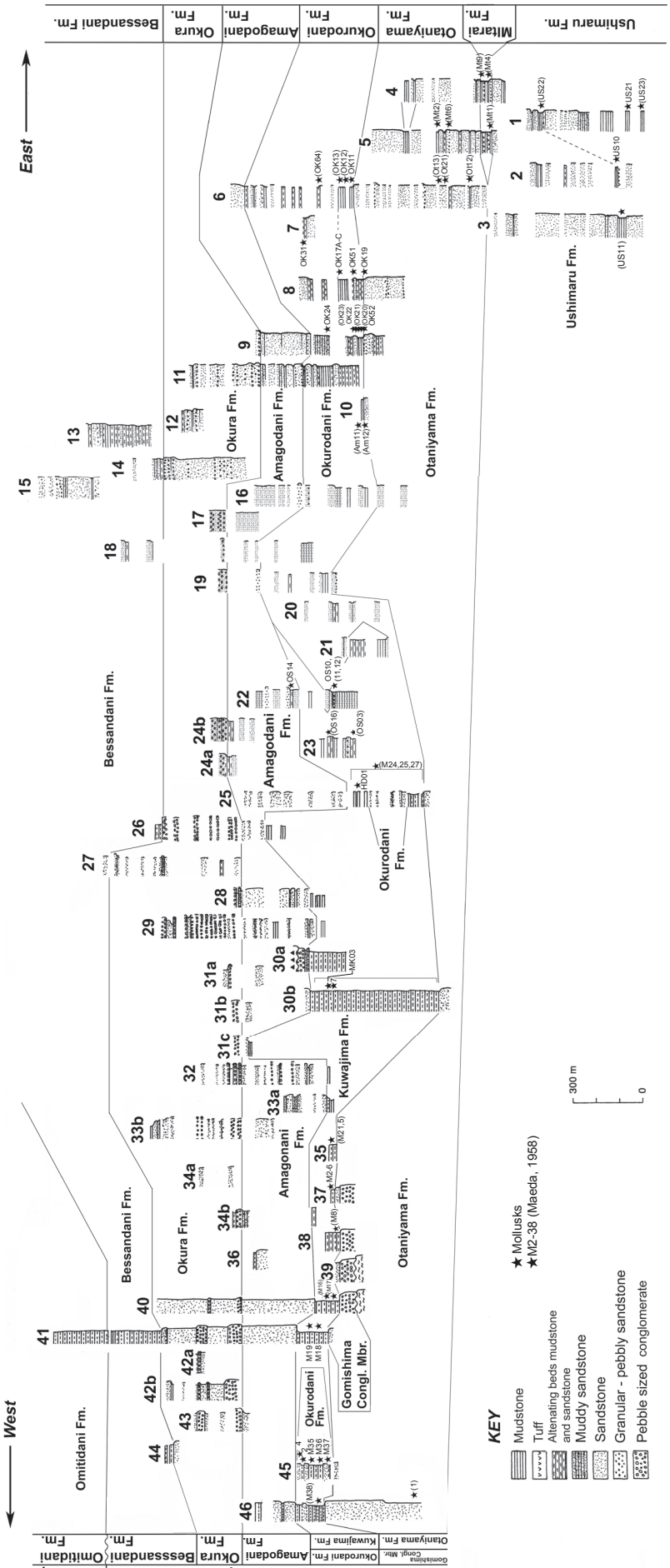

Fig.4-1. Individual columnar sections of the Tetori Group in the Hakusan area, Hakusan section, central Japan. Locations of numbered columns are shown on Figure 3-1. Fm.: Formation, Gp.: Group, Mbr.: Member. Modified from Matsukawa et al. (2006).

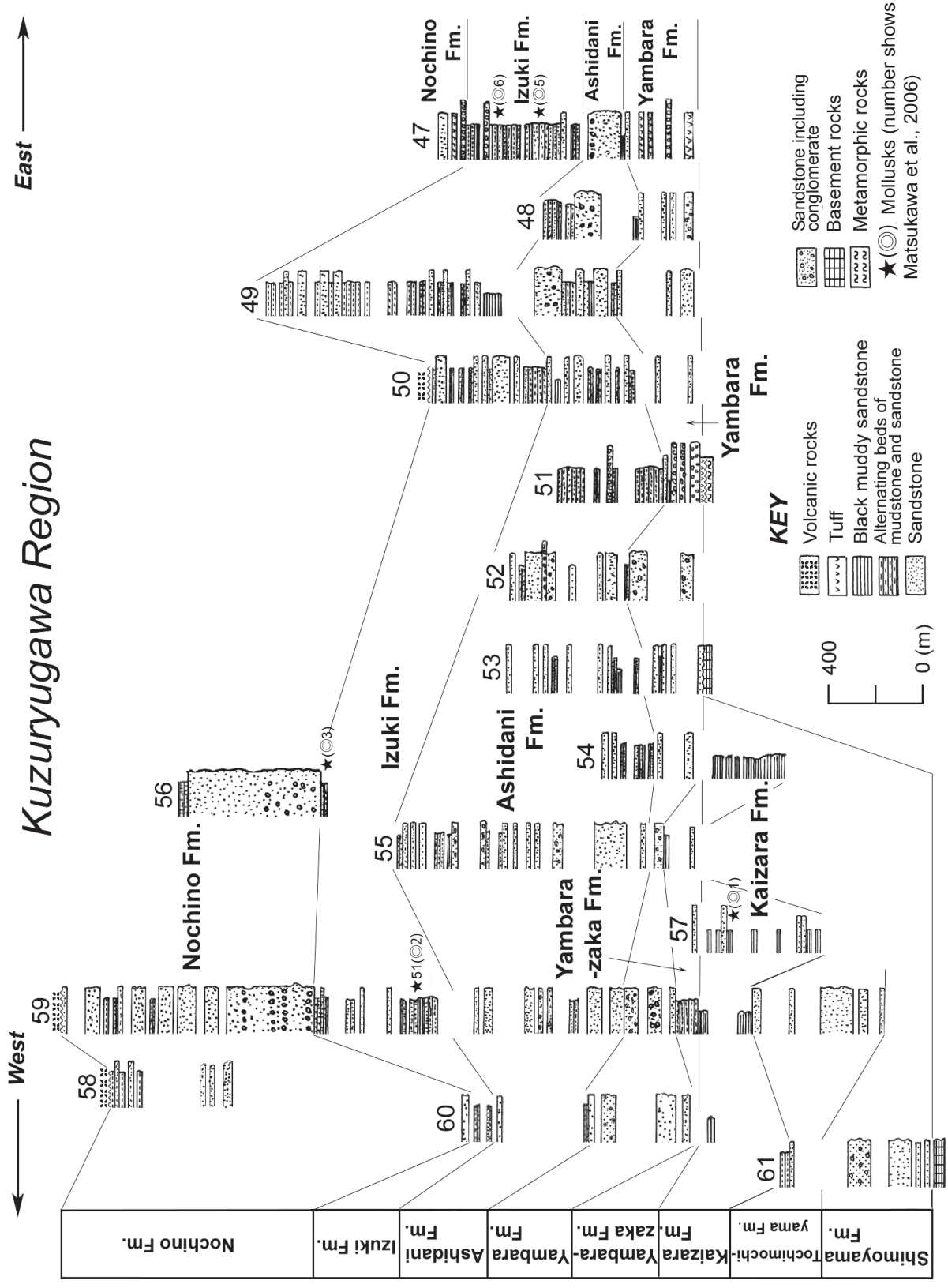

Fig.4-2. Individual columnar sections of the Tetori Group in the Kuzuryugawa region, Hakusan section. Locations of numbered columns are shown on map Figure 3-1. Fm.: Formation. Modified from Matsukawa et al. (2003c).

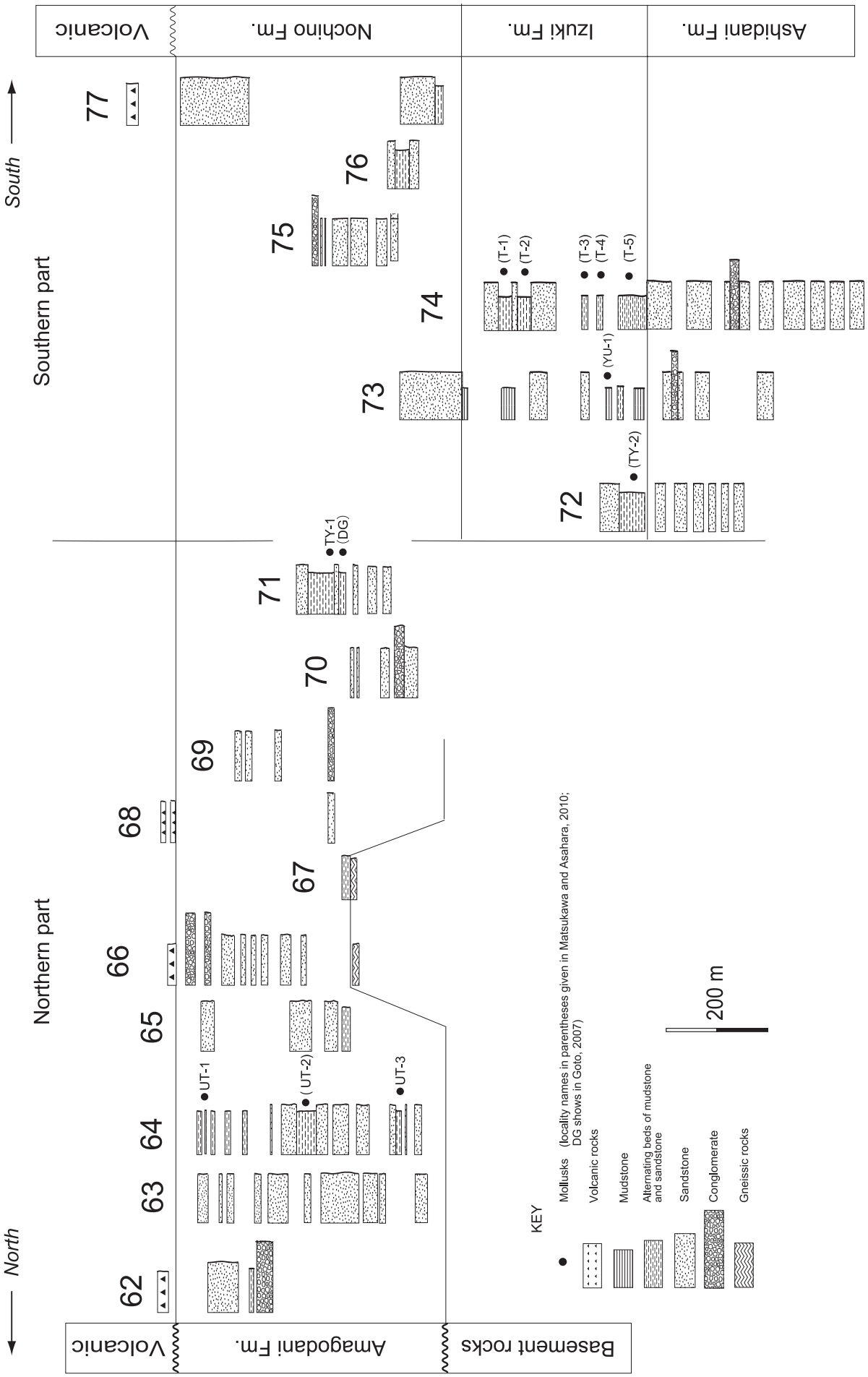

Fig.4-3. Columnar sections of the Tetori Group in the Takinamigawa area, Hakusan section. Locations of numbered columns are shown on map Figure 3-2. Fm.: Formation, DG shown in GOTO (2007). Modified from Matsukawa and Asahara (2010).

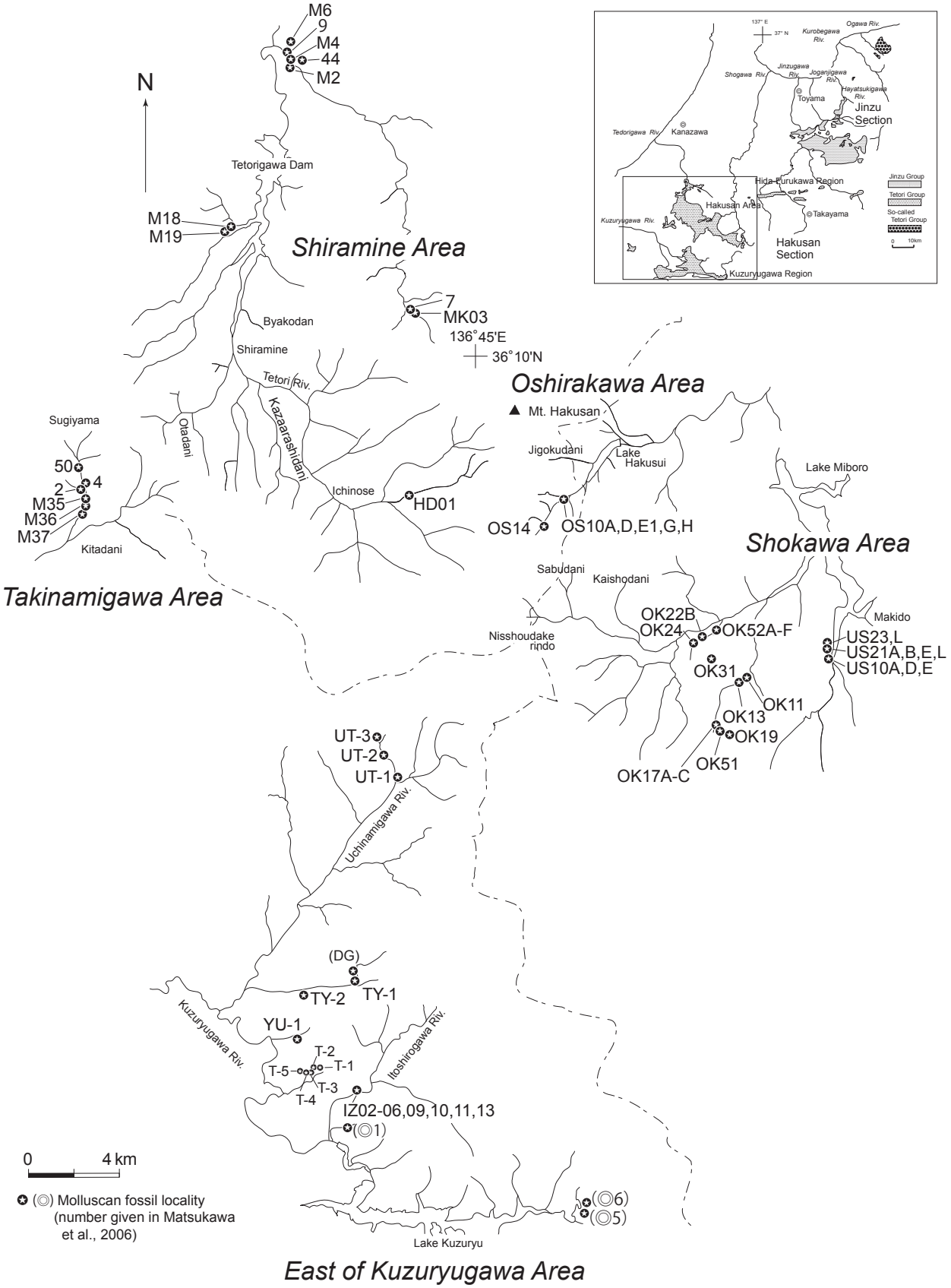

Fig.5. Map showing location of the fossil localities in the Hakusan area and Kuzuryugawa region, Hakusan section. Riv.: River, Mt.: Mountain.

Table 2. List of fossil species from the Izuki and Amagodani formations of the Tetori Group in the Kuzuryugawa region, Hakusan section, Fukui Prefecture, central Japan.

Taxa	Kuzuryugawa Region																						
	Kaizara Fm.	Yambarazaka Fm.	Yambara Fm.	Izuki Fm.																	Amagodani Fm.		
				51 (Matsukawa et al., 2006)									Matsukawa and Asahara (2010)						Fujita et al. (1998)			
				IZ02	IZ03	IZ04	IZ05	IZ06	IZ09	IZ10	IZ11	IZ13	T-1	T-2	T-3	T-4	T-5	YU-1	Loc. 3	UT-1	UT-3	TY-1
Inoceramus (*Inoceramus*) *maedae* Hayami																			3			
I. (*Mytiloides*) *hamadae* Hayami	■																					
I. (*M*.?) sp. A	■																					
I. ? *naganoensis* Hayami	■																					
Isognomonidae gen. et sp. indet.																				2		
Exogyrinae gen. et sp. indet.																				1	1	
Ostreinae gen. et sp. indet.											◎		●							5		
Unio antiqua (Kobayashi and Suzuki)						5																
Archaeounio kagaensis gen. nov.				1																		
Latitrigonia tetoriensis Kobayashi		◆																				
L. *orbicularis* Kobayashi		◆																				
L. *horii* Maeda	△(3)																					
L. *kasaii* Maeda	△(1)																					
Ibotrigonia tetoriensis Maeda	△(2)																					
Myophorella (*Promyophorella*) *orientalis* Kobayashi	△(2)	◆																				
Vaugonia (*Vaugonia*) *yambarensis* Kobayashi			◇																			
V. (*V*.) *fukuiensis* Maeda		▲																				
V. (*V*.) *kuzuryuensis* Maeda	◇(1)																					
Cultellidae gen. et sp. indet.						1																
Neomyrene tetoriensis (Kobayashi and Suzuki)			□	2	356	31	158	66	63	24		90	●	●	●	●	●	1		4	4	1
Tetoria yokoyamai (Kobayashi and Suzuki)					11	66				2		20				●		4		8		2
Sphaerium coreanicum Kobayashi and Suzuki				5																		

(□ Kobayashi and Suzuki, 1937; ◇ Kobayashi, 1956; ◆ Kobayashi, 1957; ■ Hayami, 1960a; △ Maeda, 1963; ▲ Maeda and Kawabe, 1963; ◎ Matsukawa et al. 2003b; ● Matsukawa and Asahara, 2010 observed at field)
Fm. = Formation

Table 3. List of fossil species from the Ushimaru, Mitarai, Otaniyama, Kuwajima, and Okurodani formations of the Tetori Group in the Hakusan area, Hakusan section, Gifu, Fukui, and Ishikawa prefectures, central Japan. Taxa, number of specimens and localities of the Mitarai Formation are cited from Hayami (1959a).

Hakusan Area

Taxa	Ushimaru Fm.									Mitarai Fm.			Otaniyama Fm.						
										Hayami (1959a)			Matsuwaka and Nakada (1999)						
	US10A	US10D	US10E	US21A	US21B	US21E	US21L	US23	US23L	M3	M2	Hayami (1960a)	OK52A	OK52B	OK52C	OK52D	OK52E	OK52F	OK19 (OT-01)
Palaeonucula makitoensis (Hayami)										5	10								
P. sp.										2									
Palaeoneilo ? sp.										2									
Solemya suprajurensis Hayami										1									
Brachidontes ? sp.										1									
Modiolus (*Modiolus*) *maedae* Hayami										2	20								
Pinna (*Pinna*) aff. *sandsfootensis* Arkell											5								
Inoceramus (*Inoceramus*) *maedae* Hayami												5							
Oxytoma tetoriensis Hayami										6									
Entolium inequivalve Hayami										20									
Camptonectes ? sp.										3									
Chlamys (*Chlamys*) *mitaraiensis* Hayami										5	5								
Limatula ? *iwayae* Hayami										20									
Unio antiqua (Kobayashi and Suzuki)																			
U. cf. *longus* (Zhu)																			
Tetoriunio okurodaniensis (Komatsu et al.) emend.																			
Nagdongia soni Yang																			
Archaeounio kagaensis gen. nov.																			
Nippononaia ryosekiana (Suzuki)																			
N. tetoriensis Maeda																			
Plicatounio (*Plicatounio*) *naktongensis* Kobayashi and Suzuki																			
Pseudohyria aff. *matsumotoi* Yang																			
Trigonioides (*Wakinoa*) *tetoriensis* Maeda																			
Protocardia ? sp. Hayami											7								
Neomyrene tetoriensis (Kobayashi and Suzuki) gen. nov.	112	30	66	6	9	20	11	100					3	33	35	11	48	29	33
Tetoria yokoyamai (Kobayashi and Suzuki)	12	8	2	19	4		4	50	12						6		11	9	
Sphaerium coreanicum Kobayashi and Suzuki																			
Tetorimya carinata Hayami										2	35								
Pleuromya hidensis Hayami										10									
Thracia shokawensis Hayami										10	10								
Unio ? *ogamigoensis* Kobayashi and Suzuki																			

Taxa	Kuwajima Fm.														
	M18 (KWJ-01)	M19 (KWJ-02)	9 (KWJ-03)	M4 (KWJ-04)	M2 (KWJ-06)	M6 (KWJ-10)	M5 (KWJ-11)	44 (KWJ-12)	MK03	7 (MK06)	HD01-01	HD01-02.2	HD01-03	HD01-04	HD01-05
Palaeonucula makitoensis (Hayami)															
P. sp.															
Palaeoneilo ? sp.															
Solemya suprajurensis Hayami															
Brachidontes ? sp.															
Modiolus (*Modiolus*) *maedae* Hayami															
Pinna (*Pinna*) aff. *sandsfootensis* Arkell															
Inoceramus (*Inoceramus*) *maedae* Hayami															
Oxytoma tetoriensis Hayami															
Entolium inequivalve Hayami															
Camptonectes ? sp.															
Chlamys (*Chlamys*) *mitaraiensis* Hayami															
Limatula ? *iwayae* Hayami															
Unio antiqua (Kobayashi and Suzuki)															
U. cf. *longus* (Zhu)										1					
Tetoriunio okurodaniensis (Komatsu et al.) emend.															
Nagdongia soni Yang															
Archaeounio kagaensis gen. nov.							9		16	12	3	1	42	9	
Nippononaia ryosekiana (Suzuki)															
N. tetoriensis Maeda															2
Plicatounio (*Plicatounio*) *naktongensis* Kobayashi and Suzuki															
Pseudohyria aff. *matsumotoi* Yang															
Trigonioides (*Wakinoa*) *tetoriensis* Maeda															
Protocardia ? sp. Hayami															
Neomyrene tetoriensis (Kobayashi and Suzuki) gen. nov.	1	4	28	7	28	20	5	6							
Tetoria yokoyamai (Kobayashi and Suzuki)	5				10	1	32	2							
Sphaerium coreanicum Kobayashi and Suzuki															
Tetorimya carinata Hayami															
Pleuromya hidensis Hayami															
Thracia shokawensis Hayami															
Unio ? *ogamigoensis* Kobayashi and Suzuki															

Taxa	Okurodani Fm.																								Okura Fm.
																	Matsukawa et al. (1999)								
	M37 (KT-000)	M36 (KT-001)	M35 (KT-002)	4 (KT-003)	50 (KT-004)	2 (KT-005)	OK11	OK13	OK17A	OK17B	OK17C	OK22	OK24	OK31	OK51	unknown	OS10A	OS10D	OS10E1	OS10G	OS10H	OS14	Komatsu et al. (2003)	Isaji (1993)	Isaji (1993)
Palaeonucula makitoensis (Hayami)																									
P. sp.																									
Palaeoneilo ? sp.																									
Solemya suprajurensis Hayami																									
Brachidontes ? sp.																									
Modiolus (*Modiolus*) *maedae* Hayami																									
Pinna (*Pinna*) aff. *sandsfootensis* Arkell																									
Inoceramus (*Inoceramus*) *maedae* Hayami																									
Oxytoma tetoriensis Hayami																									
Entolium inequivalve Hayami																									
Camptonectes ? sp.																									
Chlamys (*Chlamys*) *mitaraiensis* Hayami																									
Limatula ? *iwayae* Hayami																									
Unio antiqua (Kobayashi and Suzuki)								1							2										
U. cf. *longus* (Zhu)																									
Tetoriunio okurodaniensis (Komatsu et al.) emend.																							5		
Nagdongia soni Yang	2	25	3	6	2	1							3												
Archaeounio kagaensis gen. nov.									1										6		6	14			
Nippononaia ryosekiana (Suzuki)																								1	2
N. tetoriensis Maeda				1				1	1																
Plicatounio (*Plicatounio*) *naktongensis* Kobayashi and Suzuki	2	46	12			4																			
Pseudohyria aff. *matsumotoi* Yang	6					1																			
Trigonioides (*Wakinoa*) *tetoriensis* Maeda		3	11	1																					
Protocardia ? sp. Hayami																									
Neomyrene tetoriensis (Kobayashi and Suzuki) gen. nov.								6									34	30	1	23	40				
Tetoria yokoyamai (Kobayashi and Suzuki)							1	2		2		1					3	3	1			1			
Sphaerium coreanicum Kobayashi and Suzuki										200	200	200		200											
Tetorimya carinata Hayami																									
Pleuromya hidensis Hayami																									
Thracia shokawensis Hayami																									
Unio ? *ogamigoensis* Kobayashi and Suzuki																1									

Fm. = Formation

1.2 Hakusan Sequence

In the Hakusan area, the Tetori Group is composed mainly of conglomerate, sandstone, and mudstone, and is subdivided into eight formations: the Ushimaru, Mitarai, Otaniyama, Kuwajima, Okurodani, Amagodani, Okura, and Bessandani formations, in ascending order (Matsukawa et al., 2003a). Based on finds of specimens of the ammonites *Delphinella* cf. *obtusenodosa*, *Berriasella* sp., and others, the Mitarai Formation is assigned an age of Tithonian to Berriasian (Sato et al., 2003). Marine bivalve fossils are found in the Mitarai Formation, including *Inoceramus* (*I.*) *maedae* (Hayami, 1960a) and others are listed in the formation (Hayami, 1959a, b). Nonmarine bivalve fossils described in this paper have been found in the Ushimaru, Otaniyama, Kuwajima, and Okurodani formations (Table 3).

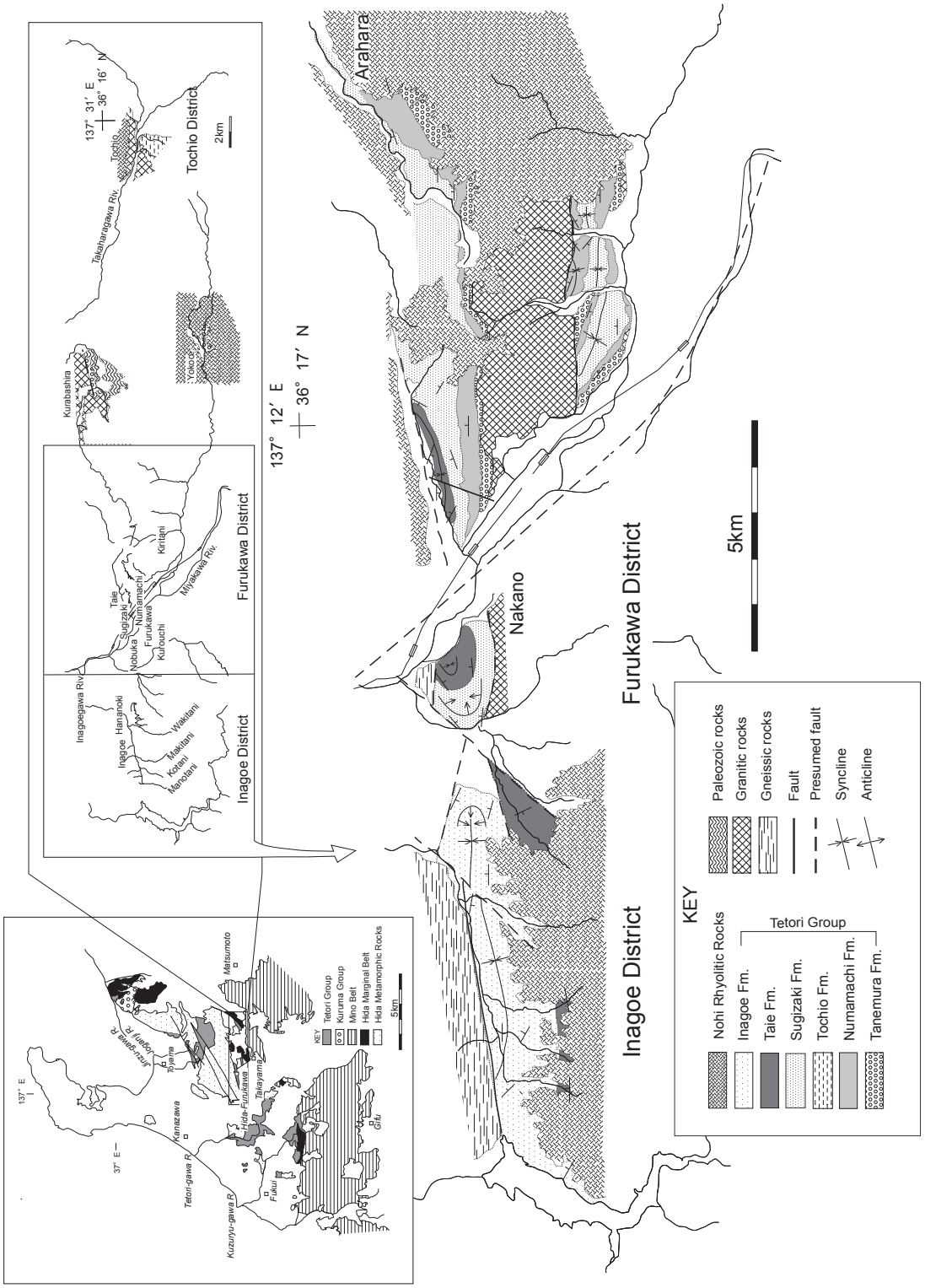

Fig. 6. Geological map of the Tetori Group in vicinity of the Hida-Furukawa region, Hakusan section, Gifu Prefecture, central Japan. Riv.: River. Modified from Matsukawa and Fukui (2009).

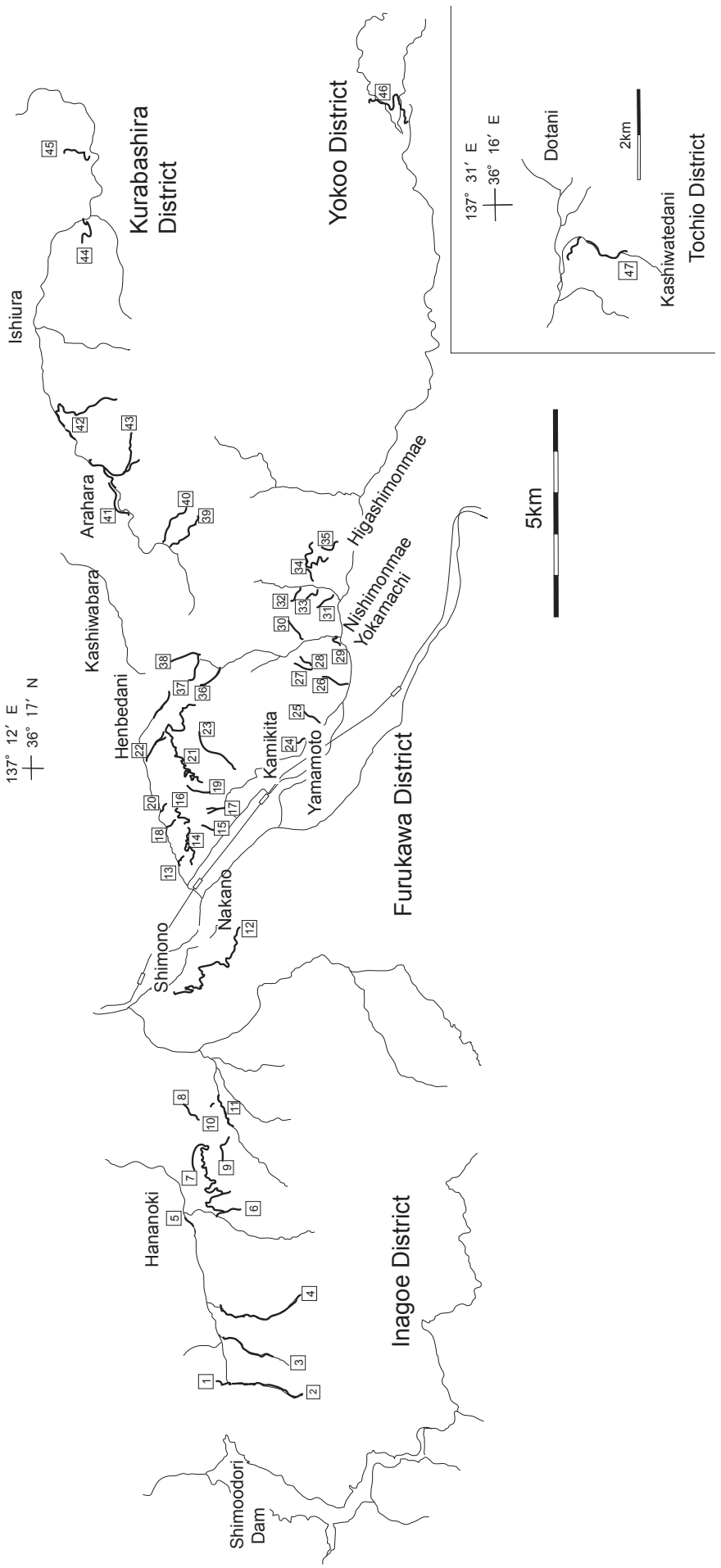

Fig. 7. Map showing locations of the Hida-Furukawa region, routes along which columnar sections were measured. After Matsukawa et al. (2007).

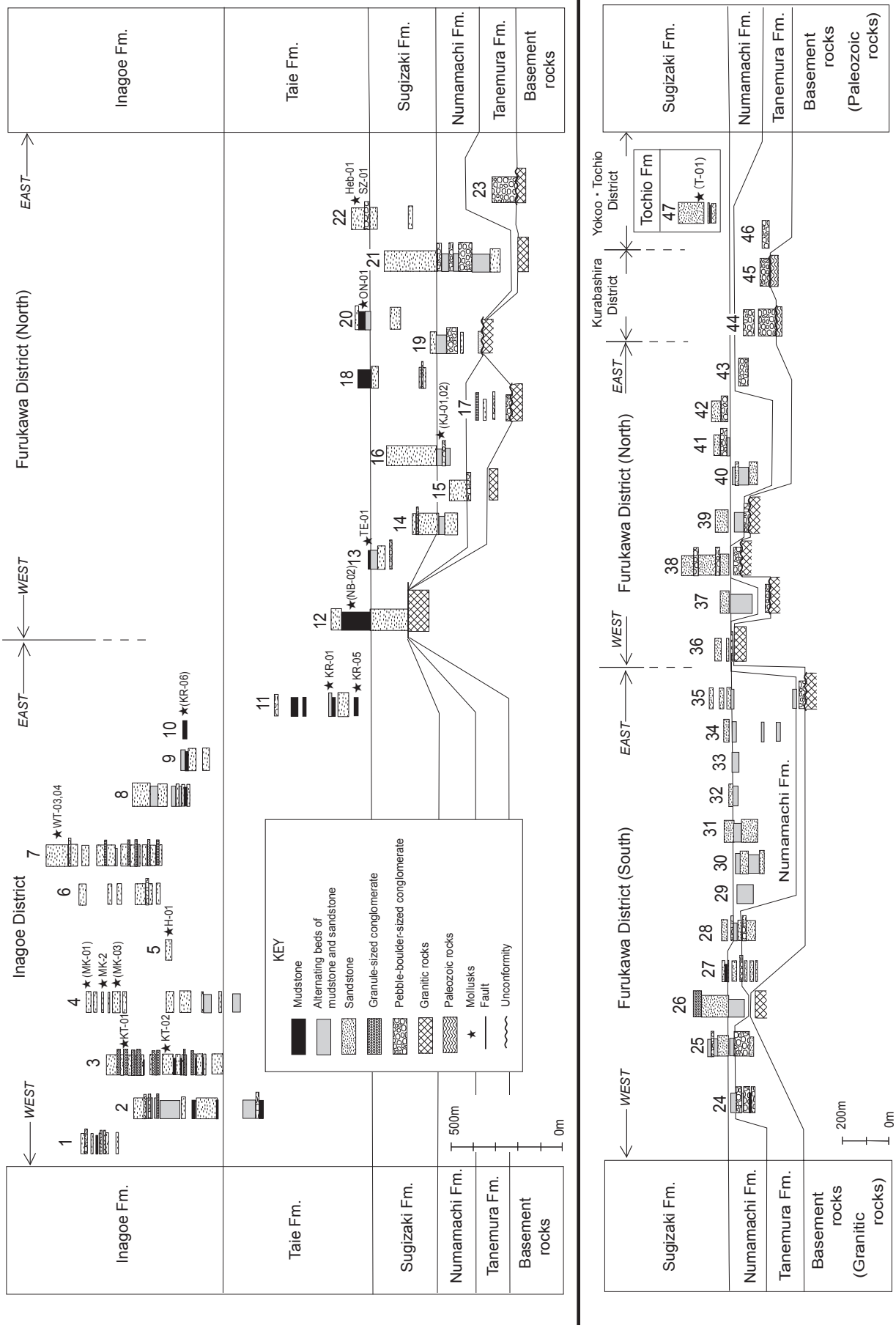

Fig.8. Individual columnar sections of the Tetori Group in the Hida-Furukawa region. Locations of numbered columns are shown on map Figure 7. Fm.: Formation. After Matsukawa et al. (2007).

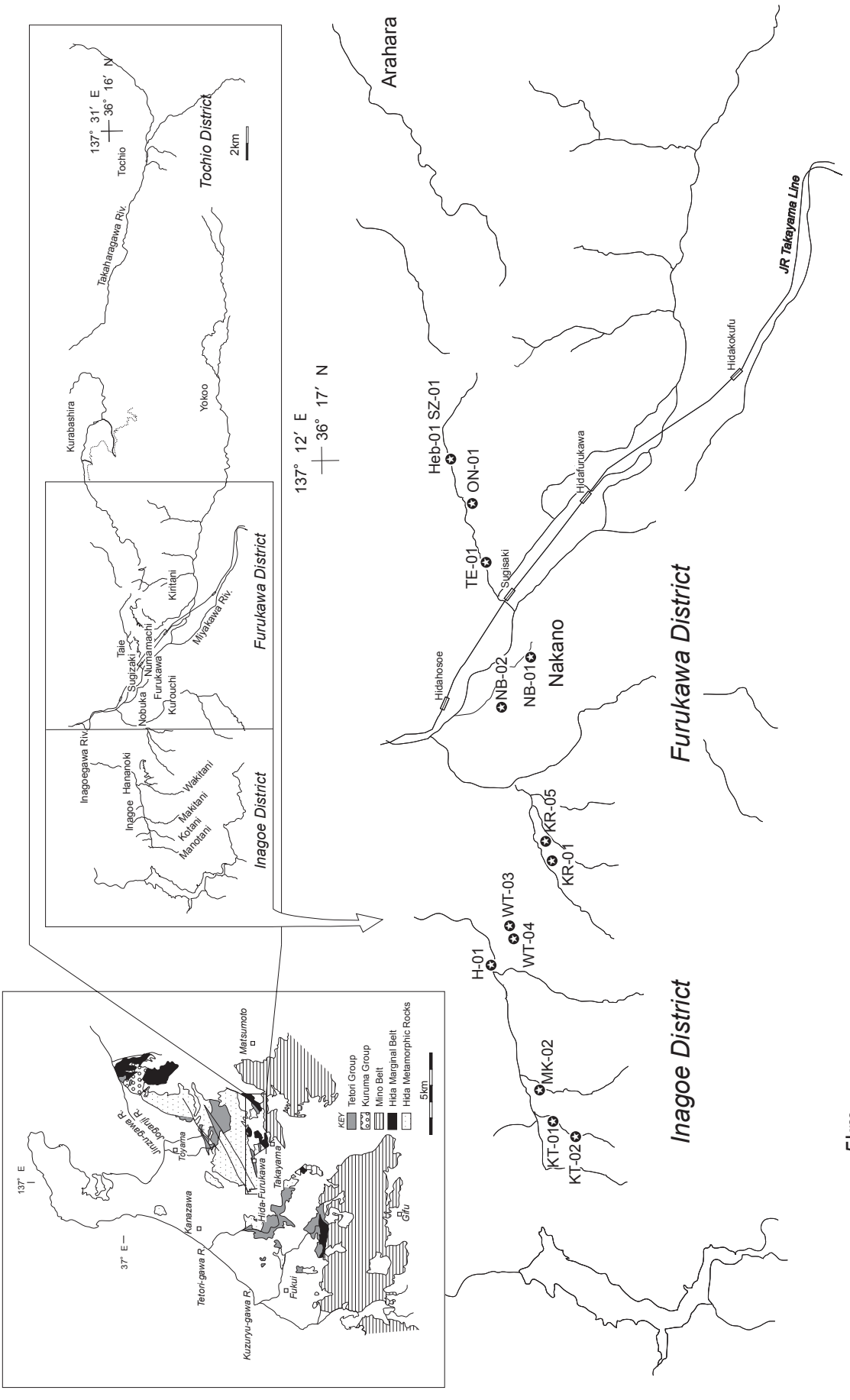

Fig. 9. Map showing location of the fossil localities in the Hida-Furukawa region. Riv.: River. Modified from Matsukawa et al. (2007).

1.3 Hida-Furukawa Sequence

In the Hida-Furukawa region, the Tetori Group is composed of pebble-boulder-sized conglomerate, granule-sized conglomerate, sandstone, and mudstone, and can be divided into six formations: in ascending order, the Tanemura, Numamachi, Sugizaki/Tochio, Taie, and Inagoe formations (Matsukawa et al., 2007). Based on the presence of the ammonite species, *Phyllopachyceras infundibulum*, *Pseudothurmannia* aff. *baleare*, and *Acrioceras* (*Paraspinoceras*) sp., the Inagoe Formation is assignable to Hauterivian to Barremian (Matsukawa and Fukui, 2009).

Marine bivalves are noted in the Sugizaki and Inagoe formations (Hayami, 1959c; Matsukawa and Fukui, 2009), and nonmarine bivalves described herein have been found in the Numamachi, Tochio, and Taie formations (Figs. 6, 7, 8, 9) (Table 4).

Table 4. List of fossil species from the Numamachi, Sugizaki, Taie, and Inagoe formations of the Tetori Group in the Hida-Furukawa region, Hakusan section, Gifu Prefecture, central Japan. Taxa, number of specimens, and localities are cited from Matsukawa et al. (2007), and Matsukawa and Fukui (2009).

Taxa	Hida-Furukawa Region (Matsukawa and Fukui, 2009)																
	Numamachi Fm.	Tochio Fm.	Sugizaki Fm.	Taie Fm.								Inagoe Fm.					
	KJ-02	Maeda (1959)	NB-01	KR-01	KR-05	NB-02	TE-01	ON-01	Heb-01	Sz-01	KT-01	KT-02	MK-2	H-01	WT-03	WT-04	
Mytilus? sp.														1			
Inoceramus (*Inoceramus*) *maedae* Hayami			1									1					
Oxytoma sp.															1		
Limidae gen. et sp. indet.						1											
Exogyrinae gen. et sp. indet.													1				
Ostreinae gen. et sp. indet											1						
Anisocardioides hulinensis Gu						3											
Unio antiqua (Kobayashi and Suzuki)					1												
Crenotrapezium kobayashii (Maeda)		4															
Neomyrene tetoriensis (Kobayashi and Suzuki) gen. nov.	200			166	88		24	10	10	10							
Tetoria yokoyamai (Kobayashi and Suzuki)					6			1	3	7							
Filosina? sp.														1			
Corbula (*Eoursivivas*?) aff. *matsumotoi* Hase															2		
Pachymya (*Arcomya*) *longzhaouensis* Yu and Li															20	38	
Pleuromya baoqingensis (Yu et Li)															1	1	
Thracia shokawensis Hayami															9	15	

Fm. = Formation

※ Number of *Neomyrene tetoriensis* from Numamachi Fm. (KJ-02) is cited from Matsukawa et al. (2007)

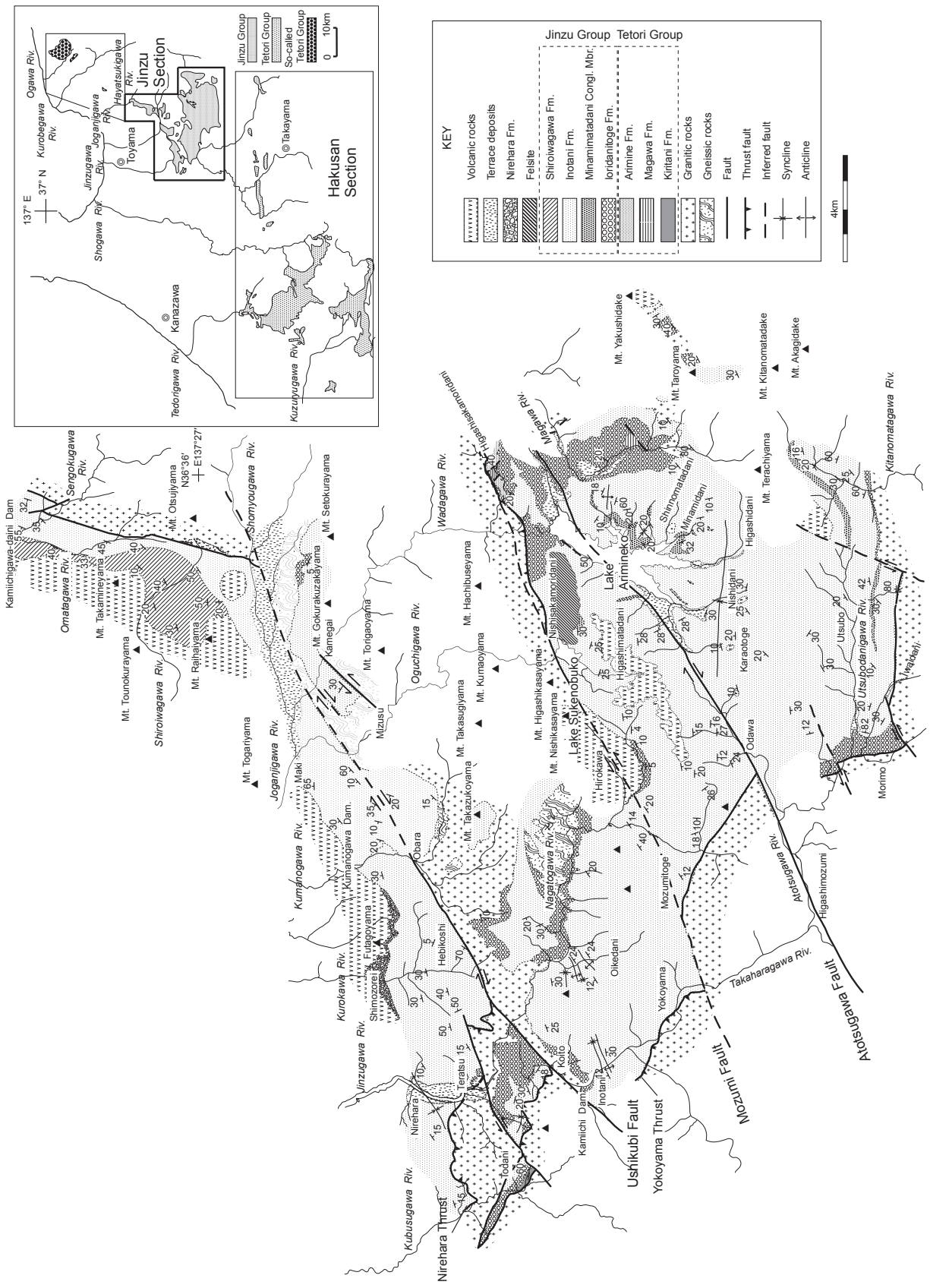

Fig.10. Geological map of the Tetori and Jinzu groups in northern Gifu and southern Toyama prefectures, central Japan. Fm.: Formation, Mbr.: Member, Riv.: River, Mt.: Mountain. After Matsukawa et al. (2014a).

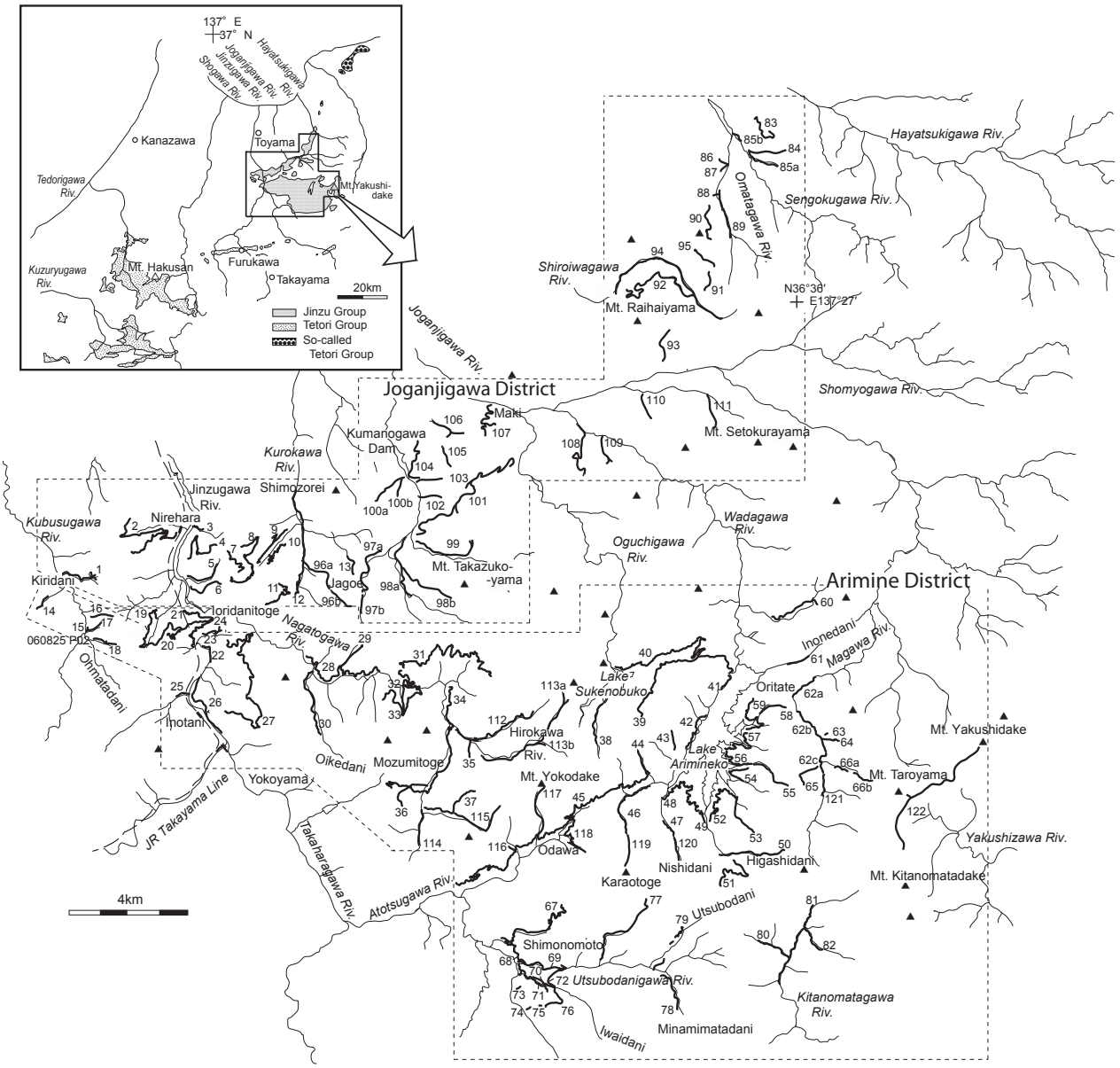

Fig.11. Map showing locations of the routes in northern Gifu and southern Toyama prefectures along which columnar sections were measured. Riv.: River, Mt.: Mountain. After Matsukawa et al. (2014a).

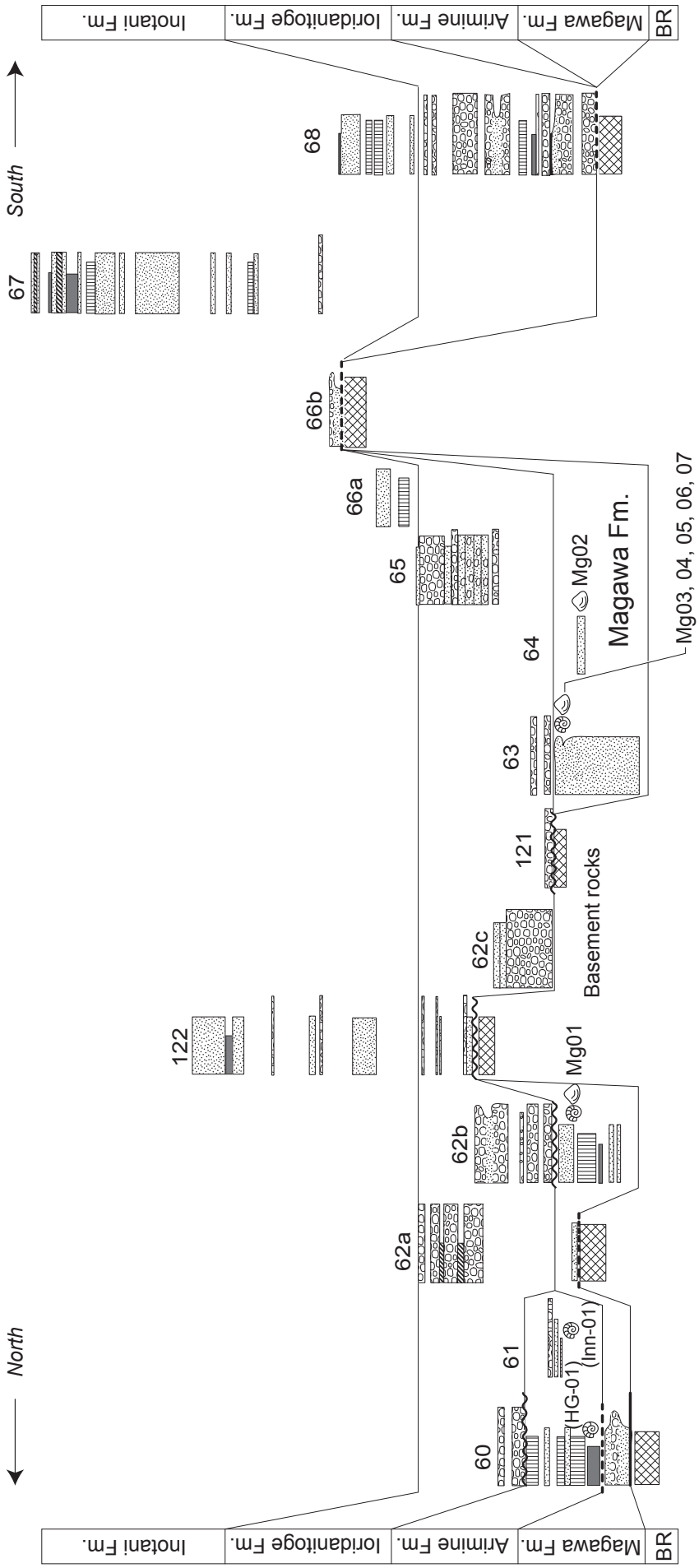

Fig.12-1. Columnar sections of the Tetori and Jinzu groups in the Jinzu section, northern Gifu and southern Toyama prefectures, central Japan. The locations of numbered columns are shown on the map in Figure 11. Fm.: Formation, BR: basement rocks. Modified from Matsukawa et al. (2014a).

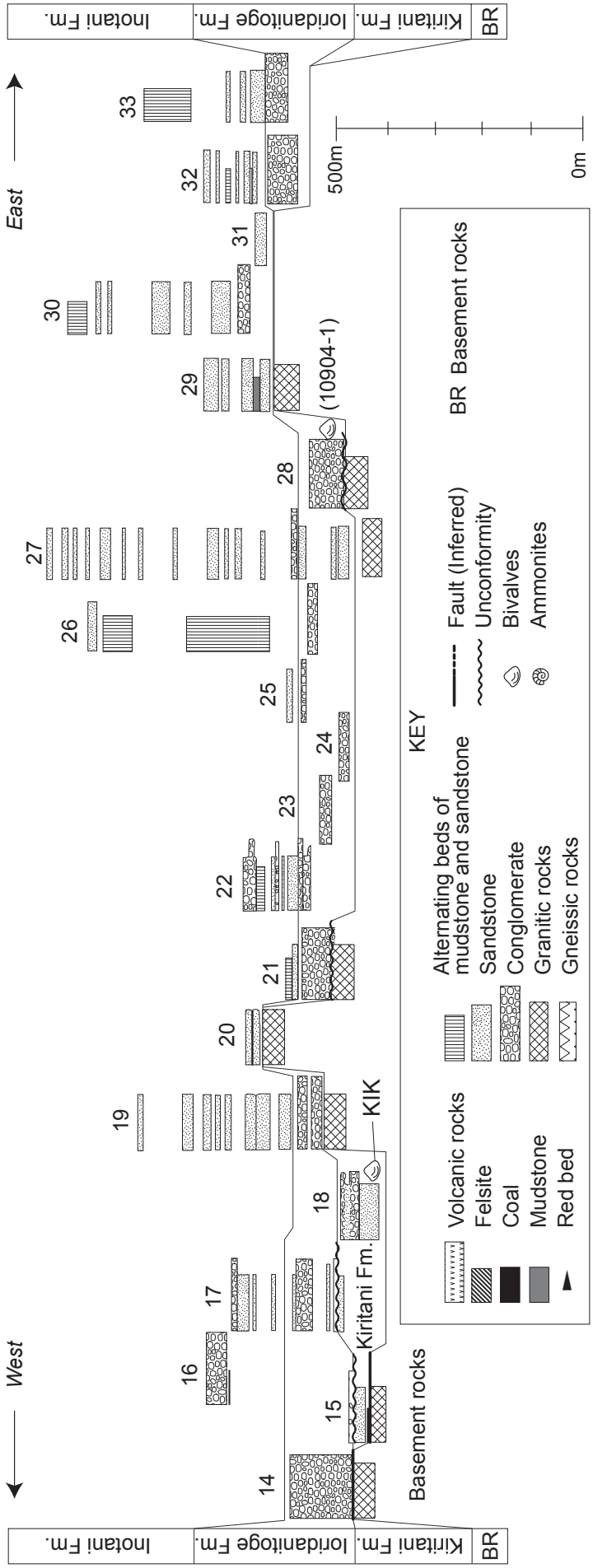

Fig.12-2. Columnar sections of the Tetori and Jinzu groups in the Jinzu section, Toyama Prefecture, central Japan. The locations of numbered columns are shown on the map in Fig.11. Fm.: Formation, BR: basement rocks. Modified from Matsukawa et al. (2014a).

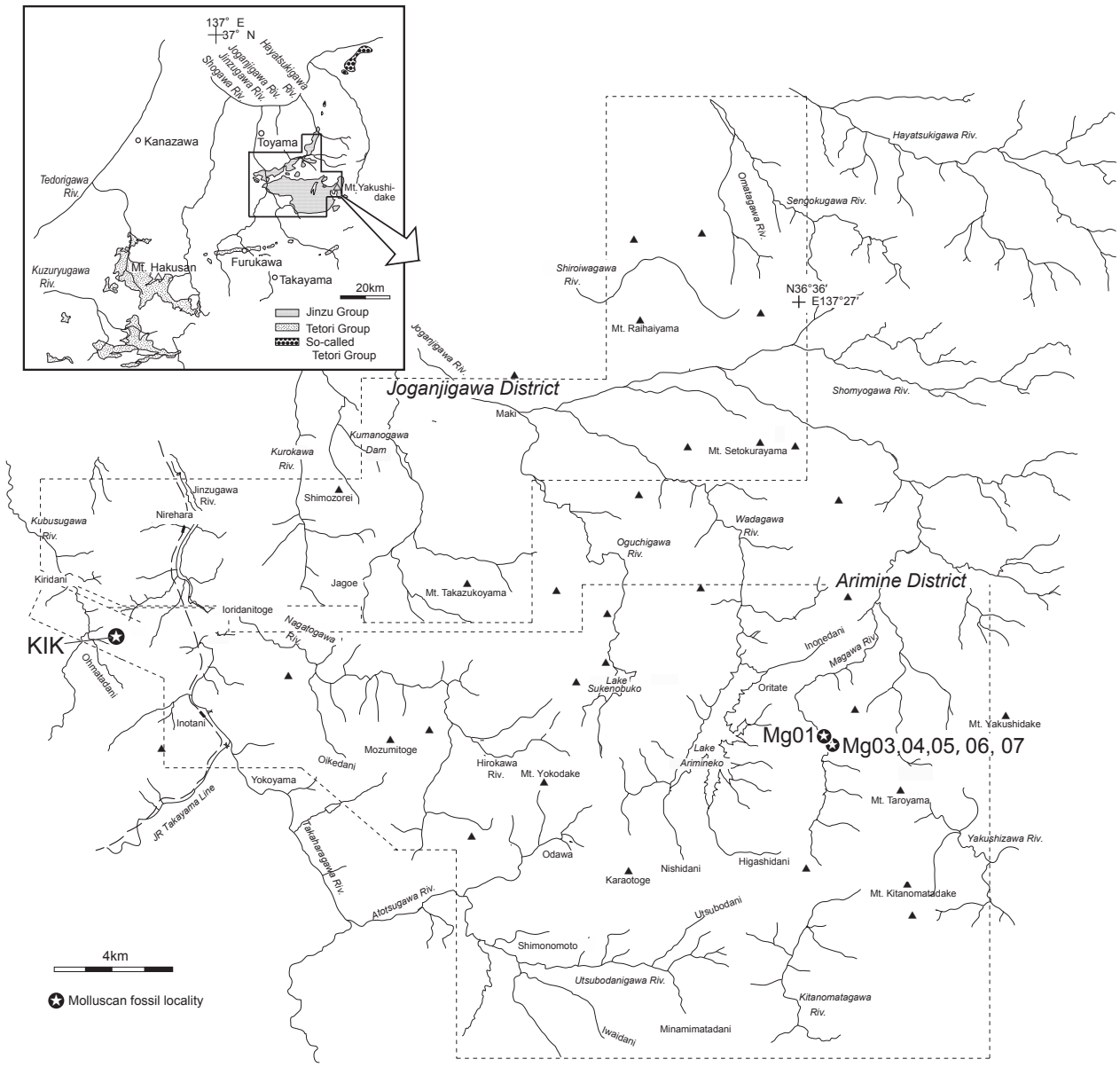

Fig.13. Map showing location of the fossil localities in the Arimine District and Joganjigawa District Jinzu section. Riv: River, Mt: Mountain.

2. Jinzu Section

Late Mesozoic deposits in the Jinzu section are divided into the Tetori Group and overlying Jinzu Group (Matsukawa et al., 2014a). The Tetori Group here consists of marine deposits bearing Jurassic ammonites, while the Jinzu Group consists of terrestrial deposits.

The Tetori Group in the Jinzu section is composed mainly of conglomerate, sandstone, and black mudstone, and is divided into three formations, the Magawa Formation, the conformably overlying Arimine Formation, and its stratigraphic equivalent, the Kiritani Formation (Matsukawa et al., 2014a) (Figs. 10, 11, 12-1, 12-2, 13). Based on the ammonite *Perisphinctes* (*Kranaosphinctes*) *matsushimai*, the Arimine Formation is assigned to the Oxfordian (Matsukawa et al., 2008b). Marine bivalves are noted in the both Magawa and Kiritani formations (Table 5).

Table 5. List of fossil species from the Magawa and Kiritani formations of the Tetori Group in the Arimine District, Jinzu section, Toyama Prefecture, Japan.

Taxa	Arimine District						
	Magawa Fm.						Kiritani Fm.
	Mg01	Mg03	Mg04	Mg05	Mg06	Mg07	KIK
Palaeonucula makitoensis (Hayami)	2			4			
P. cf. *makitoensis* (Hayami)							6
Nuculana (*Nuculana*) sp. A							24
N. (*N*.) sp. B							6
N. (*Praesaccella*) sp.							4
Mytilus sp.							6
Modiolus (*Modiolus*) *magatama* Hayami				2			
M. (*M*.) *setiniae* Hayami	1	3			1		
M. (*M*.) *toyamensis* sp.nov.	7				1		6
Pinna (*Pinna*) *ariminensis* sp. nov.	8	2		8	3		
Inoceramus (*Mytiloides*?) sp. B							2
Entolium inequivalve Hayami	1			1			
Chlamys (*Chlamys*) cf. *mitaraiensis* (Hayami)	1			1			
Myophorella (*Promyophorella*) *imamurai* Kobayashi	3		1	12	2	2	5
Nipponitrigonia sagawai (Yehara)							64
Vaugonia (*Vaugonia*) cf. *yambarensis* Kobayashi							1
Fimbria sp.							4
Protocardia sp.	11			1			
Cultellidae gen. et sp. indet.	2						
Tancredia (*Tancredia*) sp.							12
Isocyprina sp.							3
Pleuromya? sp.							1
Cercomya (*Cercomya*) cf. *gurgitis* (Pictet and Campiche)	7						
C. (*Capillimya*) sp.	4			1			
Thracia? sp.							1
Bivalvia gen. et sp. indet. A							2
Bivalvia gen. et sp. indet. B	6						
Bivalvia gen. et sp. indet. C							3

Fm. = Formation

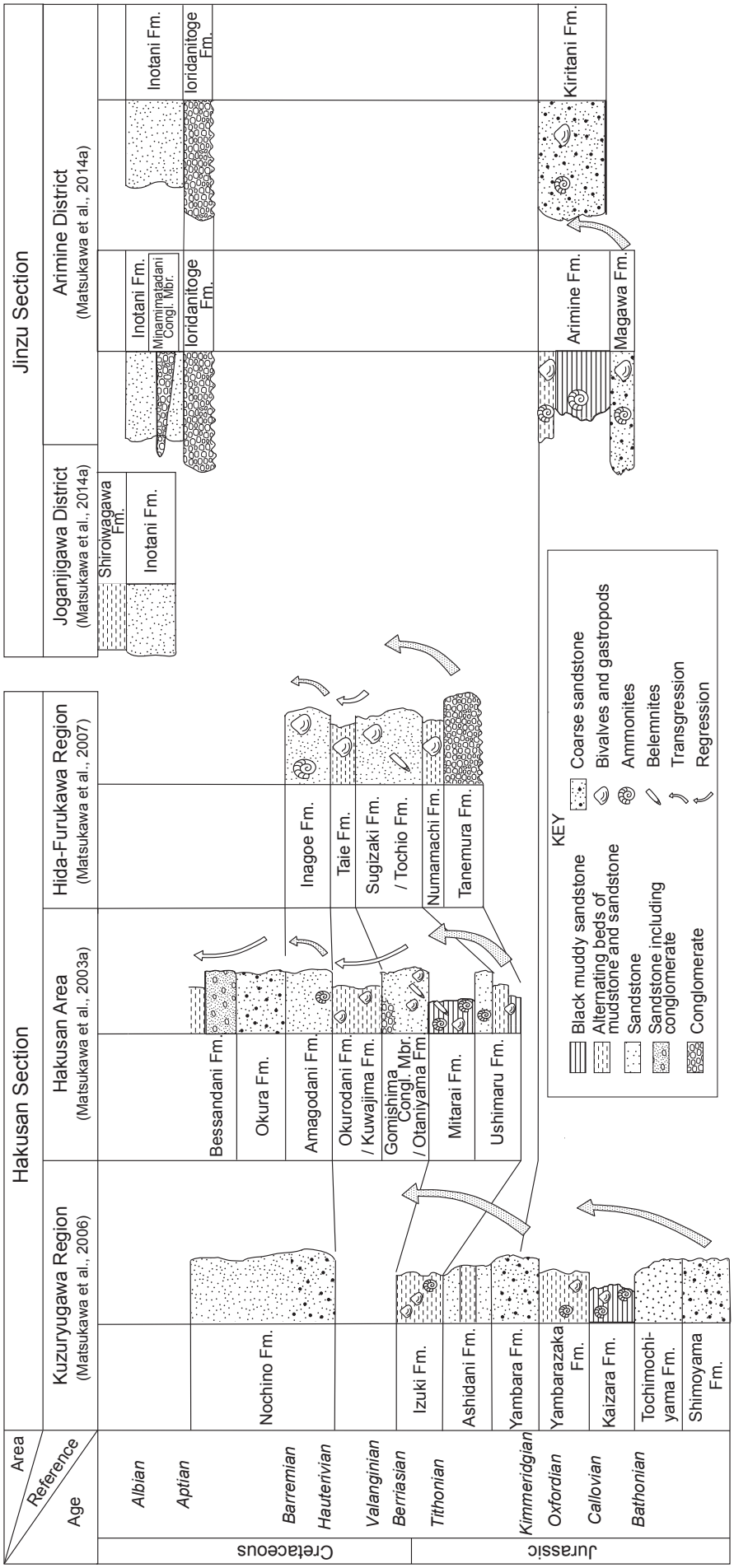

Fig. 14. Geological correlation of the Tetori and Jinzu groups between the Hakusan and Jinzu sections. Fm.: Formation, Mbr.: Member. Modified from Matsukawa et al. (2014a).

3. Correlation of the Tetori Group between the Hakusan and Jinzu sections

There are marine intercalations in the dominantly nonmarine deposits of the Tetori Group. Matsukawa et al. (2014a) presented a geological correlation of the Tetori Group between the Hakusan and Jinzu sections using ammonite indices and marine transgressive events. Figure 14 shows a correlation of the Tetori Group between the Hakusan and Jinzu sections. Marine sequences in the regions are recognized in several areas. (1) In the Kuzuryugawa region of the Hakusan section, the sequence from the Kaizara to Yambara Formation can be assigned to Bathonian to Oxfordian, and the Izuki Formation, bearing nonmarine bivalves is correlated to Tithonian to Berriasian. (2) In the Hakusan area of the Hakusan section, the marine sequence from the upper Ushimaru Formation through the Mitarai and lower Otaniyama formations is correlative with Tithonian to Berriasian. (3) In the Hida-Furukawa region of the Hakusan section, the sequence from the Sugizaki Formation to the lower Taie Formation is correlative with Tithonian to Berriasian, and the Inagoe Formation is assignable to Hauterivian to Barremian. (4) In the Jinzu section, the sequence of the Magawa and Arimine formations is correlative with Oxfordian to lower Kimmeridgian. Therefore, the sequence of the Magawa and Arimine formations in the Jinzu section is correlative with the sequence from the Kaizara to Yambara formations in the Hakusan section. As the result, nonmarine formations bearing bivalves correspond to the following ages: the Izuki Formation is assigned to Tithonian to Berriasian; the sequence from upper Otaniyama Formation through the Okurodani and lower Amagodani formations is assigned to Tithonian to Barremian; the Numamachi Formation is assigned to Tithonian to Berriasian; and the Taie Formation is assigned to Berriasian to Hauterivian.

4. Sedimentary environments of formations bearing bivalve fossils

During the time of deposition of the lower Tetori Group, the Japanese Islands were situated at the eastern margin of the Asian continent. Based on facies analysis (Ito and Matsukawa, 2002) and fossils (Matsukawa et al., 2003a, b, 2006, 2007, 2014a, b), a reconstruction of the sedimentary environments of the Tetori Group is presented in Figure 15. According to Matsukawa et al. (2006), a number of different sedimentary environments and their changes through time can be recognized. Principally, Lower Cretaceous strata include a simple array of sedimentary facies representing deposition in continental, back-arc, fore-arc, and trench settings and the setting in Middle to Late Jurassic time is fundamentally the same (Matsukawa et al., 1997, 1998). Thus, the Tetori Basin faced the paleo-Pacific to the east and a land area existed on the western and southern flanks of the basin, as a part of the eastern margin of the Asian continent. This interpretation is supported by the sequence from the Shimoyama to Tochimochiyama formations in the Kuzuryugawa region in the Hakusan section, representing alluvial fan deposits and overlying gravelly braided-river deposits, and by the sequence from the Kaizara to Yambarazaka formations, representing inner shelf, delta front, shoreface, and delta plain environments. The complete sequence from the Shimoyama to Yambarazaka formations reflects the first transgressive phase. In the Jinzu section, the sequence from the Magawa Formation to the Arimine Formation and its equivalent, the Kiritani Formation, is correlative with the sequence from the Kaizara to Yambarazaka formations, and was also deposited in this transgressive phase. Therefore, this marine transgression expanded eastward in the Jinzu section.

The Yambara Formation, consisting of alluvial fan deposits, reflects a regressive phase, and the sequence from the Ashidani to Izuki formations in the Kuzuryugawa region, consisting of sandy braided-river, lacustrine delta, and delta plain deposits, as well as the sequence from the Ushimaru to Mitarai formations in the Hakusan area, consisting of estuary, bay-head delta, shoreface, and inner shelf deposits, reflects the second transgression. The sequence from the Tanemura Formation to the Sugizaki Formation and its equivalent, the Tochio Formation in the Hida-Furukawa region, consisting of alluvial fan, deltaic, and shallow marine deposits also indicates a second marine transgression.

In the Hakusan area, the sequence from the Otaniyama Formation and its equivalent the Gomishima Conglomerate Member, to the Kuwajima Formation and its equivalent the Okurodani Formation, conformably overlies the Mitarai Formation, but there is a barren interval with unconformable relationship in correlative formations in the Kuzuryugawa region. The northern distribution of the Tetori Group in the Hakusan area indicates an expansion and northward shifting of the basin and a uplift in the Kuzuryugawa region. This is interpreted to reflect duplication of Jurassic to lower Lower Cretaceous accretionary complexes and

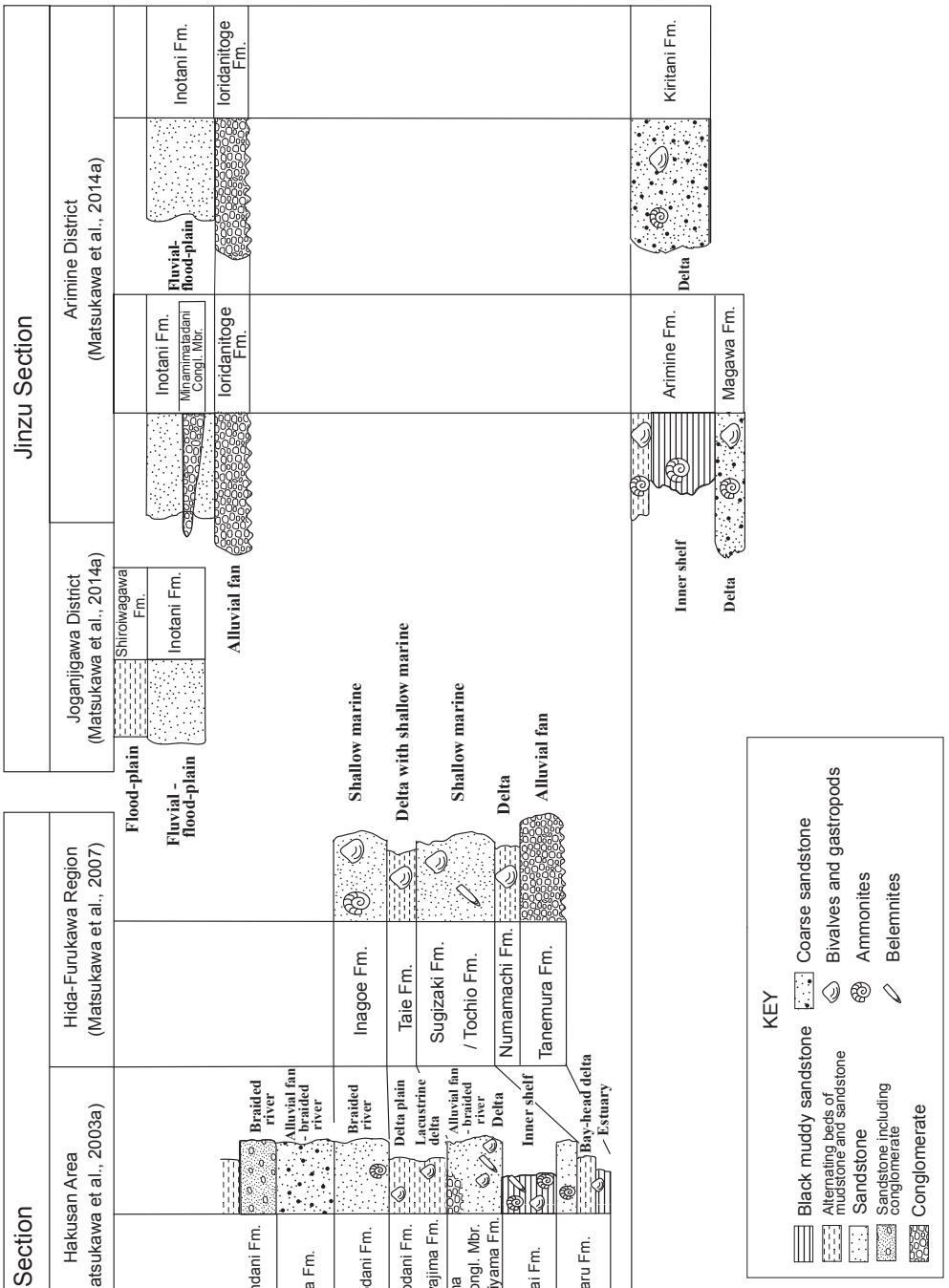

Fig.15. Depositional environments of the Tetori and Jinzu groups. Fm.: Formation.

associated strike-slip movement (Matsukawa et al., 1997, 1998). The duplication led to the eastward shifting of development of the fore-arc basins along a new trench, and also caused uplift of the former fore-arc basin, resulting in its change to an intra-arc basin. During this time, the Tetori Basin is interpreted to have changed into an intra-arc basin (Matsukawa et al., 1997, 1998). Northward of the group, westward and eastward paleocurrents in deltaic and alluvial fan deposits suggest a hinterland existed on the southern, western, and eastern flanks of the basin (Ito and Matsukawa, 2002). In support of this interpretation, the successions from the Okura to the Bessandani formations in the Hakusan area, and the Nochino Formation in the Kuzuryugawa region, are characterized by alluvial fan to gravelly and sandy braided-river deposits.

The sequence from the Taie to Inagoe formations, consisting of deltaic and shallow marine deposits, conformably overlies the Sugizaki and Tochio formations in the Hida-Furukawa region, it indicating the third transgressive phase. The equivalent sequence in the Hakusan area from the Otaniyama Formation and its equivalent the Gomishima Conglomerate Member, to the Kuwajima Formation and its equivalent the Okurodani Formation, represents a regressive phase which was caused by uplift. As a result, the locus of the basin shifted from west to east, because the Hida-Furukawa region is located to the east of the Hakusan area.

The transgressive sequence of the Tetori Group provides evidence of this. Formations bearing nonmarine bivalve fossils demonstrate that the Ashidani and Nochino formations in the Kuzuryugawa region accumulated in sandy braided-river, lacustrine delta, and delta plain environments. In the Hakusan area, the Ushimaru Formation reflects estuarine bay-head delta environments, while the sequence from the upper Otaniyama through Kuwajima formations and equivalent strata reflect estuarine, delta front, delta plain, shoreface, lacustrine delta, and sandy braided river environments. Finally, the Numamachi and Taie formations in the Hida-Furukawa region reflect deltaic depositional environments.

II. Systematic paleontology of bivalve fossils from the Tetori Group

Specimens illustrated are deposited in the Department of Environmental Sciences, Tokyo Gakugei University, Tokyo (TGUSE). Specimens referred to in the paper are housed in the University Museum of the University of Tokyo (UMUT), the Department of Science Education, University of Teacher Education Fukuoka, Fukuoka, (GF), the Department of Earth Science, Hiroshima Univeristy, Hiroshima (IGSH), the Kaiinkan Museum, Toyama (Yatsuo Fossil Museum; KIK) and the Department of Earth-Sciences, College of Education, Kyungpook National University, Daegu, Korea (KPE). Higher systematic nomenclature follows the Treatise (Cox et al., 1969). Morphological terms used are defined in the Treatise (Cox et al., 1969). *Abbreviations*. LV = left valve, RV = right valve, L = shell length, H = shell height, T = thickness, D = distance from anterior end to umbo, L/H = the length/height ratio, T/L = the thickness/length ratio, D/L = the distance/length ratio.

Class Bivalvia Linné, 1758
Subclass Palaeotaxodonta Korobkov, 1954
Order Nuculoida Dall, 1889
Superfamily Nuculacea Gray, 1824
Family Nuculidae Gray, 1824
Genus *Palaeonucula* Quenstedt, 1930

Palaeonucula makitoensis (Hayami, 1959)

Fig. 16 A, B, C, D

1959a *Nuculopsis* (*Palaeonucula*) *makitoensis*; Hayami, p.143-145, pl.12, figs.4-6 (erroneously spelled *mitaraiensis* in p.143).
1975 *Nuculopsis* (*Palaeonucula*) *makitoensis*; Hayami, p.20.
1997 *Palaeonucula* cf. *makitoensis*; Gu et al., 1997, p.7-8, pl.1, figs.8-12.

Material. Six specimens, from localities Mg01 (TGUSE-MM7713, -MM7718) and locating Mg05 (TGUSE-MM7714 to -MM7717). They consist of a single external cast of left valve (TGUSE-MM7715), two external casts of a right valve (TGUSE-MM7717, -MM7718), a single external mold of a left valve (TGUSE-MM7713), a single internal cast of a left valve (TGUSE-MM7716), and a single internal cast of a right valve (TGUSE-MM7714). All specimens were collected by K. Suzuki, Y. Fujimoto, M. Matsukawa, and K. Koarai.

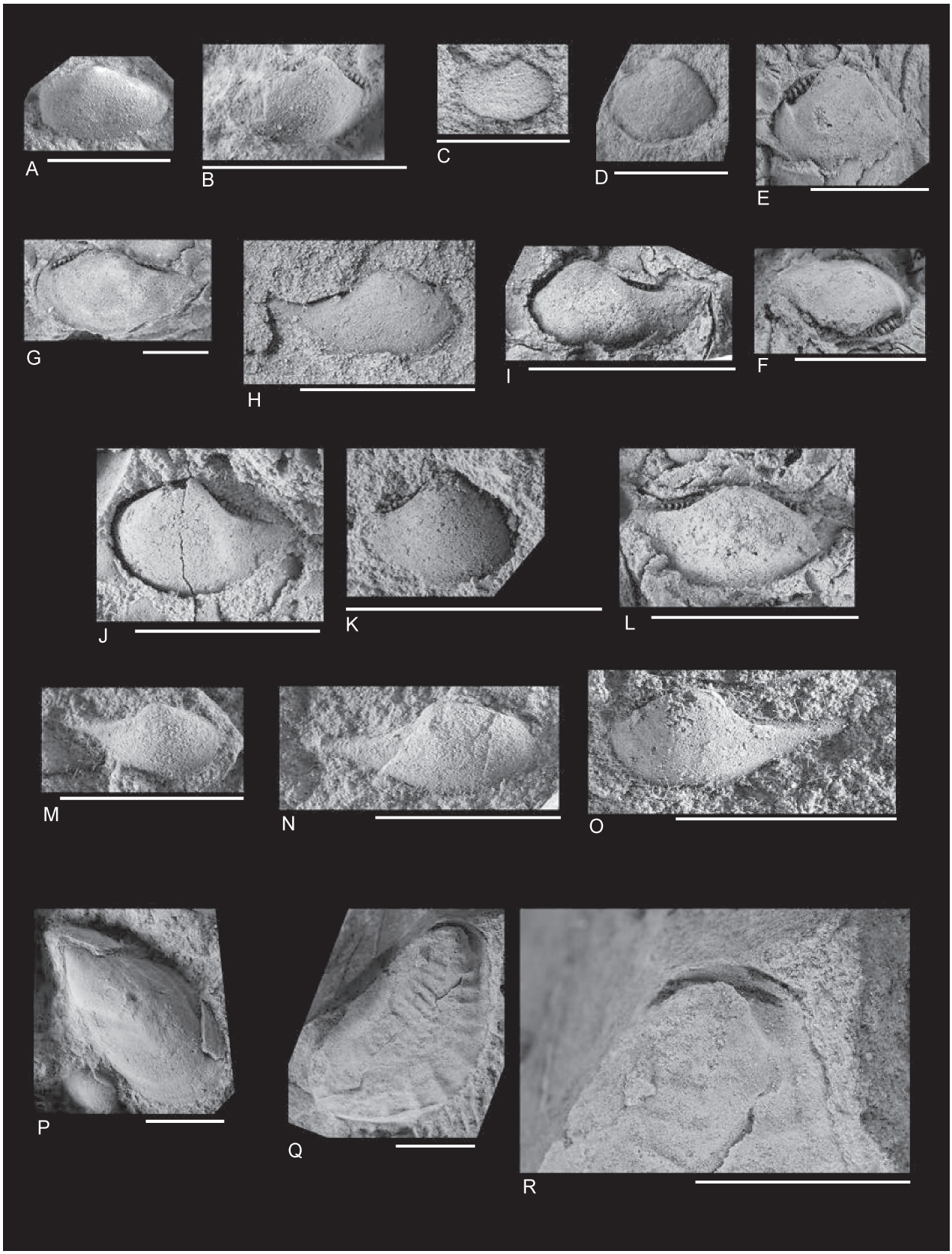

Fig.16. A-D, *Palaeonucula makitoensis* (Hayami); A, TGUSE-MM7713, external cast of left valve, Magawa Formation (loc. Mg01); B, TGUSE-MM7714, internal cast of right valve, Magawa Formation (loc. Mg05); C, TGUSE-MM7717, external cast of right valve, Magawa Formation (loc. Mg05); D, TGUSE-MM7718, external cast of right valve, Magawa Formation (loc. Mg01); E, F, *Palaeonucula* cf. *makitoensis* (Hayami), KIK0370, internal cast of left valve, Kiritani Formation; E, left view; F, hinge structure; G, H, *Nuculana* (*Nuculana*) sp. A; G, KIK0014, internal cast of left valve, Kiritani Formation; H, KIK0317, internal cast of right valve, Kiritani Formation; I-L, *Nuculana* (*N.*) sp. B; I, KIK0319v, internal cast of left valve, Kiritani Formation; J, KIK0382c, internal cast of left valve, Kiritani Formation; K, KIK0382i, internal cast of right valve, Kiritani Formation; L, KIK0319t, internal cast of right valve, Kiritani Formation; M-O, *Nuculana* (*Praesaccella*) sp.; M, KIK0013a, internal cast of right valve, Kiritani Formation; N, KIK0013b, internal cast of right valve, Kiritani Formation; O, KIK0314, internal cast of left valve, Kiritani Formation; P-R, *Mytilus* sp.; P, KIK0016a, internal cast (partly external) of left valve, from the Kiritani Formation; Q, KIK0386a, internal cast of right valve, Kiritani Formation; R, KIK0386a, hinge structure of right valve, Kiritani Formation. Scale bars show 1 cm.

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7713	10.5	5.9	1.9	1.78
TGUSE-MM7714	6.9	5.0	1.0	1.37
TGUSE-MM7715	7.7	5.1	-	1.51
TGUSE-MM7716	8.6	5.9	2.4	1.46
TGUSE-MM7717	7.2	5.0	1.2	1.44
TGUSE-MM7718	8.5	6.3	1.2	1.35

Description. Shell very small size, equivalve, inequilateral, subtrigonal, gentle convexity, slightly longer than height; umbo little elevated, opisthogyrate, situated at about two-fifths of shell length from leading edge; apical angle ranging from 100 to 116 degrees; surface marked with coarse concentric growth lines; dentition taxodont type, comprising about nine denticles of anterior series and about five denticles of posterior series; adductor scars suboblicular; inner ventral margin smooth (non-crenulate); pallial sinus absent.

Remarks. Based on the very small size of shell, subtrigonal form, concentric ribs, and taxodont teeth, the specimens belong to the genus *Palaeonucula*, as defined by Cox et al. (1969). The specimens are identified as *Palaeonucula makitoensis* (Hayami, 1959a, p.143-145, pl.12, figs.4-6), from the Lower Cretaceous Mitarai Formation (Matsukawa et al., 2007), in having a very small, elongated subtrigonal shell form with coarse concentric ribs. The present specimens are similar to the illustrated specimens of *Palaeonucula* cf. *makitoensis* (Hayami) (Gu et al., 1997, p.7-8, pl.1, figs.8-12) from the Lower Cretaceous Qihulin Formation and the Yunshan Formation, Heilongjiang, China, in having an elongated shell form. The present specimens are different from the illustrated specimen of *Palaeonucula* cf. *ishidoensis* (Gu et al., 1997, p.5-7, pl.1, figs.2-7) from the Lower Cretaceous Peide, Yunshan, and Dongrong formations, Heilongjiang, China, in that the Chinese specimens is characterized by taxodont denticles, a smooth ventral margin, transversally elongated shell form, very prominent umbo, and the location of the umbo at the anterior side; the umbo of the present specimens is somewhat prominent and is located near the center of the valve. Because of the subtrigonal and elongated shell outline and prosogyrate umbo, the illustrated specimens of *Palaeonucula yonghongensis* (Gu et al., 1997, p.8-10, pl.1, figs.13-17) from the Lower Cretaceous Peide and Yunshan formations, Heilongjiang, China differ from the present specimens with elongate shells. Based on taxodont denticles and well-marked adductor scars, the present specimens are similar to the illustrated specimens of *Palaeonucula peidensis* (Gu et al., 1997, p.10-11, pl.1, figs.18-19) from the Lower Cretaceous Peide Formation, Heilongjiang, northeast China, although the former is characterized by a subtrigonal outline and the latter is characterized by a subcircular outline. Based on the location of the umbo, the present specimens differ from the illustrated specimens of *Palaeonucula saigonensis* (Hayami, 1972, p.182-184, pl.18, figs.1,2) from the Lower Jurassic Loc.2 of Lo-Duc, north-northeast of Ho Chi-Minh City (Saigon),Vietnam; the former is characterized by the umbo located at two-fifths of the length from the anterior end, while the latter is characterized by the umbo situated at one-third of the length from the anterior end (Table 6).

Table 6. Comparison of taxodont teeth and shell size of species of *Palaeonucula* in Japan (Hayami, 1959a), northeast China (Gu et al., 1997) and Vietnam (Hayami, 1972).

Reference		Hayami (1959a)	Gu et al. (1997)		Hayami (1972)	This study
Taxa		*Palaeonucula makitoensis*	*P*. cf. *makitoensis*		*P*. *saigonensis*	*P*. *makitoensis*
Registered numbers		-	81337	81338	-	TGUSE-MM7715
number of taxodont denticles	anterior	ca. 20	ca. 27	ca. 23	ca. 8	ca. 9
	posterior	ca. 9	ca. 11	ca. 9 - 10	ca. 14	ca.4
shell size	length (mm)	13.0 - 15.0	17.5	19.6	16.6 - 20.8	7.7
	height (mm)	9.5 - 11.0	12	15	11.4 - 15.2	5.1

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River (Mg01) and tributary of Magawa River (Mg05) at Arimine, Toyama City, Toyama Prefecture, Japan.

Palaeonucula cf. *makitoensis* (Hayami, 1959)

Fig. 16 E, F

Material. Six specimens (KIK0368a, -0368b, -0369b, -0370, -0383j, -0383k) collected at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. All specimens are internal casts of right valves (T. Hamuro Coll.). All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0368a	10.1	7.4	2.2	1.37	90
KIK0368b	9.9	7.8	1.8	1.26	88
KIK0369b	-	-	-	-	90
KIK0370	10.5	9.5	2.0	1.15	90
KIK0383j	5.6	5.2	-	1.08	90
KIK0383k	5.3	4.8	-	1.11	90

Description. Small shell, inequilateral, subtrigonal in outline, moderately convex, length a little longer than height; umbo slightly opisthogyrous, located at almost mid-point of shell length; apical angle about 90 degrees; dentition taxodont type, consisting of about seven denticles of anterior series and about eight denticles of posterior series; adductor scars elliptical; inner ventral margin smooth, without pallial sinus.

Remarks. The present specimens are similar to the holotype of *Palaeonucula makitoensis* (Hayami, 1959a, p.143-145, pl.12, figs.4-6) from the Lower Cretaceous Mitarai Formation, Tetrori Group, Gifu Prefecture, in having a subtrigonal shell outline, opisthogyrate umbo, and taxodont dentition. However, the apical angle of the present specimens is less than that of the specimens of *Palaeonucula makitoensis*; the former is 90 degrees, whereas the latter is about 115 degrees and we therefore classify the present specimens as *Palaeonucula* cf. *makitoensis* (Hayami).

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Palaeonucula sp.

1959a *Nuculopsis* (*Palaeonucula*) sp. indet.; Hayami, p.145, pl.12, fig.7

Remarks. Hayami (1959a) identified an internal specimen from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M2 member of the Mitarai Formation, which is middle part of the Mitarai Formation (Matsukawa and Nakada, 1999), as *Nuculopsis* (*Palaeonucula*) sp. indet. The inflated nature of the valve, as well as its *Nucula*-type hinge,suggest this specimen belongs to the genus *Palaeonucula* sp.

Superfamily Nuculanacea H. Adams and A. Adams, 1858
Family Milletiidae H. Adams and A. Adams, 1858
Genus *Palaeoneilo* Hall and Whitfield, 1869

Palaeoneilo ? sp.

1959a *Palaeoneilo* sp. indet.; Hayami, p.143, pl.12, figs.2,3.

Remarks. Hayami (1959a) identified two internal specimens from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M1 member of the lower part of the Mitarai Formation (Matsukawa and Nakada, 1999), as *Palaeoneilo* sp. indet. Based on Cox et al. (1969), the genus *Palaeoneilo* is defined by a faint posterior radial groove, concentric sculpture, and lack of an internal septum. The specimens UMUT-MM 3139 and 3140 are characterized by posteriorly elongate outline and predominantly external ligament; surface sculpture cannot be observed as they are internal moulds. We therefore tentatively assign the genus name for these specimens.

Family Nuculanidae H. Adams and A. Adams, 1858
Genus *Nuculana* Link, 1807
Subgenus *Nuculana* Cox et al., 1969

Nuculana (*Nuculana*) sp. A

Fig. 16 G, H

Material. 24 specimens (KIK0014, -0317, -0319q, -0329s, -0372-0381, -0382a, -0382d, -0382e, -0382h, -0383h, -0383i, -0383l, -0383n, -0383w), collected at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. They consist of 18 internal casts of left valves, five internal casts of right valves, and a single external cast of a left valve. All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture (T. Hamuro and A. Yamada Coll.).

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0014	12.4	6.7	1.3	1.85	128
KIK0372	12.8	6.7	2.0	1.92	-
KIK0373	12.3	8.0	1.7	1.54	126
KIK0375	8.9	5.2	1.2	1.72	126
KIK0376	6.7	3.8	-	1.77	124
KIK0378	21.8	15.4	3.3	1.41	110
KIK0380	9.2+	6.5	1.5	1.31+	110
KIK0381	11.7+	7.4	2.4	1.58+	-
KIK0382h	10.5	5.7	2.1	1.85	110

Description. Small shell, inequivalve, inequilateral, subelliptical form, posterior side elongate and gently rostrate, main body moderately inflated; end of rostrum rounded; umbo arcuate and located at one-third from the anterior end; apical angle ranging from 106 to 130 degrees (average: 118.3 degrees); surface ornamented by numerous fine concentric ribs; dentition taxodont type, composed of from seven to nine denticles of anterior series and from seven to nine denticles of posterior series; adductor scars elliptical; inner ventral margin smooth.

Remarks. The present specimens are different from the illustrated specimens of *Nuculana* (*Praesaccella*) *erioensis* Kimura (Tamura, 1960, p.56, pl.6, figs.3-6), from the Upper Jurassic Sakamoto Formation, southern Kumamoto Prefecture, Japan, based on their greater number of taxodont teeth (anterior = about 30, posterior = about 50), and obtuse apical angle (ranging from 140 to 150 degrees).

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Nuculana (*Nuculana*) sp. B

Fig. 16 I, J, K, L

Material. Six specimens (KIK0319t, -0319u, -0319v, -0382c, -0382g, -0382i) found at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. They consist of two internal casts of left valves and four internal casts of right valves. All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture (T. Hamuro Coll.).

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0319t	9.7	5.5	-	1.76	134
KIK0319u	10.3	7.2	-	1.42	120
KIK0319v	10.7	6.7	-	1.61	124
KIK0382c	9.9	6.7	-	1.49	110
KIK0382g	9.0	4.7	-	1.90	100
KIK0382i	6.8+	4.6	-	1.49+	114

Description. Small shell, inequivalve, strongly inequilateral, subelliptical form, main body strongly convex; posterior side elongate, curved slightly upward and gently rostrate; end of rostrum rounded; umbo arcuate, and located at one-third from the anterior end; apical angle ranging from 120 to 134 degrees; dentition taxodont type, composed of five or more denticles of anterior series and four or more denticles of posterior series; adductor scars elliptical; inner ventral margin smooth.

Remarks. Based on their moderately convex main body and linear postero-dorsal margin, the present specimens differ from the illustrated specimens of *Nuculana sambonsugii* (Nagao, 1938, p.120-121, pl.14, figs.10, 10a-c) from the Upper Cretaceous Hakobuti Sandstone, Upper Ammonites beds, the Ezo Group, Urakawa-machi, Hidaka Province, Hokkaido Island, Japan.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Subgenus *Praesaccella* Cox, 1940

Nuculana (*Praesaccella*) sp.

Fig. 16 M, N, O

Material. Four specimens (KIK0013a, -0013b, -0314, -0384) collected at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan, two internal casts of right valves, two internal casts of left valves. All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0013a	11.9	4.5	1.3	2.64	120
KIK0013b	8.6	4.0	0.8	2.15	120
KIK0314	11.0	4.5	1.2	2.44	120
KIK0384	7.1	3.7	0.7	1.92	120

Description. Small shell, equivalve, very inequilateral, nuculaniform, transversally elongate, rostrate posteriorly, edge of rostrum slightly rounded, main body strongly convex, postero-dorsal margin concave; escutcheon narrow and deep; narrow carina running from umbo along postero-dorsal margin; opisthogyrous umbo located at about mid-point of length; apical angle 120 degrees; dentition taxodont type, consisting of about eight denticles of anterior series and about seven denticles of posterior series; pallial line smooth, without pallial sinus.

Remarks. Based on their slightly rounded posterior end, the present specimens are classified in the subgenus *Praesaccella* defined by Cox et al. (1969). The specimens of the present species differ from the illustrated specimen of *Nuculana* (*Dacryomya*) *konishii* (Hayami, 1961, p.114-115, pl.16, fig.1) from the Lower Jurassic Yamaoku Formation, Okayama Prefecture, Japan, in having a more elongated rostrum. However, the latter has a slightly rounded rostrum edge, so *Nuculana* (*Dacryomya*) *konishii* (Hayami, 1961) should also be classified in the subgenus *Nuculana*, as defined by Cox et al. (1969). The present specimens are different from the illustrated specimen of *Nuculana* (*Dacryomya*) *konishii* Hayami (Goto, 1983, p.80, pl.16, fig.1) from the Lower Jurassic Teradani Formation, Kuruma Group, Toyama Prefecture, Japan, based on their moderately inflated main body and very elongate rostrum. Based on the obtuse apical angle (140 degrees) and larger number of taxodont teeth (11-13), the present specimens also differ from the illustrated specimens of *Nuculana* (*Praesaccella*) *elongate* Li and Yu (Gu et al., 1997, p.25, pl.4, figs.1,2) from the Lower Cretaceous Piede Formation in Heilongjiang, China.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Superfamily Solemyacea H. Adams and A. Adams, 1857
Family Solemyidae H. Adams and A. Adams, 1857
Genus *Solemya* Lamarck, 1818

Solemya suprajurensis Hayami, 1959

1959a *Solemya suprajurensis*; Hayami, p.141-142, pl.12, figs.1a, b.
1975 *Solemya suprajurensis*; Hayami, p.26, pl.1, fig.2.

Remarks. Hayami (1959a) identified an internal specimen from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M3 member of the Mitarai Formation, which is in the upper part of the Mitarai Formation (Matsukawa and Nakada, 1999) as *Solemya suprajurensis* sp. nov. Cox et al., (1969) subdivided the genus *Solemya* into four subgenera based on internal shell characters, but our specimen cannot be assigned to any of these subgenera due to poor preservation.

Subclass Pteriomorphia Beurlen, 1944
Order Mytiloida Ferussac, 1822
Superfamily Mytilacea Rafinesque, 1815
Family Mytilidae Rafinesque, 1815
Subfamily Mytilinae Rafiniesque, 1815
Genus *Mytilus* Linné, 1758

Mytilus sp.

Fig. 16 P, Q, R

Material. Six specimens (KIK0016a, -0385, -0386a, -0387, -0388, -0389) collected at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan, two internal casts of right valves, two external casts of right valves, a single internal mold of a right valve, and a single external mold of a left valve. All specimens housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0016a	27.7	16.9	2.6	1.64	64
KIK0385	38.6+	28.3+	-	-	-
KIK0386a	23.1+	21.1+	-	-	70
KIK0387	19.1	13.6	2.5	1.40	68
KIK0388	18.6	9.9	2.5	1.89	-
KIK0389	27.2	16.2	-	1.68	70

Description. Medium shell, inequilateral, mytiliform, wedge-shaped, hinge line nearly straight, anterior margin straight; moderately convex; apical angle ranging from 64 to 70 degrees (average = 64.0 degrees; N = 4); surface marked with irregular concentric folds and numerous fine growth lines; very narrow dysodont teeth along anterior margin; inner ventral margin smooth.

Remarks. The present specimens are similar to the illustrated specimens of *Mytilus* (*Falcimytilus*) *heranirus* (Hayami, 1958, p.160, pl.24, figs.3, 4) from the Lower Jurassic Tsuchizawa Formation, Kuruma Group, Otari-mura, Nagano Prefecture, in having a mytiliform shape and concentric folds. However, the apical angle of the present specimens is wider than the illustrated specimens of *Mytilus* (*Falcimytilus*) *heranirus*; the former is about 64 degrees and the latter is about 50 degrees. The present specimens differ from the illustrated specimens of *Mytilus longzhaogouensis* Yu and Li (Gu et al., 1997, p.41-42, pl.5, figs.17-20), from the Lower Cretaceous Yunshan Formation, east of Yonghong in the Hulin district, China, in their wider apical angle: the former is about 64 degrees while the latter ranges from 40 to 50 degrees.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Genus *Brachidontes* Swainson, 1840

Brachidontes ? sp.

1959a *Brachidontes*? sp. indet.; Hayami, p.147, p.12, fig.11.

Remarks. Hayami (1959a) identified an internal mould of a bivalved specimen from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M3 member of the Mitarai Formation [=upper part of the Mitarai Formation (Matsukawa and Nakada, 1999)], as *Brachidontes* ? sp. indet. Fine radial striae on the surface of this specimen support the placement of the specimen witimin the genus *Brachidontes*, but bifurcating ribs cannot be confirmed. We thus hesitate to firmly identify the specimen as the genus *Brachidontes.*

Subfamily Modiolinae Keen, 1958
Genus *Modiolus* Lamarck, 1799
Subgenus *Modiolus* Lamarck, 1799

Modiolus (*Modiolus*) *magatama* Hayami, 1959

Fig. 17 A, B

1959d *Modiolus magatama*; Hayami, p.46, pl.5, fig.13.
1975 *Modiolus magatama*; Hayami, p.38,

Material. Two specimens from muddy sandstone beds of the Magawa Formation. TGUSE-MM7719 (K. Suzuki, and M. Matsukawa Coll.) is an external cast of a right valve, locality Mg01; TGUSE-MM7720 (K. Suzuki, and M. Matsukawa Coll.) is an external cast and mold of a right valve, locality Mg01.

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7719	15.3	16.8	8.9	0.91
TGUSE-MM7720	10.8+	15.4	4.5	0.70+

Description. Small shell, equivalve, inequilateral, modioliform, strongly inflated, with shell-obliquity about 40 degrees; anterior lobe large; junction between main body and anterior lobe forming shallow linear sulcus; posterior lobe very small, trigonal, and thin; umbo strongly prosogyrate near anterior end; hinge line straight; junction between main body and posterior lobe forming shallow sulcus; anterior-dorsal margin slightly curved; edge of anterior margin rounded, but radius of curvature shorter than posterior margin; ventral margin gently curved; posterior-dorsal margin slightly convex; surface marked with fine concentric ribs, which continue on the surface of both anterior and posterior lobes.

Remarks. The specimens are very similar to the illustrated specimens of *Modiolus magatama* (Hayami,

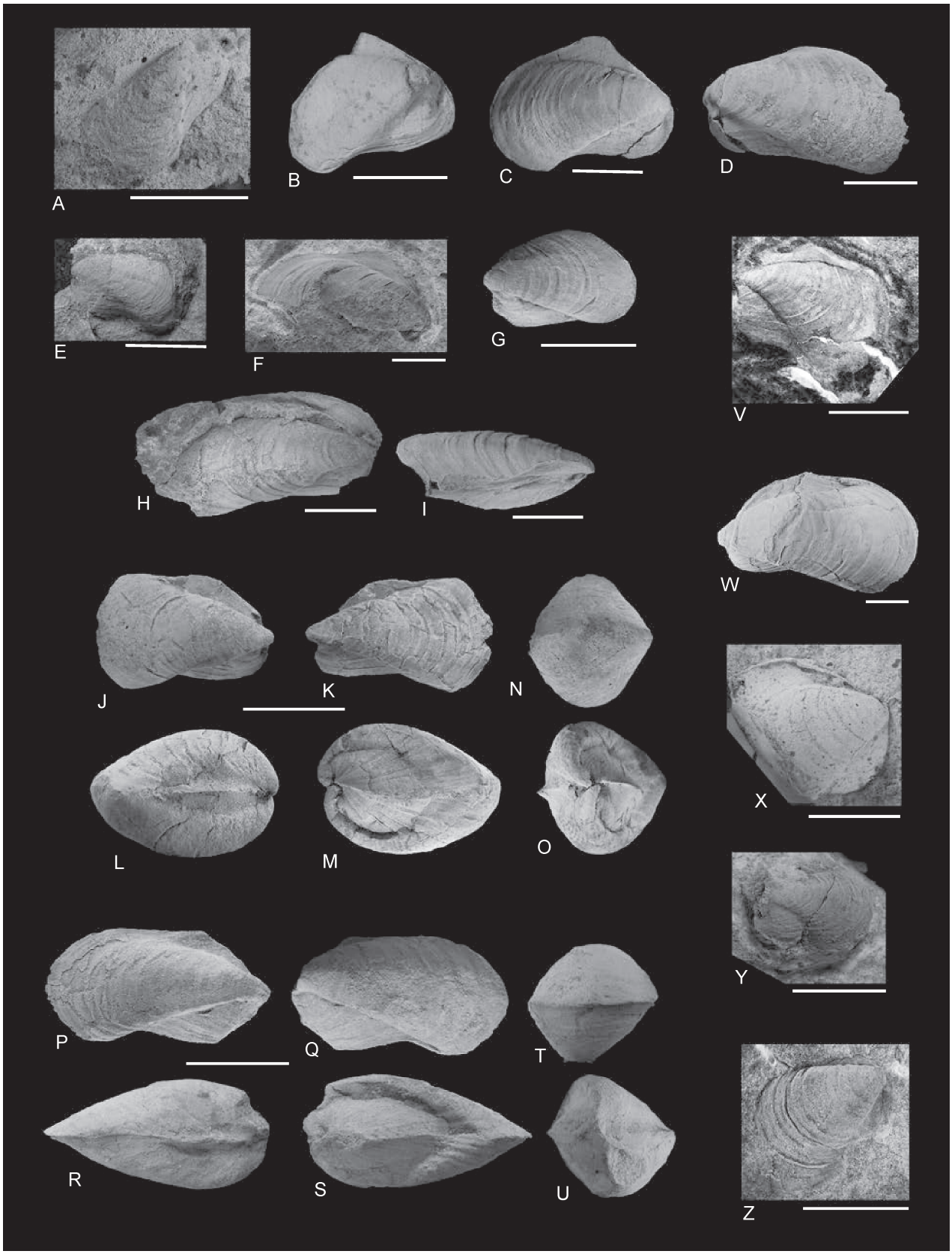

Fig.17. A,B, *Modiolus* (*Modiolus*) *magatama* Hayami; A, TGUSE-MM7720, external cast of right valve, Magawa Formation (loc. Mg01); B, TGUSE-MM7719, external cast of right valve, Magawa Formation (loc. Mg01); C-U, *Modiolus* (*M.*) *setiniae* Hayami; C, TGUSE-MM7826, external cast of right valve, Magawa Formation (loc. Mg01); D, TGUSE-MM7726, external valve of left valve, Magawa Formation (loc. Mg01); E, TGUSE-MM7724, external cast of left valve, Magawa Formation (loc. Mg01); F, TGUSE-MM7733, external cast of right valve, Magawa Formation (loc. Mg01); G, TGUSE-MM7731, external cast of left valve, Magawa Formation (loc. Mg01); H, I, TGUSE-MM7727, external cast of right valve, Magawa Formation (loc. Mg01); H, right view; I, lower view; J-O, TGUSE-MM7722, external cast of articulated valves, Magawa Formation (loc. Mg01); J, right view; K, left view; L, upper view; M, lower view; N, ventral view; O, dorsal view; P-U, TGUSE-MM7728, external cast of articulated valves, Magawa Formation (loc. Mg01); P, right view; Q, left view; R, upper view; S, lower view; T, ventral view; U, dorsal view. V-Z, *Modiolus* (*M.*) *toyamensis* sp. nov.; V, TGUSE-MM7741, external cast of left valve, Magawa Formation (loc. Mg01); W, KIK0020a, holotype, external cast of left valve, Kiritani Formation; X, TGUSE-MM7745, external mold of right valve (rubber cast), Magawa Formation (loc. Mg01); Y, TGUSE-MM7743, external cast of left valve, from the Magawa Formation (loc. Mg01); Z, TGUSE-MM7746, external cast of right valve, from the Magawa Formation (loc. Mg01). Scale bars show 1 cm.

1959d, p.46-47, pl.5, fig.13) from the Lower Jurassic Higashinagano Formation, Japan, in having small and modioliform shell, well inflated shell form, and large and strongly inflated anterior lobe. The present specimens differ from the illustrated specimens of *Modiolus maedae* (Hayami, 1959a, p.145-146, pl.12, figs.8-10) from the Lower Cretaceous Mitarai Formation, because the former has a shorter shell length. With their large and strongly inflated anterior lobe, the present specimens differ from the illustrated specimens of *Modiolus dahuashuensis* (Gu et al., 1997, p.45, pl.6, figs.1, 2) from the Lower Cretaceous Yunshan Formation, Heilongjiang, China. The present specimens, with their rounded umbo and large anterior lobe, differ from the illustrated specimens of *Modiolus sestinae* (Hayami, 1972, p.186-141, pl.33, figs.8-16) from Loc.2 of Lo-Duc, north north-east of Ho Chi-Minh City (Saigon), Vietnam, which are characterized by an elongate-modioliform shell, acute umbo, obtuse-triangular anterior lobe, straightly dorsal-margin, and umbonal angle about 40 degrees.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation (Mg01) along Magawa River at Arimine, Toyama City, Toyma Prefecture, Japan.

Modiolus (*Modiolus*) *maedae* Hayami, 1959

1959a *Modiolus maedae*; Hayami, p.145-146, pl.12, figs.8-10.
1975 *Modiolus maedae*; Hayami, p.38.

Remarks. Hayami (1959a) identified four specimens from Nonomata and Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M2 and M3 members of the Mitarai Formation [=upper part of the Mitarai Formation; (Matsukawa and Nakada, 1999)], as *Modiolus maedae.* Cox et al. (1969) divided the genus *Modiolus* into five subgenera; Our specimens are characterized by inflated shells and are thus classified as the subgenus *Modiolus*.

Modiolus (*Modiolus*) *setiniae* Hayami, 1972

Fig. 17 C - U

1972 *Modiolus setiniae*; Hayami, p.186-191, pl.33, figs.8-16.
2006 *Modiolus setiniae*; Kozai et al., pl.1, fig.5.

Material. 20 specimens from localities Mg01 (TGUSE-MM7719 to -MM7737, -MM7826), Mg03 (TGUSE-MM7738), and Mg06 (TGUSE-MM7739). Two specimens are external casts of left valves, a single specimen is an external cast of a left valve, seven specimens are external casts of right valves, a single specimen is an external mold of a right valve, and nine specimens are external molds of articulated valves (K. Suzuki, Y. Fujimoto, A. Ishitoya, M. Matsukawa, and K. Koarai Coll.).

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
TGUSE-MM7721	18.6	9.0	4.5	2.05	38
TGUSE-MM7722	16.8	11.7	6.6	1.44	42
TGUSE-MM7723	26.2	15.9	5.9	1.65	40
TGUSE-MM7724	12.4+	9.9	2.6	1.26+	38
TGUSE-MM7725	18.2+	11.1+	2.8	-	42
TGUSE-MM7726	26.5	18.6	8.6	1.42	38
TGUSE-MM7727	30.9	17.8	7.6	1.73	38
TGUSE-MM7728	19.7	10.9	5.3	1.82	40
TGUSE-MM7729	-	16.8	-	-	-
TGUSE-MM7730	21.6	14.9	6.3	1.45	40
TGUSE-MM7731	19.2	11.4	4.9	1.68	40
TGUSE-MM7734	14.1	9.0	2.1	1.57	40
TGUSE-MM7735	-	-	-	-	38
TGUSE-MM7736	26.5	16.5+	6.8	-	40
TGUSE-MM7737	11.2	6.6	2.5	1.70	38
TGUSE-MM7739	15.5	7.6	3.5	2.04	36

Description. Shell small, equivalve, inequilateral, elongate-modioliform, much longer than high, strongly inflated, test thin; anterior lobe obtuse-triangular, clearly separated from main body by obvious sulcus, occupying about one-fifth of surface area; hinge line nearly straight; posterior margin gently arcuate; umbo acute, very prosogyrate, almost terminal; apical angle ranging from 36 to 42 degrees (average = 39.2 degrees); surface marked with numerous undulations.

Remarks. Because of their modioliform shell, with very prosogyrate umbo, strongly convex and smooth hinge line, and numerous fine concentric ribs, the present specimens are identified as the genus *Modiolus* (Cox et al., 1969). The specimens are very similar to the illustrated specimens of *Modiolus sestiniae* (Hayami, 1972, p.186-191, pl.33, figs.8-16) from the Lower Jurassic Loc.2 of Lo-Duc, north-northeast of Ho Chi-Minh City (Saigon), Vietnam, in having an elongated-modioliform shell, very prosogyrate and obtuse umbo, triangular anterior lobe, and numerous fine concentric lirae. The present specimens are characterized by modioliform shell, acute umbo (apical

angle about 40 degrees), obtuse triangular anterior lobe, whereas the illustrated specimens of *Modiolus maedae* (Hayami, 1959a, p.145-146, pl.12, figs.8-10) from the Lower Cretaceous Mitarai Formation, are characterized by an expanded and very acurate ventral area (apical angle from 25 to 28 degrees). The illustrated specimen of *Modiolus* sp. (Gu et al. 1997, p.46-47, pl.6, fig.5), from the Lower Cretaceous Peide Formation in Heilongjiang, China, differs from the present specimens in its rounded umbo and lack of anterior lobe. Based on elongate shell outline and numerous fine concentric ribs, the present specimens are similar to the illustrated specimen of *Modiolus imbricatus* (Kozai et al., 2006, pl.2, fig.12), from the Lower Jurassic Klo Tho Formation, Umphang Group, Umphang area, northwestern Thailand; although the former is characterized by an elongate-modioliform shell and triangular anterior lobe, the latter is characterized by posterior lobe, and the axis of the main body forms a slight arcuate curve.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine in Toyama Prefecture, Japan.

Modiolus (*Modiolus*) *toyamensis* sp. nov.

Fig. 17 V - Z

Diagnosis. Apical angle is about 60 degrees.

Types. Holotype is KIK0020a (E. Nanasawa Coll.), locality Kiritani Formation; paratypes are TGUSE-MM7741 and TGUSE-MM7743 (K. Suzuki and M. Matsukawa Coll.), locality Mg01.

Derivation of name. Meaning *Modiolus* from Toyama Prefecture, Japan.

Horizon and Locality. The type specimens were discovered from the Magawa Formation along the Magawa River, Arimine district, Toyama City, Toyama Prefecture, Japan.

Material. Eight specimens from localities Mg01 (TGUSE-MM7740 to -MM7746) and Mg06 (TGUSE-MM7747). They consist of four external casts of a left valve, a single external cast of a right valve, two external casts of articulated valves, and a single external mold of a right valve (K. Suzuki, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.).

Six more -or- less deformed specimens (KIK0020a, -0020b, -0322, -0390a, -0390b, -0390c) found at Todani, Yatsuo area, Toyama City, Toyama Prefecture, are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture. These include a single external cast of a right valve, and five external casts of articulated valves (M. Asai, E. Nanasawa, H. Iwatani, and T. Hamuro Coll.).

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
TGUSE-MM7741	20.1	14.9	4.9	1.35	60
TGUSE-MM7743	13.3	8.9	4.1	1.49	56
TGUSE-MM7745	-	-	-	-	68
TGUSE-MM7746	14.0	10.5	4.3	1.33	60
TGUSE-MM7747	19.4	12.9	4.2	1.51	64
KIK0020a	38.5	30.5	8.8	1.26	54
KIK0020b	20.9+	18.3+	-	-	-
KIK0322	27.1+	26.1+	-	-	-
KIK0390a	27.5+	24.0+	-	-	-
KIK0390b	25.4+	21.8+	-	-	-
KIK0390c	29.6	23.1	4.9	1.28	60

Description. Small shell, equivalve, inequilateral, modioliform, much longer than high, strongly inflated; hinge line nearly straight; anterior lobe large, trigonal, and strongly inflated; posterior lobe small, flat, thin, and obtuse-trigonal; antero-dorsal margin moderately rounded; junction between main body and posterior lobe forming obvious shallow sulcus; joint between main body and anterior lobe forms shallow obvious sulcus; umbo strongly prosogyrate, located at one-third of shell length from front; apical angle ranging from 56 to 68 degrees (average = 61.6 degrees); surface of main body and anterior and posterior lobe marked with numerous fine undulations.

Remarks. The specimens differ from the illustrated specimen of *Modiolus* (*Modiolus*) *nagatoensis* (Tokuyama, 1960, p.36, pl.4, fig.14) from the the Carnian Aso Formation, Mine Group, because the latter lacks an anterior lobe. Because of their large strongly inflated anterior lobes, the illustrated specimens of *Modiolus* (*M.*) *magatama* (Hayami, 1959d, p.46, pl.5, fig.13) from the Lower Jurassic Higasinagano Formation, Toyora Group, are different from the present specimens. The present material also differs from the illustrated specimens of the *Modiolus* (*M.*) *sestinae* (Hayami, 1972, p.186-191, pl.33, figs.8-16) from the Lower Jurassic Loc.2 of Lo-Duc, north-northeast of Ho Chi-Minh City (Saigon), Vietnam, in that the former have a

narrow apical angle (about 40 degrees), while the latter are characterized by a wide apical angle (about 60 degrees).

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine in Toyama Prefecture, Japan (TGUSE-MM7740-7746 and MM7747). Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan (KIK0020a, -0020b, -0322, -0390a, -0390b, -0390c).

Superfamily Pinnacea Leach, 1819
Family Pinnidae Leach, 1819
Genus *Pinna* Linné, 1758
Subgenus *Pinna* Linné, 1758

Pinna (*Pinna*) aff. *sandsfootensis* Arkell, 1933-1934

1959a *Pinna* sp. ex gr. *sandsfootensis*; Hayami, p.147-148, pl.12, figs.12,13.
1975 *Pinna* (*Pinna*) sp. aff. *sandsfootensis*; Hayami, p.40.

Remarks. Hayami (1959a) identified two specimens of external molds in having twelve radial ribs from Mitarai and Nonomata, Shokawa area, Takayama City, Gifu Prefecture, in M2 member of the Mitarai Formation, as *Pinna* sp. ex gr. *sandsfootensis*, because he recognized a difference in the mode of median parting and radial ornamentation between Japanese material and English specimens of *Pinna sandsfootensis* Arkell (1933-1934). Subsequently, Hayami (1975) classified the two Japanese specimens as *Pinna* (*Pinna*) sp. aff. *sandsfootensis*, because he recognized the alliance of the two forms.

Pinna (*Pinna*) *ariminensis* sp. nov.

Fig. 18 A - P

1997 *Pinna* sp.; Gu et al., p.47, pl.4, fig.6.

Diagnosis. Sectional form rhombic. Surface ornamented with distinct radial ribs and fine concentric ribs. Radial ribs vary in number from five to eight on dorsal slope, and from five to seven on ventral slope. Radial and concentric ribs intersect reticulately at dorsal slope.

Types. Holotype is TGUSE-MM7749 (K. Suzuki and M. Matsukawa Coll.), locality Mg01; paratypes are TGUSE-MM7756, 7758, 7762 (K. Suzuki, M. Matsukawa and K. Koarai Coll.), locality Mg01.

Derivation of name. Meaning *Pinna* from Arimine district, Toyama Prefecture, Japan.

Horizon and Locality. The type specimens were discovered from Mg01, the Magawa Formation of the Tetori Group, along Magawa River at Arimine area, Toyama City, Toyma Prefecture, Japan.

Material. 21 specimens (TGUSE-MM7748 to -MM7768, -MM7825) came from localities Mg01, Mg03, Mg05 and Mg06. A single one of these is an external cast of a left valve, three specimens are external casts of right valves, ten specimens are external casts of articulated valves, three specimens are external molds of left valves, two specimens are external molds of right valves, and a single specimen is an internal cast of a right valve (K. Suzuki, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.). All specimens are more or less fragmental. Test is partly preserved.

Measurements (in mm except for Number of radial ribs)

Specimen	L	H	T	Number of radial ribs (dorsal area)	Number of radial ribs (ventral area)
TGUSE-MM7748	46.2+	10.8+	3.2	-	-
TGUSE-MM7749	50.6+	17.8	-	6	6
TGUSE-MM7752	-	-	-	-	7
TGUSE-MM7753	-	-	-	6	-
TGUSE-MM7754	-	-	-	-	5
TGUSE-MM7755	53.4+	19.8	-	-	5
TGUSE-MM7756	59.5+	24.6+	-	5	7
TGUSE-MM7757	65.2+	24.9+	7.9+		-
TGUSE-MM7758	71.3+	-	-	7	-
TGUSE-MM7759	30.9+	8.2+	2.0+	-	-
TGUSE-MM7760	41.1+	17.9+	8.6+	-	-
TGUSE-MM7761	50.6+	17.8	-	8	6
TGUSE-MM7762	91.4+	17.6+	-	-	6
TGUSE-MM7763	-	-	-	7	-
TGUSE-MM7764	-	-	-	6	6
TGUSE-MM7767	37.6+	25.3+	11.4+	6	6

Description. Shell medium to large, equivalve, cuneiform, strongly inflated, rhombic form in section; beaks situated at anterior end of hinge line; hinge line very long, almost straight; median ridge of shell very sharp and straight, dividing shell into dorsal and ventral areas; surface of dorsal slope marked with from five to eight radial ribs and numerous concentric ribs spaced at regular intervals;

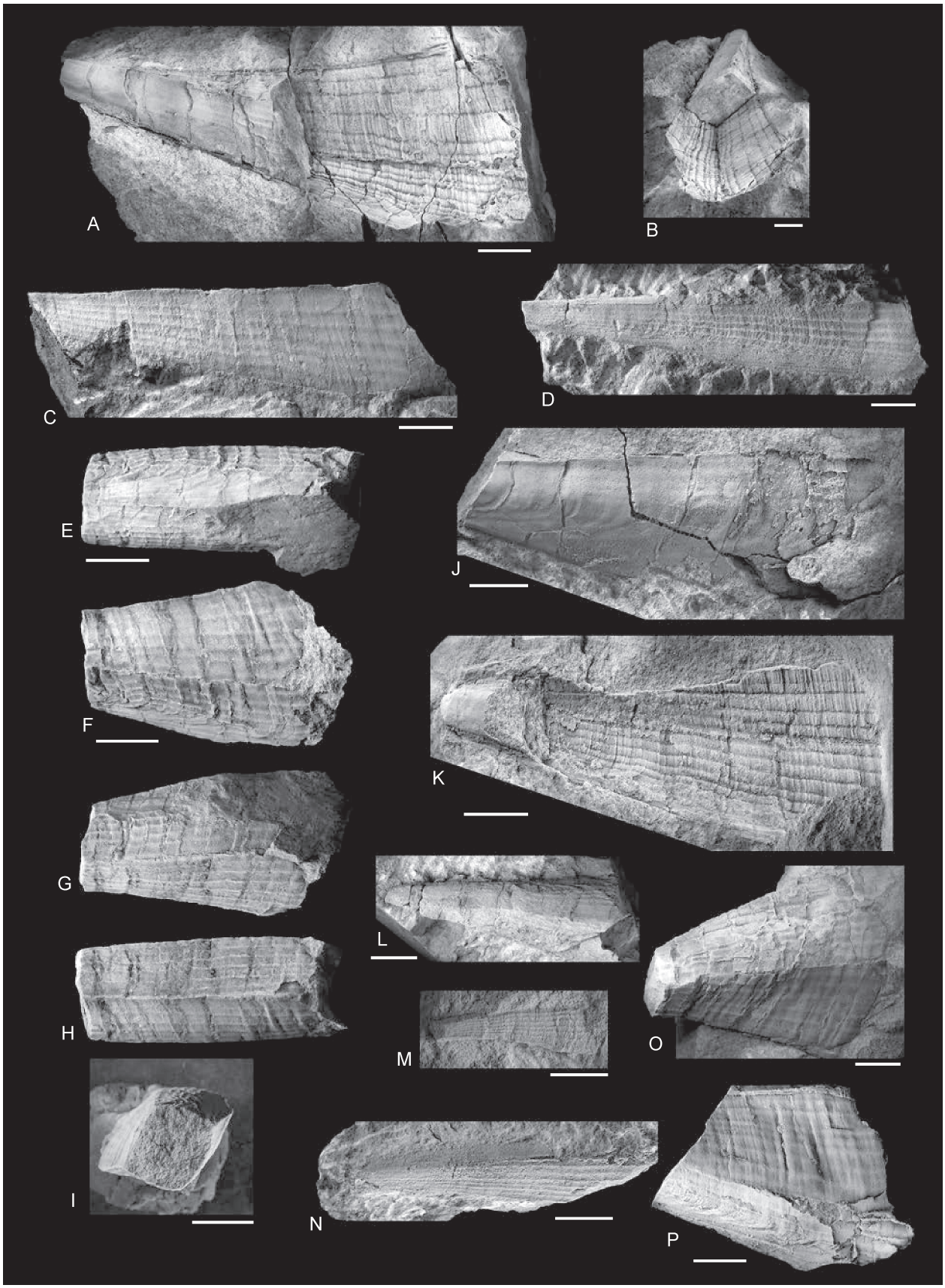

Fig.18. A-P, *Pinna* (*Pinna*) *ariminensis* sp. nov.; A,B, TGUSE-MM7749, holotype, external cast and mold of articulated valves; A, left view and external mold of right valve, Magawa Formation (loc. Mg01); B, section; C, TGUSE-MM7758, external cast of articulated valves, left view, Magawa Formation (loc. Mg05); D, TGUSE-MM7762, external cast of right valve, Magawa Formation (loc. Mg05); E-I, TGUSE-MM7767, external cast of articulated valves, Magawa Formation (loc. Mg06); E, dorsal view; F, left view; G, right view; H, ventral view; I, section; J, TGUSE-MM7766, internal cast of right valve, Magawa Formation (loc. Mg06); K, TGUSE-MM7825, external mold of right valve, Magawa Formation (loc. Mg05); L, TGUSE-MM7757, external cast of articulated valves, left view, Magawa Formation (loc. Mg05); M, TGUSE-MM7759, external cast of articulated closed valves, right view, Magawa Formation (loc. Mg05); N, TGUSE-MM7748, external cast of articulated closed valves, left view, Magawa Formation (loc. Mg01); O, TGUSE-MM7756, external cast of articulated closed valves, right view, Magawa Formation (loc. Mg03); P, TGUSE-MM7764, external cast of articulated closed valves, ventral view, Magawa Formation (loc. Mg05). Scale bars show 1 cm.

surface of ventral slope ornamented with from five to seven radial ribs, regularly spaced and converging toward umbo, and many concentric ribs becoming hook-shaped toward ventral area; very narrow gape on ventral margin; apical angle, forming between hinge line and antero-ventral margin, ranges from 26 to 30 degrees; test very thin.

Remarks. Because of its cuneiform, equivalve shell with umbo located at the anterior end of a long hinge, very narrow gape ending at the anterior end of the ventral margin, and shell surface marked with numerous concentric ribs and few clear radial ribs, the present specimens are assigned to the genus *Pinna* (Cox et al., 1969). Furthermore, the well-defined median ridge and nearly straight ventral margin allow the present specimens to be assigned to the subgenus *Pinna* (Cox et al., 1969).

Pinna sp. (Gu et al., 1997, p.47, pl.6, fig.6), from the Lower Cretaceous Dongrong Formation, Heilongjiang, China, is also assigned to the present species in having the same number of radial ribs on the dorsal slope. Because of its larger number of radial ribs, with four radial ribs on the ventral area and nine radial ribs on the dorsal area, the illustrated specimens of *Pinna* cf. *mitis* (Tamura, 1960, p.278-279, pl.32, figs.12-14), from the Upper Jurassic Soma Group, Japan, differ from our specimens. Based on 12 radial ribs on dorsal area, the illustrated specimens of *Pinna* sp. ex gr. *sandsfootensis* (Hayami, 1959a, p.147, pl.12, figs.12,13) from the Lower Cretaceous Mitarai Formation of the Tetori Group in Gifu Prefecture, Japan, are also different from the new species. With a greater number of radial ribs (nine ribs) on the dorsal slope, specimens of *Pinna* (*Pinna*) *ariminensis* sp. nov. differs also from the illustrated specimen of *Pinna* cf. *mitis* (Cox, 1940, p.132-133, pl.10, fig.11), from the Callovian Lamellibranch fauna of Kachh, India. The present specimens are distinguished from the illustrated specimens of *Pinna* (*P.*) *mitis* (Lazar et al., 2004, p.235, pl.2, figs.3-5), from the Lower Callovian Dealul Zanei Marls Formation, Anina-Ponor Quarry, Romania, in that the latter has a greater number of radial ribs (ventral area 15-17, dorsal area 19-24) . The illustrated specimen of *Pinna pontica* (Anderson, 1938, p.98, pl.2, fig.2) from the California Academy of Sciences (CAS) locality 1353 (Hauterivian) near the bridge over the North Fork of Cottonwood Creek, Shasta County, California, has eight radial ribs on the ventral area, while our specimens have five to seven; thus, *Pinna pontica* differs from our specimens. Because of the presence of 12 radial ribs on the dorsal area, the illustrated specimens of *Pinna kotsiensis* (Packard and Jones, 1965, p.912-913, pl.108, figs.3, 4), from the US Geological Survey Mesozoic locality M1977 (Hauterivian), southern Alaska, Kotsina-Kuskulana area are also different from the present material. Finally, the illustrated specimen of *Pinna equivillana* (Anderson, 1938, p.98, pl.2, fig.1), from the California Academy of Sciences (CAS) locality 1659 (late Aptian to middle Albian), Hulen Creek, Shasta County, California, differs from the present specimens in the number of radial ribs, with six to seven on dorsal area and eight to nine on ventral area, (Table 7).

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine area in Toyama Prefecture, Japan.

Order Pterioida Newell, 1965
Suborder Pteriina Newell, 1965
Superfamily Pteriacea Gray, 1847
Family Inoceramidae Giebel, 1852
Genus *Inoceramus* Sowerby, 1814
Subgenus *Inoceramus* Sowerby, 1814

Remarks. Based on Cox et al. (1969), the genus *Inoceramus* is subdivided into eight subgenera: *Inoceramus*, *Birostrina*, *Cataceramus*, *Cremnoceramus*, *Endocostea*, *Haenleinia*, *Mytiloceramus* and *Mytiloides*. Because the present specimens display a posterodorsal wing present, they are assigned to the subgenus *Inoceramus*.

Subgenus *Mytiloides* Brongniart, 1822

Inoceramus (*Mytiloides*) *hamadae* Hayami, 1960

1960a *Inoceramus hamadae*; Hayami, p.302, pl.15, fig.14.
1975 *Inoceramus* (*Mytiloides*) *hamadae*; Hayami, p.51.

Remarks. Hayami (1960a) described one left valve (UMUT MM 3601) from Shimoyama, Izumi area, Ono City, Fukui Prefecture, in the Kaizara Formation as *Inoceramus hamadae*, sp. nov. Afterward, Hayami (1975) classified the specimen (UMUT MM 3600) as *Inoceramus* (*Mytiloides*) *hamadae* without reason. Based on Cox et al. (1969), the specimen belongs to the subgenus *Mytiloides*, because it has an obliquely ovate, slightly convex and short hinge line, and concentric plications.

Inoceramus (*Inoceramus*) maedae Hayami, 1960

Table 7. Number of radial ribs of *Pinna* (*Pinna*) *ariminensis* sp. nov., *Pinna* (*P.*) ex gr. *sandsfootensis* (Hayami, 1959a), *Pinna* sp. (Gu et al., 1997), *Pinna* sp. (Hayami, 1972), *Pinna* (*P.*) *mitis* (Lazar et al., 2004), *Pinna* cf. *mitis* (Cox, 1940, Indian specimen) and *Pinna* cf. *mitis* (Cox, 1940, English specimen).

Taxa	Reference	number of radial ribs		shell height (mm)
		dorsal area	ventral area	
Pinna (*Pinna*) *ariminensis* sp. nov.	this study	5 - 8	5 - 7	44.8+
P. sp. ex gr. *sandsfootensis*	Hayami (1959a)	12	several	45.5+ - 58.0
P. sp.	Gu et al. (1997)	5	-	70 - 80
P. sp.	Hayami (1972)	-	17	-
P. (*P*.) *mitis*	Lazar et al. (2004)	19 - 24	15 - 17	40 - 45
P. cf. *mitis* (Indian specimen)	Cox (1940)	9	0	-
P. cf. *mitis* (English specimen)	Cox (1940)	6 -7	4	-
P. *pontica*	Anderson (1938)	6-7	8	68
P. *kotsinensis*	Packard and Jones (1965)	12	6-7	27
P. *equivillana*	Anderson (1938)	6-7	8-9	144

1960a *Inoceramus maedae*; Hayami, p.308, text-fig.2, pl.17, figs.1-3.

1960a *Inoceramus maedae*; Hayami var b, p.311, pl.18, fig.1.

1975 *Inoceramus* (*Inoceramus*) *maedae*; Hayami, p.52.

1998 *Inoceramus* cf. *maedae*; Fujita et al., p.52-55, figs.4-1, 2, 3.

2009 *Inoceramus* (*Inoceramus*) *maedae*; Matsukawa and Fukui, p.621, figs.5M, N, O.

Remarks. Hayami (1960) identified specimens from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in lower part of the Mitarai Formation as *Inoceramus maedae*. Because of posterodorsal wings present, the specimens suggest the species belongs to the subgenus *Inocerams*.

Inoceramus ? *furukawensis* Hayami, 1960

1960a *Inoceramus furukawensis*; Hayami, p. 311-312, pl. 16, fig. 8.

1975 *Inoceramus furukawensis*; Hayami, p.58.

Remarks. Hayami (1960) identified a single internal mold of left valve from Waki-dani, former Kawai Village, Hida-Furukawa area, Hida City, Gifu Prefecture, in the Sugizaki Sandy Formation (=Inagoe Formation; Matsukawa et al., 2007), as *Inoceramus furukawensis*. The species is characterized by smaller dimensions of L/H and absent of both wings. Based on Cox et al. (1969), however, the genus *Inoceramus* is defined by posterior wing variably developed. So, the species is tentatively identified as *Inoceramus* ? *furukawensis*.

Inoceramus (*Mytiloides* ?) sp. A

1960a *Inoceramus* cf. *nitescens*; Hayami, p.302, pl.15, fig.15.

1975 *Inoceramus* (*Mytiloides*) sp.; Hayami, p.75.

Remarks. Hayami (1960a) described one left valve (UMUT MM 3600) from Nagano, Izumi area, Ono City, Fukui Prefecture, in the "Nagano Formation" [=a junior synonym of the Kaizara Formation; Matsukawa at al. (2006)] as *Inoceramus* cf. *nitescens* Arkell, 1933. Afterward, Hayami (1975) subsequently reclassified the specimen UMUT MM 3600 as *Inoceramus* (*Mytiloides*) sp. because widely spaced concentric rings are not present on the specimen. The subgenus *Mytiloides* is defined by medium-sized shells, obliquely ovate, elongate and of slight convexity, with short hinge line and concentric plications (Cox at al., 1959). The obliquely ovateness, and slight convexity of the valves on the present specimen, as well as concentric plications confirm that it belongs to the subgenus *Mytiloides*.

Inoceramus (*Mytiloides* ?) sp. B

Fig. 19 A, B

Material. Two specimens (KIK0391, -0392) collected at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan, include a single external cast of a right valve and a single external cast of articulated valves. Both specimens are kept at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture (M. Asai Coll.).

Measurement (in mm)

Specimen	L	H	T	L/H
KIK0391	29.3+	-	-	-

Description. Shell medium size, subequivalve, inequilateral, mytiliform; surface marked with strong concentric plications, with interspaces widening gradually from dorsal to ventral areas.

Remarks. Because of their obliquely ovate and elongate shell form, the present specimens appear to belong to the subgenus *Mytiloides* (Cox et al., 1969). However, prismatic calcite of the outer ostracum is not preserved in the present specimens, so we hesitate to conclude that the present specimens belong to the genus *Inoceramus*, sensu stricto.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Family uncertain

Inoceramus ? *naganoensis* Hayami, 1960

1960a *Inoceramus* ? *naganoensis*; Hayami, p.315, pl.18, fig.6.
1975 *Inoceramus* ? *naganoensis*; Hayami, p.59.

Remarks. Hayami (1960a) identified a single left internal mold of specimen from Nagano, Izumi area, Ono City, Fukui Prefecture in the "Nagano Formation" (=Kaizara Formation; Matsukawa et al., 2006), as *Inoceramus* ? *naganoensis*. Since the prismatic layer and ligament structure are not observable on this speciman, Hayami (1960a) questioned whether it is actually an inoceramid or a member of the genus *Isognomon*. Based on the surface markings, Hayami (1960a) tentatively assigned the specimen to the genus *Inoceramus*.

Superfamily Pectinacea Rafinesque, 1815
Family Entoliidae Korobkov, 1960
Genus *Entolium* Meek, 1865

Entolium inequivalve Hayami, 1959

Fig. 19 C - G

1959b *Entolium inequivalve*; Hayami, p.154-156, pl.13, figs.3-8.
2001 *Entolium inequivalve*; Komatsu et al., fig.4.

Material. Two specimens (TGUSE-MM7768, -MM7769) from the Magawa Formation at localities Mg01 and Mg05. One of these (TGUSE-MM7768) is an external mold and internal cast of articulated valves, while the other (TGUSE-MM7769) is an external mold and internal cast of a right valve. Both specimens are incomplete. Specimens were collected by K. Suzuki, Y. Fujimoto, A. Ishitoya, M. Matsukawa, and K. Koarai.

Measurements (in mm excepts for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7768	29.6+	30.5+	9.9	-

Description. Shell medium size, inequivalve, subequilateral, orbicular in outline, length almost same as height, moderately convex, apical angle about 110 degrees; anterior auricle above hinge line of both valves of external mold; umbo located at about mid-point of length; surface marked with fine concentric ribs with numerous growth lines between ribs; a single adductor scar, subelliptical, located at posterior area.

Remarks. Based on the orbicular shell outline, centrally located umbo, small anterior auricle located above hinge line, concentric fine ribs and growth lines, and a single adductor scar, the specimens are classified as the genus *Entolium* (Cox et al., 1969). The specimens are identified as *Entolium inequivalve* (Hayami, 1959b, p.154, pl.13,figs.3-8) from the Lower Cretaceous Mitarai Formation of the Tetori Group, in having a subequal shell size with apical angle about 110 degrees, anterior auricle (posterior auricle unconfirmed), and fine concentric ribs and growth lines. The present specimens differ from the illustrated specimens of *Entolium* cf. *cingulatum* (Gu et al., 1997, p.78, pl.9, figs.14-19, pl.10, figs.1-9) from the Lower Cretaceous Yunshan

Fig.19. A,B, *Inoceramus* (*Mytiloides* ?) sp. A, KIK0392, external cast of articulated valves, the Kiritani Formation; B, KIK0391, external cast of left valve, Kiritani Formation; C-G, *Entolium inequivalve* Hayami; C,D, TGUSE-MM7769, external mold and internal cast of right valve, Magawa Formation (loc. Mg01); C, external mold; D, internal cast; E-G, TGUSE-MM7768, external mold and internal cast of articulated closed valves, Magawa Formation (loc. Mg05); E, right view of external mold; F, left view of internal cast; G, right view of internal cast; H,I, *Chlamys* (*C.*) cf. *mitaraiensis* (Hayami), TGUSE-MM7771, internal cast and external mold of right valve, Magawa Formation (loc. Mg05); H, internal cast; I, external mold; J, *Vaugonia* (*Vaugonia*) cf. *yambarensis* Kobayashi, KIK0023, external mold of left valve, Kiritani Formation; K,L, *Fimbria* sp., KIK0025, internal cast of right valve, Kiritani Formation; K, right view; L, hinge structure; M-U, *Protocardia* sp.; M, TGUSE-MM7793, internal cast of right valve, Magawa Formation (loc. Mg01); N, TGUSE-MM7794, internal cast of right valve, Magawa Formation (loc. Mg01); O, TGUSE-MM7800, internal cast of right valve, Magawa Formation (loc. Mg01); P, TGUSE-MM7803, internal cast of left valve, Magawa Formation (loc. Mg05); Q, TGUSE-MM7792, internal cast of left valve, Magawa Formation (loc. Mg01); R, TGUSE-MM7797, internal cast of articulated closed valves, Magawa Formation (loc. Mg01); S, TGUSE-MM7799, internal cast of right valve, Magawa Formation (loc. Mg01); T, TGUSE-MM7796, internal cast of articulated closed valves, Magawa Formation (loc. Mg01); U, TGUSE-MM7798, internal cast of left valve, Magawa Formation (loc. Mg01); V,W, *Tancredia* (*Tancredia*) sp.; V, KIK0398, internal cast of left valve, Kiritani Formation; W, KIK0383j, internal cast of left valve, Kiritani Formation; X,Y, Cultellidae gen. et sp. indet. X, TGUSE-MM7804, external cast of articulated open valves, Magawa Formation (loc. Mg01); Y, TGUSE-MM7805, external cast of left valve, Magawa Formation (loc. Mg01); Z, *Isocyprina* sp., KIK0027a, internal cast of right valve, Kiritani Formation; AA, *Pleuromya* ? sp., TGUSE-MM7806, external cast of right valve, Magawa Formation (loc. Mg06). Scale bars show 1 cm.

Formation, in Heilongjiang, China, because the Chinese specimens are characterized by obscure concentric ribs, while the Japanese specimens have obvious concentric ribs. With nearly circular outline and length shorter than height, the present specimens differ from the illustrated specimen of *Entolium lunare* (Kozai et al., 2006, pl.2, fig.19) from the Khun Huai Formation of the Hua Fai Group at locality Mae Sot 1, Mae Sot area, Tak Province, northwestern Thailand.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine area in Toyama Prefecture, Japan.

Family Oxytomidae Ichikawa, 1958
Genus *Oxytoma* Meek, 1864
Subgenus *Oxytoma* Cox et al., 1969

Oxytoma (*Oxytoma*) *tetoriensis* Hayami, 1959

1959a *Oxytoma tetoriense*; Hayami, p.148-149, figs.14, 15.
1959a *Pteria* (*s. l.*) sp. indet.; Hayami, p.149-150, pl.12, fig.16.
1975 *Oxytoma* (*Oxytoma*) *tetoriensis*; Hayami, p.63.

Remarks. Hayami (1959a) identified two specimens from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M3 member of the Mitarai Formation [=upper part of the Mitarai Formation; Matsukawa and Nakada (1999)], as *Oxytoma tetoriense*, sp. nov. Although Hayami (1975) suggested the species belongs to the subgenus *Oxytoma*, he did not provide reasons for the assignment. However, the presence of ribs on the left valve suggest the specimens do indeed belong to the subgenus *Oxytoma.*

Family Pectinidae, Rafinesque, 1815
Genus *Camptonectes* Agassiz in Meek, 1864

Camptonectes ? sp.

1959b *Camptonectes* sp. indet.; Hayami, p.153-154, pl.13, figs.1,2.

Remarks. Hayami (1959b) identified three specimens from Mitarai, Shokawa area, Gifu Prefecture, in M3 member of the Mitarai Formation, as *Camptonectes* sp. indet. Based on Cox et al. (1969), the Camptonectes Group was defined by having the left valve more convex than the right, with strong *Camptonectes* (divaricate striae) sculpture and a large byssal notch. However, the large byssal notch was not confirmed on Hayami's specimens due to poor preservation. Numerous faint concentric growth-lamellae and radial striae on our specimens suggest that they may belong to the genus *Camptonectes*, so, we assign them tentatively to the genus.

Genus *Chlamys* Röding, 1798
Subgenus *Chlamys* Röding, 1798

Chlamys (*Chlamys*) *mitaraiensis* Hayami, 1959

1959b *Chlamys mitaraiensis*; Hayami, p.151-153, pl.12, figs.17-20.
1975 *Chlamys mitaraiensis*; Hayami, p.78.

Remarks. Hayami (1959b) identified specimens from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M2 and M3 members of the Mitarai Formation, as *Chlamys mitaraiensis* sp. nov. Based on Cox et al. (1969), Family Pectinidae is divided into 11 groups and one uncertain group, and of those, the Chlamys Group is subdivided into 33 genera. The present specimens can be assigned to the subgenus *Chlamys* because they are characterized by a shell mould higher than long, the anterior auricle longer than posterior one, and surface ornamentation consisting of numerous fine radial ribs.

Chlamys (*Chlamys*) cf. *mitaraiensis* Hayami, 1959

Fig. 19 H, I

Material. Two specimens from the Magawa Formation at localities Mg01 and Mg05 (K. Suzuki and M. Matsukawa Coll.) include a single external cast and internal mold of a right valve (TGUSE-MM7770) and a single external cast of a left valve (TGUSE-MM7771). The anterior ear of these specimens is lacking.

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7770	8.9	8.4+	2.4	-
TGUSE-MM7771	10.0	12.2	1.9	0.82

Description. Small shell, triangular, inequilateral, gently convex toward ventral area, height slightly greater than length; apical angle 75 degrees; small trigonal posterior auricle situated at posterior side; anterior auricle lacking;

byssal notch existing below the posterior auricle; umbo prosogyrate and located almost centrally; surface ornamented with very fine reticulation; posterior auricle marked with very fine net-like pattern running from main body.

Remarks. Because of their trigonal shell form, height greater than length, small auricles, and radial and concentric sculpture, the present specimens belong to the genus *Chlamys*, as defined by Cox et al. (1969). The present specimens are similar to the illustrated specimens of *Chlamys mitaraiensis* (Hayami, 1959b, p.151-153, pl.12, figs.17-20) from the Lower Cretaceous Mitarai Formation, Japan, in having a trigonal shell form, small subequilateral auricle, small apical angle, and a reticulated surface of the main body and auricle. However, the present specimens are shorter than the specimens of *Chlamys mitaraiensis*; the ratio of shell length to height of the former (TGUSE-MM7771) is 0.82, while in the latter it is 0.92 (UMUT MM03161, paratype). Therefore, the present specimens are identified as *Chlamys* cf. *mitaraiensis*.

The present specimens differ from the illustrated specimen of *Chlamys kurumensis* (Hayami, 1957, p.119, pl.20, fig.1) from the Lower Jurassic Kuruma Group, Nagano Prefecture in their numerous distinctly radial costae and apical angle of 90 degrees. They also differ from the illustrated specimens of *Chlamys kotakiensis* (Hayami, 1957, p.121, pl.20, figs.3-5) from the Lower Jurassic Kitamatadani Formation, Kuruma Group, Niigata Prefecture, in that the former has a more acute apical angle than the latter. With their surface ornamented with many clearly radial costae, and its more obtuse apical angle, the present specimens differs from the illustrated specimen of *Chlamys* ex gr. *C. textoria* (Hayami, 1963, p.168, pl.7, fig.9), from the Lower Jurassic Huu-Nien, South Vietnam.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine area in Toyama Prefecture, Japan.

Superfamily Limacea Rafinesque, 1815

Family Limidae Rafinesque, 1815
Genus *Limatula* Wood, 1839

Limatula ? *iwayae* Hayami, 1959

1959b *Limatula iwayae*; Hayami, p.157-158, pl.13, figs.9,10.
1975 *Limatula* ? *iwayae*; Hayami, p.88.

Remarks. Hayami (1959b) identified specmens from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in M3 member of the Mitarai Formation, as *Limatula iwayae*, sp. nov. Subsequently, Hayami (1975) reclassified the species as *Limatula* ? *iwayae*. The presence of an auricle, a characterics of the Family Limidae, is not be confirmed on the specimens due to poor preservation, but the roof-like radial plicae and inflated body of the genus *Limatula* are certainly present, so the specimens probably belong to the genus *Limatula*, supporting Hayami's (1975) tentative assignment of the material to the genus *Limatula*.

Order Unioida Stoliczka, 1871
Superfamily Unionacea Fleming, 1828
Family Unionidae Fleming, 1828
Subfamily Unioninae Fleming, 1828
Genus *Unio* Philipsson, 1788 (see Retzius. 1788)

Unio antiqua (Kobayashi and Suzuki, 1937)

Fig. 20 A - N

1937 *Batissa* (*Batissa*) *antiqua*; Kobayashi and Suzuki, p.42-44, pl.4, figs.1-2.
1943 *Corbicura* (*Tetoria*) *antiqua*; Suzuki and Oyama, p.141,147.
1975 *Tetoria* (*Tetoria*) *antiqua*; Hayami, p.142.
1993 "*Batissa*" *antiqua*; Matsukawa and Ido, fig.3O.

Material. UMUT MM 7002 (holotype; illustrated by Kobayashi and Suzuki, 1937, p.42-44, pl.4, figs.1-2), from the Tetori Group in Itsuki, Ono City, Fukui Prefecture, Japan. 12 specimens (TGUSE-MM 5419a-c, MM5420 to -MM5425, and TGUSE-MM5551 to -MM5553) from: mudstone beds of the Izuki Formation located at IZ04 (TGUSE-MM5419a, -MM5419b, -MM5419c, -MM5420, -MM5421), Itsuki, Ono City, Fukui Prefecture, Japan (Matsukawa and Ido, 1993); mudstone beds of the Taie Formation located at KR-05 (TGUSE-MM5422 to -MM5424), Kurouchi, Hida City, Gifu Prefecture, Japan (Matsukawa and Fukui, 2009); and mudstone beds of the Okurodani Formation at localities OK13 (TGUSE-MM5551, -MM5552), OK15 (TGUSE-MM5553), and OK51 (TGUSE-MM5425), Okurodani, Shokawa,

Takayama City, Gifu Prefecture, Japan (Matsukawa and Nakada, 1999). These consist of four external casts of left valves, two external casts of right valves, three external casts of articulated valves, two internal casts of left valves, and a single of internal cast of a right valve (M. Matsukawa, K. Ido, and M. Fukui Coll.).

Measurements (in mm except for L/H and D/L)

Specimen	L	H	T	D	L/H	D/L
TGUSE-MM5419a	63.0	49.0	17.8	22.0	1.29	1.29
TGUSE-MM5419b	55.6	46.7	11.2	18.2	1.19	1.19
TGUSE-MM5420	55.8	46.8	12.0	22.0	1.19	1.19
TGUSE-MM5421	51.6+	55.9	13.1	-	-	-
TGUSE-MM5422	34.3	26.0	8.8	11.3	1.32	1.32
TGUSE-MM5423	25.6	20.0	5.0	10.4	1.28	1.28
TGUSE-MM5424	27.9+	24.4	4.2	11.0	-	-
TGUSE-MM5425	46.3	42.9	8.9	20.0	1.08	1.08

Description. Shell medium to large, equivalve, inequilateral, suborbicular, shell length longer than height, moderately convex; umbo prominent, prosogyrate, located at about one-third distance from anterior end; surface smooth, marked with very fine concentric growth lines; test thick (about 2 mm at center of LV; TGUSE-MM5422); dental formula: *2a 2b 4a 4b / 3a 3b,* pseudocardinal teeth on anterior edge (2a, 2b on LV, 3 on RV) and lamellar teeth on posterior edge (2b 4b in LV, 3b in RV), pseudocardinal teeth slightly long and stout, lamellar teeth long, arcuate with smooth surface; anterior adductor scar presenting suboval, located near the end of pseudocardinal teeth, posterior adductor scar showing slender oval, located near ventral end of lamellar teeth; pallial line smooth.

Remarks. Kobayashi and Suzuki (1937) established the species *Batissa* (*B*.) *antiqua* on specimens from the Tetori Group with characteristic shell outline, surface ornament, and partlial dental characteristics. The present specimens are similar to the type specimens of *Batissa* (*B*.) *antiqua* in a having suborbicular shell outline and very fine concentric growth lines on the shell surface. Since the present specimens have unioid dentition, one and two pseudocardinal teeth on RV and LV, one and two lamellar teeth on RV and LV respectively, and have sulcation on the surface of pseudocardinal teeth the specimens described as *Batissa* (*B*.) *antiqua* by Kobayashi and Suzuki (1937) should be classified as *Unio antiqua* (Kobayashi and Suzuki, 1937).

Occurrence. Mudstone beds of the Izuki Formation located at IZ04 (Itsuki, Ono City, Fukui Prefecture, Japan (Matsukawa and Ido, 1993); mudstone beds of the Taie Formation located at KR-05 (Kurouchi, Hida City, Gifu Prefecture, Japan (Matsukawa and Fukui, 2009); mudstone beds of the Okurodani Formation at OK51, Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan (Matsukawa and Nakada, 1999).

Unio cf. *longus* (Zhu, 1976)

Fig. 20 U

cf. 1976 *Pseudelliptio longus* Zhu. p.23, pl.1, figs.5,7-11.

Material. A single specimen, TGUSE-MM5426 an external mold of articulated valves, came from locality 7 (MK06), Mekko-dani, Shiramine area, Hakusan City, Ishikawa Prefecture (R. Nakanishi and K. Koarai Coll.).

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
TGUSE-MM5426	102.7	45.7	9.3	2.25	ca. 140

Descriptive remarks. Shell is large, inequilateral, equivalve, elongate elliptical, with length twice the height. Umbo is large and round and located at about one-third the distance from the anterior end. Apical angle is about 140 degrees. Surface is marked with fine, irregular growth lines. Test is thick (about 2.5 mm). The present specimen is similar to the illustrated specimen of *Unio longus* (Sha et al., 2006, p.265-271, fig.4 A1-G, fig.5. A-E), from the Lower Cretaceous upper member of the Khuren Dukh Formation, northern Choyr Basin, southeastern Mongolia, in having a transversally elliptical shell outline and thick test. The unionid dental characters are not observed on the present specimen due to poor preservation, so, we assign it to the present specimen should be identified as *Unio* cf. *longus* (Zhu, 1976).

Occurrence. Mudstone beds of the Okurodani Formation located at 7 (Mekko-dani) Shiramine area, Ishikawa Prefecture, Japan.

Genus *Tetoriunio* gen. nov.

Diagnosis. Unionoid dentition (*AⅠ, AⅢ, 3a, 3b, PⅠ, PⅢ / AⅡ, 4b, PⅡ*) and clear pallial sinus.

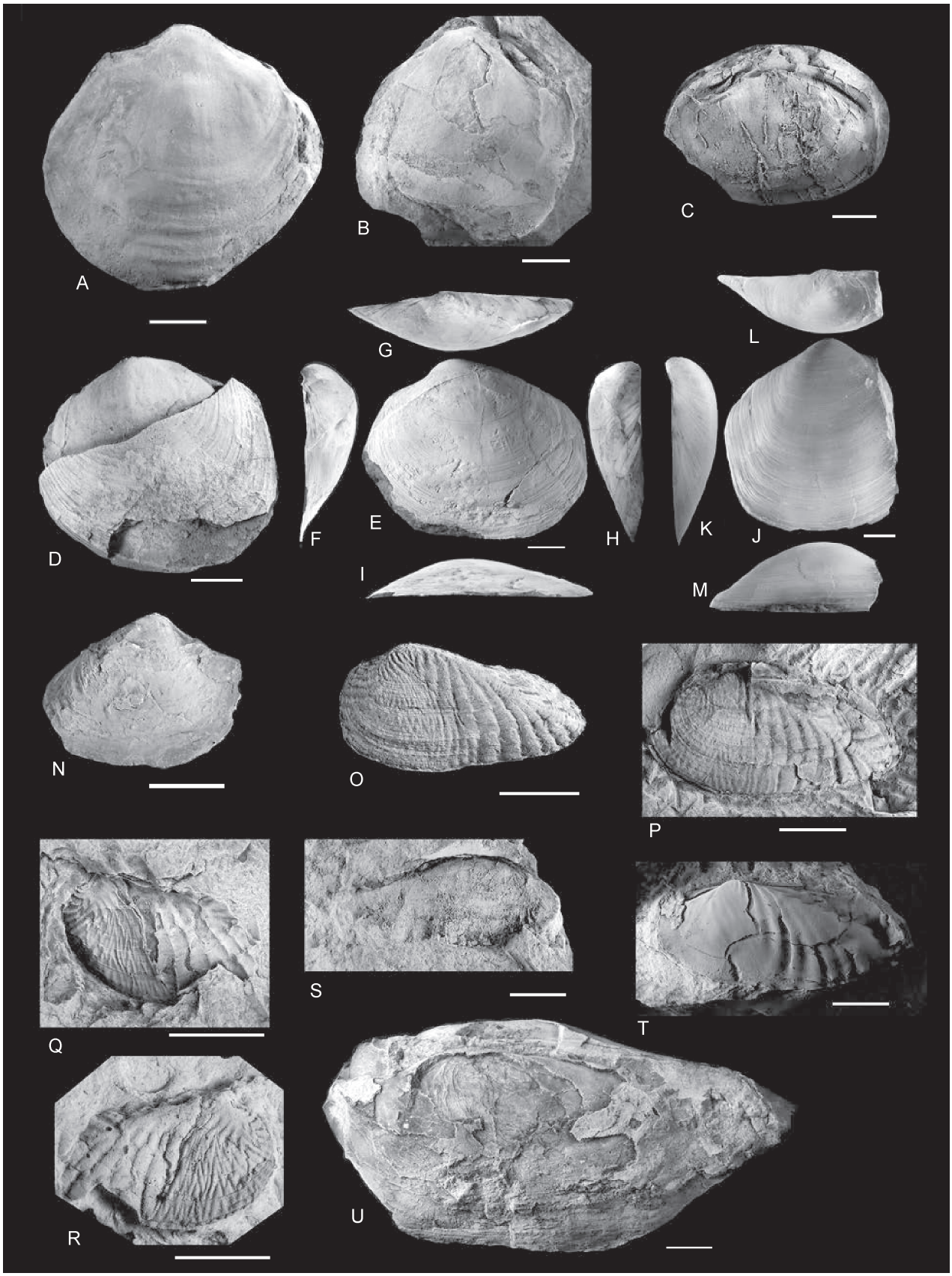

Fig.20. A-N, *Unio antiqua* (Kobayashi and Suzuki); A, TGUSE-MM5425, external cast of left valve, Okurodani Formation (loc. OK51); B, TGUSE-MM-5551, internal cast of right valve, Okurodani Formation (loc. OK13); C, TGUSE-MM5420, internal cast of left valve, the Izuki Formation (loc. IZ04); D, TGUSE-MM5553, internal and external cast of left valve, Okurodani Formation (loc. OK51); E-I, TGUSE-MM5419a, external cast of left valve, Izuki Formation (loc. IZ04); E, left view; F, anterior view; G, upper view; H, posterior view; I, ventral view; J-M, TGUSE-MM5421, external cast of right valve, Izuki Formation (loc. IZ04); J, right view; K, posterior view; L, upper view; M, ventral view; N, TGUSE-MM5423, external cast of right valve, Taie Formation (loc. KR-05); O-T, *Nippononaia tetoriensis* Maeda; O, TGUSE-MM5547, external cast of left valve, Kuwajima Formation (loc. HD01-05); P, TGUSE-MM5546, external cast of left valve, Okurodani Formation (loc. 4 (KT003)); Q,R, TGUSE-MM5550, external mold of right valve, Okurodani Formation (loc. OK13); Q, right view of internal mold; R, right view of rubber mold; S, TGUSE-MM5549, internal cast of right valve, Okurodani Formation (loc. OK17); T, TGUSE-MM5548, internal cast of left valve, Okurodani Formation (loc. 4 (KT003)); U, *Unio* cf. *longus* (Zhu), TGUSE-MM5426, external cast of articulated valves, Okurodani Formation (loc. MK-06). Scale bars show 1 cm.

Type species. *Tetoriunio okurodaniensis* (Komatsu et al., 2003) emend.

Derivation of name. Tetori and *Unio* meaning *Unio* from Tetori.

Remarks. Komatsu et al. (2003) described specimens from the Okurodani Formation, Shokawa area, Gifu Prefecture, Japan, as *Megasphaerioides okurodaniensis* gen. and sp. nov., based on the characters of dentition and pallial sinus. Although, they tentatively assigned *Megasphaerioides* to the Family Pisidiidae?, this family is defined by a small to medium shell and no more than two small cardinal teeth (Cox et al., 1969). Since species of the genus *Megasphaerioides* are large in size (ranging from 46.3 to 55.3 mm, average 48.5 mm in shell length; N = 4), the new genus of Komatsu et al. (2003) should be placed in the Family Unionidae, defined by variable shell size and mostly with two cardinal teeth and two posterior lamellar teeth on the LV and a single cardinal and lamellar tooth on the RV. It is very strange that the genus *Megasphaerioides* belongs to the Family Unionidae, because the genus *Sphaerioides* is attached to the Family Pisidiidae. We are confused by the assigment of the genus *Megasphaerioides* to the Family Pisidiidae and propose instead that the genus *Megasphaerioides* is changed to a new genus, which we define as *Tetoriunio*. Thus, *Megasphaerioides okurodnaiensis* Komatsu et al. (2003, Fig.2, 1-7) is revised to *Tetoriunio okurodaniensis* (Komatsu et al., 2003).

Genus *Nagdongia* Yang, 1975
Nagdongia soni Yang, 1975

Fig. 21 A-R

1975 *Nagdongia soni*; Yang, p.180-185, pl.16.
1990 *Nagdongia soni*; Tamura, pl.10, figs.1-4.
1993 *Nagdongia soni*; Matsukawa and Ido, p.369, fig.3.
1993 *Nagdongia* sp.; Matsukawa and Ido, p.369, fig.3.

Material. 42 specimens came from the Okurodani Formation at localities M37 (KT000) (TGUSE-MM7520, -MM7538), M36 (KT001) (TGUSE-MM7515 to -MM7518, -MM7521, -MM7522, -MM7524 to -MM7533, -MM7536, -MM7537, -MM7539, -MM7541, -MM7544, -MM7546, -MM7549, -MM7600, -MM7614), M35 (KT002) (TGUSE-MM7519, -MM7523, -MM7534), 4 (KT003) (TGUSE-MM7542, -MM7543, -MM7545, -MM7547, -MM7548, -MM7646), 50 (KT004) (TGUSE-MM7535, -MM7540) and 2 (KT005) (TGUSE-MM7645), all Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan; and OK24 (TGUSE-MM7550 to -MM7552) Kobudani, Shokawa, Takayama City, Gifu Prefecture, Japan. All specimens were collected by K. Ido and M. Matsukawa. The material consists of 16 external casts of left valves, two internal casts of left valves, a single external mold of a left valve, 11 external casts of right valves, three internal casts of right valves, a single external mold of a right valve, and eight external casts of articulated valves.

Measurements (in mm except for L/H, T/L, and Apical angle)

Specimen	L	H	T	L/H	T/L	Apical angle (°)
TGUSE-MM7515	40.5	32.3	8.9	1.25	0.22	104
TGUSE-MM7519	26.1	21.7	7.8	1.20	0.30	100
TGUSE-MM7522	27.1	23.8	4.4	1.14	0.16	116
TGUSE-MM7524	34.1	28.3	7.8	1.21	0.23	-
TGUSE-MM7525	34.4	29.9	6.7	1.15	0.20	96
TGUSE-MM7527	19.5	16.8	4.4	1.16	0.23	110
TGUSE-MM7528	42.4	34.1	9.5	1.24	0.22	100
TGUSE-MM7531	37.0	29.7	10.3	1.25	0.28	114
TGUSE-MM7536	43.8	36.5	6.2+	1.20	-	104
TGUSE-MM7645	62.9	48.5	14.1	1.30	0.22	100

Description. Shell medium size, equivalve, inequilateral; shell outline showing various forms, trigonally suboval, subelliptical, trigonally or subquadrate elongate; ratio of shell length to height ranging from 1.12 to 1.87 (average 1.29, N = 20); moderately convex; blunt posterior ridge running along posterior slope; umbo rounded, prominent, prosogyrate, location of umbo ranging from one-third to two-third the distance from anterior end; test thick, surface smooth, marked with fine irregular growth lines; hinge formula one stout pseudocardinal tooth and two long posterior lateral teeth on RV, two pseudocardinal teeth and single long posterior lateral tooth on LV, producing dental formula: *2 PⅡ PⅣ / 3 1 PⅢ*; posterior adductor muscle scar larger than anterior one, showing subtrigonal form, anterior half-circle form; pallial line smooth.

Remarks. Yang (1975) established *Nagdongia soni* as a new species from the Lower Cretaceous Yeonhwadong and Hasandong formations, Nagdong Subgroup of the Gyeongsang Group, South Korea. Yang (1975) recognized

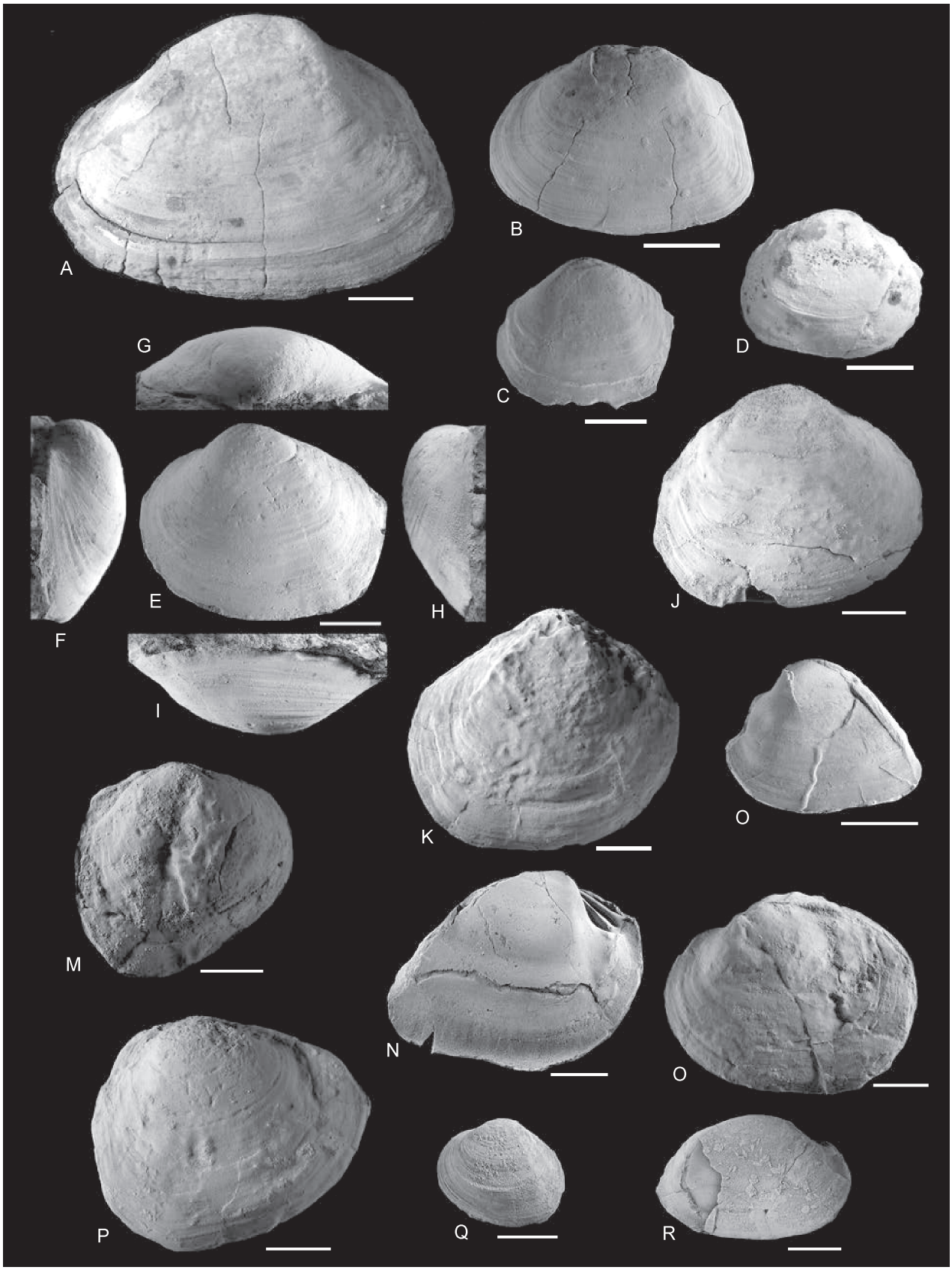

Fig.21. A-R, *Nagdongia soni* Yang; A, TGUSE-MM7646, external cast of left valve, Okurodani Formation (loc. 4 (KT003)); B, TGUSE-MM7538, external cast of left valve, Okurodani Formation (loc. M37 (KT000)); C, TGUSE-MM7522, external cast of left valve, Okurodani Formation (loc. M36 (KT001)); D, TGUSE-MM7519, external cast of right valve, Okurodani Formation (loc. M35 (KT002)); E-I, TGUSE-MM7515, external cast of left valve, Okurodani Formation (loc. M36 (KT001)); E, left view; F, anterior view; G, upper view; H, posterior view; I, ventral view; J, TGUSE-MM7518, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); K, TGUSE-MM7530, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); L, TGUSE-MM7539, external cast of left valve, Okurodani Formation (loc. 50 (KT004)); M, TGUSE-MM7531, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); N, TGUSE-MM7614, internal cast of right valve, Okurodani Formation (loc. M36 (KT001)); O, TGUSE-MM7536, external cast of articulated valves, Okurodani Formation (loc. M36 (KT001)); P, TGUSE-MM7528, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); Q, TGUSE-MM7527, external cast of left valve, Okurodani Formation (loc. M36 (KT001)); R, TGUSE-MM7548, external cast of right valve, Okurodani Formation (loc. 4 (KT003)). Scale bars show 1 cm.

substantial morphological variation of the shell form in those unionids, confirmed in the range of shell forms in the types of *Nagdongia soni*. This idea is further supported by numerous Recent unionid species, the following as typical examples: *Velesunio ambiguus*, *Hyridella menziesi*, and *Alathyria jacksoni* from Australia (Walker et al., 2001), and *Unio pictorum* from the River Thames, southeast England (Ziertz et al., 2010).

The present specimens are similar to the type of *Nagdongia soni* (Yang, 1975, p.180-184, pl.16, figs.1-11) in having a mostly subtrigonal shell-form, smooth surface with fine concentric growth lines, one pseudocardinal tooth and one lateral tooth on the LV, and two pseudocardinal teeth and two lateral teeth on the RV. The present specimens differ from the illustrated specimens of *Nagdongia leei* (Yang, 1976, 324-331, pl.34, figs.1-60) from the Lower Cretaceous Myogog Formation, Nagdong Subgroup of the Gyongsang Group, South Korea, in having weaker inflation and larger size of shell. Shell length of the former species ranges from 19.1 to 63.0 mm, but that of the latter species ranges from 12.9 to 28.6 mm in length. The specimens of *Nagdongia* sp. (Matsukawa and Ido, 1993, p.369, fig.3-d) from the Lower Cretaceous Okurodani Formation, Kitadani, Fukui Prefecture, Japan, can also be classified as named *Nagdongia soni* because the shell outlines of the specimens are subelliptical, subquadrate and trigonal elongate (Table 8).

The present specimens are similar in shell form and surface ornamentation to the illustrated specimens of *Nakamuranaia chingshanensis* (Suzuki, 1943a, p.213-216, pl.19, figs.1-19) from the Lower Cretaceous Kinbu and Sinsyu (Chinju) formations in the Rakuto Series, South Korea; however, they differ in their dental formula. Dentition of the former species consists of two pseudocardinal teeth and a single of posterior lateral tooth on the RV, and two posterior lateral teeth on the LV, while the latter species consists of two puseudocardinal teeth and two posterior lateral teeth on the RV, and two pseudocardinal teeth and a single of posterior lateral tooth on the LV (Table 9). The holotype of *Nakamuranaia chingshanensis* was unfortunately destroyed during World War Ⅱ (Yang, 1975).

Occurrence. Mudstone beds of the Okurodani Formation at localities M37 (KT000), M36 (KT001), M35 (KT002), 4 (KT003), 50 (KT004), and 2 (KT005), Kitadani, Shiramine area, along Sugiyamagawa river, Katsuyama City, Fukui Prefecture, Japan.

Genus *Archaeounio* gen. nov.

Diagnosis. Hinge structure consisting of two pseudocardinal teeth and two lamellar teeth on LV and two pseudocardinal teeth and a single of lamellar tooth on RV. Dental formula showing *2a 4a 4b* / *3a 3b 5a*. Teeth 2a, 3a and 5a are pseudocardinal teeth, tooth 3a is obliquely crenulated.

Type species. *Archaeounio kagaensis* sp. nov.

Derivation of name. *Archaeo* and *Unio* meaning archaic *Unio*.

Type locality. HD01 (Matsukawa et al., 2006).

Type horizon. Kuwajima Formation, Tetori Group at Hosodani, Shiramine, Hakusan City, Ishikawa Prefecture, Japan.

Remarks. *Archaeounio* gen. nov. differs from all genera within Subfamily Unioninae (*Unio*, *Acuticosta*, *Afropareysia*, *Arcidopsis*, *Arconaia*, *Balwantia*, *Caelatura*, *Cafferia*, *Canthyria*, *Caudiculatus*, *Chamberlainia*, *Contradens*, *Ctenodesma*, *Cumerunio*, *Cuneopsis*, *Diauroa*, *Elliptio*, *Elongaria*, *Gonidea*, *Haasodonta*, *Hendeana*, *Hyriopsis*, *Inversidens*, *Lamellidens*, *Lanceolaria*, *Lastena*, *Legumainaia*, *Mesafra*, *Nephronaias*, *Nippononaia*, *Nitia*, *Oxynaia*, *Palinodonaia*, *Paranodonta*, *Parreysia*, *Physunio*, *Plethobasus*, *Pleurobema*, *Plicatounio*, *Pressidens*, *Prisodontopsis*, *Prohyriopsis*, *Protelliptio*, *Protunio*, *Pseudodon*, *Ptychorhynchoideus*, *Rectidens*, *Rhabdotophorus*, *Shistodesmus*, *Solenaia*, *Sulcatula*, *Trapezioideus*, *Uniomerus*, *Unionea*, *Vetulonia*, *Virgus*) in the number of pseudocardinal teeth. The new genus *Archaeounio* has two pseudocardinal teeth on both the LV and RV, while the others all have two pseudocardinal teeth on the LV and a single on the RV.

Kobayashi and Suzuki (1937) identified a specimen from the Okurodani Formation (Matsukawa et al., 2003) in Ogamigo, Tetori area, as new species *Unio ogamigoensis*, but they did not describe the characters of crenulated pseudocarinal teeth in this specimen. Subsequently, Hayami (1975) proposed *Unio*? *ogamigoensis* as the revised assignment for the species. We follow Hayami's (1975) opinion, because the crenulated pseudocarinal teeth are not confirmed. So, we can not deside the taxonomic position for the species.

Table 8. Shell size and ratio of shell length (L) to shell height (H) between *Nagdongia soni* (Yang, 1975; Matsukawa and Ido, 1993; This study) and *Nagdongia leei* (Yang, 1976).

Taxa		*Nagdongia soni*	*Nagdongia leei*	*Nagdongia soni*
References		Yang (1975)	Yang (1976)	This study
Number of specimen		93	65	19
L (mm)		-	20.2	36.0
H (mm)	average	-	14.4	27.9
I (mm)		-	5.3	7.80
L / H	max	1.87	1.56	1.87
	min	1.29	1.27	1.14
	average	1.55	1.41	1.30
I / L	max	0.24	0.32	0.30
	min	0.10	0.19	0.15
	average	0.17	0.26	0.22

Table 9. Number of pseudocardinal teeth between *Nagdongia* (Yang, 1975) and *Nakamuranaia* (Suzuki, 1943a).

Taxa		number of pseudocardinal teeth	number of posterior lateral teeth
Nagdongia (Yang, 1975)	right valve	2	1
	left valve	-	2
Nakamuranaia (Suzuki, 1943a)	right valve	2	2
	left valve	2	1

Archaeounio kagaensis sp. nov.

Fig. 22 A-BB

1990 *Unio* ? *ogamigoensis*; Tamura, p.10, figs.5-18.

1993 *Unio* ? *ogamigoensis*; Matsukawa and Ido, p.368, table 1, fig.3. (Izuki Formation, Kuzuryugawa area)

2000 *Unio ogamigoensis*; Shiramine Village Board of Education, pl.12, figs.1, 2. (Okurodani Formation, Shokawa area)

2009 *Unio* (?) *ogamigoensis*; Matsuura, pl.2-8, figs.8-12. (figs.2-11, Kuwajima Formation, Kuwajima; fig.12, Kuwajima Formation, Yanagi-dani)

Diagnosis. As for genus.

Type specimens. TGUSE-MM5479 (holotype), TGUSE-MM5436 (paratype), TGUSE-MM5454 (paratype), TGUSE-MM5459 (paratype), TGUSE-MM5462 (paratype).

Derivation of name. Meaning Archaeounio from Kaga province.

Material. Holotype TGUSE-MM5479; paratypes TGUSE-MM5436, -MM5454, -MM5459 and -MM5462, -MM7647; 96 specimens (TGUSE-MM5427 to -MM5521) were collected from the Izuki Formation (IZ02), Itsuki, Ono City, Fukui Prefecture, Japan; from the Kuwajima Formation located at M5 (Seto); at localities HD01-03, HD01-04 and HD01-02-2 (Yanagi-dani) and MK03 and 7 (MK06, Mekko-dani), Shiramine, Hakusan area (Okurodani, Yanagi-dani and Mekko-dani), Hakusan City, Ishikawa Prefecture, Japan; and from the Okurodani Formation located at OK17A1, Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan. These specimens consist of 33 external casts of left valves, three internal casts of left valves, 38 external casts of right valves, 18 external casts of articulated valves, three external molds of left valves, and a single external cast of a valve that can not

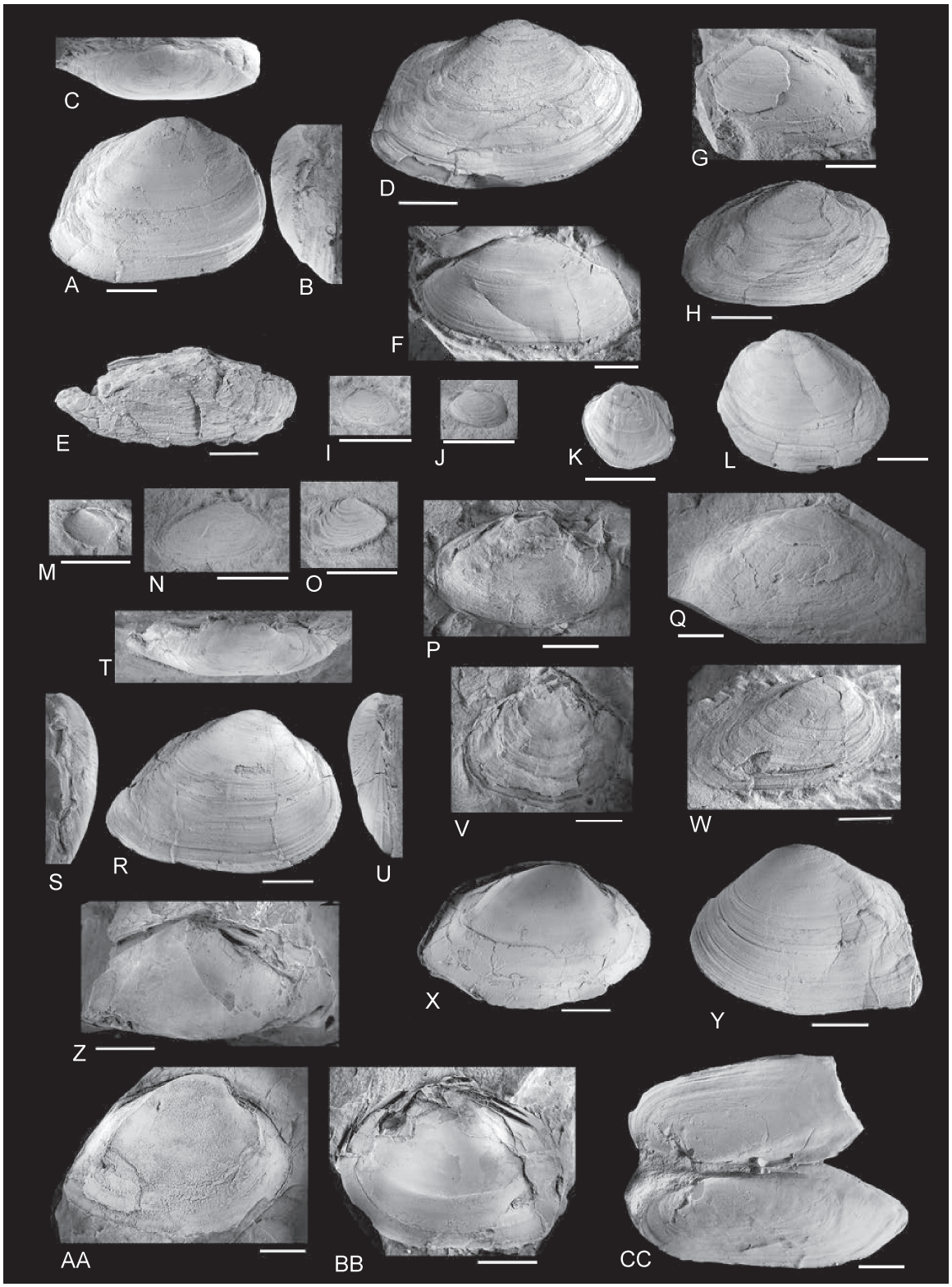

Fig.22. A-BB, *Archaeounio kagaensis* gen. nov. ; A-C, TGUSE-MM5479, holotype, external cast of right valve, Kuwajima Formation (loc. HD01-03); A, right view; B, anterior view; C, upper view; D, TGUSE-MM5439, paratype, external cast of right valve, Kuwajima Formation (loc. HD01-03); E, TGUSE-MM7647, external cast of right valve, Izuki Formation (loc. IZ02); F, TGUSE-MM5484, external cast of left valve, Kuwajima Formation (loc. HD01-03); G, TGUSE-MM5456, internal cast of left valve, Kuwajima Formation (loc. HD01-03); H, TGUSE-MM5436, external cast of right valve, Kuwajima Formation (loc. HD01-04); I, TGUSE-MM5512, external cast of left valve, Kuwajima Formation (loc. MK-06); J, TGUSE-MM5497, external cast of left valve, Kuwajima Formation (loc. MK-03-004); K, TGUSE-MM5481, external cast of left valve, Kuwajima Formation (loc. HD01-03); L, TGUSE-MM5476, external cast of left valve, Kuwajima Formation (loc. HD01-03); M, TGUSE-MM5493, external cast of left valve, Kuwajima Formation (loc.MK-03-001); N, TGUSE-MM5509, external cast of right valve, Kuwajima Formation (loc. MK-06); O, TGUSE-MM5494, external cast of right valve, Kuwajima Formation (loc. MK-03-004); P, TGUSE-MM5427, external cast of right valve, Kuwajima Formation (loc. MK-06); Q, TGUSE-MM5517, external cast of right valve, Kuwajima Formation (loc. MK-06); R-U, TGUSE-MM5459, paratype, external cast of right valve, Kuwajima Formation (loc. HD01-03); R, right view; S, posterior view; T, upper view; U, anterior view; V, TGUSE-MM5431, external cast of right valve, Kuwajima Formation (loc. M5); W, TGUSE-MM5438, external cast of right valve, Kuwajima Formation (loc. HD01-04); X, TGUSE-MM5454, paratype, internal cast of right valve, Kuwajima Formation (loc. HD01-03); Y, TGUSE-MM5475, external cast of left valve, Kuwajima Formation (loc. HD01-03); Z, TGUSE-MM5487, internal cast of right valve, Kuwajima Formation (loc. HD01-04); AA, TGUSE-MM5462, paratype, internal cast of right valve, Kuwajima Formation (loc. HD01-02-2); BB, TGUSE-MM5477, internal cast of left valve, Kuwajima Formation (loc. HD01-03); CC, *Unio*? *ogamigoensis* Kobayashi and Suzuki, UMUT MM7001, holotype, external (partly internal) cast of articulated valves, Okurodani Formation. Scale bars show 1 cm.

be identified as left or right. (Coll. M. Matsukawa, K. Ido, S. Shionoya, K. Nakada, T. Matsui, and K. Koarai).

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	I/L	Apical angle (°)
TGUSE-MM5427	34.6	22.1	4.3	1.57	0.12	120
TGUSE-MM5432	22.7	16.7	5.5	1.36	0.24	135
TGUSE-MM5436	36.6	22.1	5.6	1.65	0.15	120
TGUSE-MM5438	35.7	19.7	5.2	1.81	0.14	120
TGUSE-MM5439	48.2	31.0	8.4	1.55	0.17	130
TGUSE-MM5440	30.2	18.5	3.7	1.63	0.12	110
TGUSE-MM5454	46.7	29.4	6.3	1.59	0.13	116
TGUSE-MM5459	46.4	31.9	4.6	1.46	0.10	116
TGUSE-MM5462	46.8	33.3	7.6	1.40	0.16	100
TGUSE-MM5475	39.3	26.9	6.5	1.46	0.16-	120
TGUSE-MM5479	42.4	31.6	12.1	1.34	0.22	116
TGUSE-MM5485	47.1	25.2	-	1.65	-	-
TGUSE-MM5491	9.3	6.2	0.8	1.51	0.09	110
TGUSE-MM5494	11.4	7.1	1.0	1.61	0.09	116
TGUSE-MM5509	16.0	8.5	2.3	1.88	0.14	130

Description. Shell medium, equivalve, inequilateral, moderately convex, longer than high (value of L/H ranging from 1.11 to 2.36, average = 1.64, N = 73); shell outline variable (elongate elliptical and subtrigonal), a little flat marginal carina running along posterior slope, test thin; anterior end rounded, ventral margin slightly curved forming arch, postero-dorsal margin nearly straight, corner of posterior and ventral margins slightly less than right angle, posterior ridge running from below umbo to corner of posterior and ventral margin; umbo large, located at about two-fifths distance from anterior end; surface marked with irregular concentric growth lines; hinge consisting of pseudocardinal teeth and lamella teeth, dental formula as follow: *4a 2a 2b 4b / 5a 3a 3b*; tooth 2a slightly longer, stout, nearly crescent-shaped; tooth 2b longer than 2a; tooth 4a short, slender and a little arcuate; tooth 4b very narrow, long and shallow, wider than 4b; pseudocardinal teeth represented by 2a, 4a on LV, and 3a, 5a on right valve, along antero-dorsal margin; lamella teeth represented by 2b and 4b on LV, 3b on RV lying on edge of postero-dorsal margin; tooth 3a similar to shape and length of 5a but a little curving, surface of tooth 3a marked with fine parallel shallow oblique grooves (crenate), tending toward to anterior side, tooth 5a elongate cigar-shape; tooth 3b very long, teeth 3a, 3b, and 5a linearly elongate along postero-dorsal margin and running parallel ; anterior adductor scar half oval; posterior adductor scar forming nearly obtuse-angled triangle, anterior adductor scar a little longer than posterior adductor scar; escutcheon shallow and narrow, lunule more or less deep.

Remarks. The present species is characterized by an transversely elliptical, oval and subtrigonal shell form, smooth surface with fine concentric growth lines, a little flat marginal carina, the slightly prosogyrate umbo located at about two-fifths the distance from the anterior end, and commonly two pseudocardinal teeth on the anterior side of each valve and lamellar teeth on the posterior side. The specimens at hand show various shapes. The shell outlines vary between transversely elliptical, oval, and subtrigonal. The shell length to height ratio ranges from 1.27 to 1.96 (average = 1.53; N = 9) for the specimens from the Kuwajima Formation located at M5, Seto, Shiramine, Hakusan City, Ishikawa Prefecture; from 1.11 to 2.12 (average = 1.56, N = 38) for the specimens from the Kuwajima Formation located at HD01-05 and HD01, Yanagidani, Shiramine, Hakusan City, Ishikawa Prefecture; and from 1.40 to 2.36 (average = 1.78, N = 29) for the specimens from the Kuwajima Formation located at 7 (MK06), Mekko-dani, Oguchi, Hakusan City, Ishiwaka Prefecture. Specimens of the Recent Unionidae, *Unio douglasiae nipponensis* Martens, from Kuniichi River, Matsuyama City, Ehime, exhibit a shell length to height ratio ranging from 0.97 to 2.60 (average = 2.04, N = 60) (Table 10). Walker et al. (2001) show that the shapes of the Recent Unionidae *Hyridella menziesi*, *Velesunio ambiguous* and *V. angasi* in Australia each have ovate or elongate shell forms and they suggest this wide variation in shell form is related to physiology and behavior. As the present specimens from Tetori Group also exhibit wide variation in shell form, we conclude they can be reasonably classified as the same species.

Occurrence. Muddy sandstone beds of the Kuwajima Formation located at M5, HD01-03, HD01-04, HD01-03, HD01-02-2, MK03, and 7 (M5, Seto; HD01-03, HD01-04, HD01-03 and HD01-02-2, Yanagi-dani; MK03 and 7, Mekko-dani), Shiramine, Hakusan City, Ishikawa Prefecture, Japan; Mudstone beds of the Okurodani Formation located at OK17A1, Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan; and mudstone beds of the Izuki Formation located at IZ02, Itsuki, Ono City,

Fukui Prefecture, Japan (Matsukawa and Ido, 1993; Matsukawa et al, 2006).

Family Trigonioididae Cox, 1952
Genus *Nippononaia* Suzuki, 1941
Nippononaia ryosekiana (Suzuki, 1941)

Remarks. Isaji (1993) described three specimens as *Nippononaia ryosekiana*: one small specimen (NSM-PM 15516) from locality Sugiyama Valley, near Sugiyama, Kitadani-machi, Katsuyama City, Fukui Prefecture, in the Okurodani Formation; and two tiny specimens (NSM-PM 15517, 15518) from locality Ota Valley, near Donomori, Shiramine Village (present Hakusan City), Ishikawa Prefecture in the Okura Formation. These specimens of the species are different from the specimens of *Nippononaia tetoriensis* in having numerous ribs.

Distribution and Occurrence. Mudstone beds of the Okurodani Formation at Sugiyama Valley, near Sugiyama, Kitadani-machi, Katsuyama City, Fukui Prefecture, and Okura Formation at Ota Valley, near Donomori, Shiramine Village (present Hakusan City), Ishikawa Prefecture.

Nippononaia tetoriensis Maeda, 1962

Fig. 20 O, P, Q, R, S, T

1962a *Nippononaia tetoriensis*; Maeda, p.246, pl.38, figs.1-14.
1976 *Nippononaia tetoriensis*; Gu et al., p.360, pl.95, figs.19-22.
1990 *Nippononaia tetoriensis*; Tamura, pl.8, figs.16-22.
1993 *Nippononaia tetoriensis*; Matsukawa and Ido, fig.3 (i).
2009 *Nippononaia tetoriensis*; Matsuura, pl.2-8, figs.13-17.

Material. Five specimens (TGUSE-MM5546 to -MM5550) from the Kuwajima Formation at locality HD01 (Yanagidani, Shiramine, Hakusan City, Ishikawa Prefecture), from the Okurodani Formation at locality 4 (KT003) (Kitadani, Katsuyama City, Fukui Prefecture), and from the Okurodani Formation at localities OK13 and OK17A1 (Okurodani, Shokawa, Takayama City, Gifu Prefecture). These consist of two external casts of left valves, a single internal cast of a left valve, a single internal cast of a right valve, and a single external mold of a right valve (M. Matsukawa and K. Ido Coll.).

Table 10. Ratio of shell length (L) to shell height (H) in *Archaeounio kagaensis* and *Unio douglasiae nipponensis*.

	Taxa	*Archaeounio kagaensis*			*Unio douglasiae nipponensis*
	Locality	Tetori Group (Hakusan Section)			Recent
		Kuwajima	Yanagidani	Mekko-dani	Matsuyama City, Ehime Pref.
Length / Height	Number of specimens	7	38	28	60
	average	1.53	1.56	1.78	1.56
	max	1.96	2.12	2.36	2.67
	min	1.27	1.11	1.40	0.97
	max-min	0.69	1.00	0.97	1.64
	standard deviation	0.24	0.25	0.29	0.21
	variance	0.06	0.06	0.08	0.04
	χ^2	-	6.895	6.56	9.347
	p	-	★0.0753	★0.2911	★0.055

★ normal distribution Pref. = Prefecture

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
TGUSE-MM5546	42.6	20.5	5.7	2.08	146
TGUSE-MM5547	33.7	16.8	3.1	2.00	130
TGUSE-MM5548	38.7	22.6	4.2	1.71	130
TGUSE-MM5549	40.2	15.1	5.1	2.67	130
TGUSE-MM5550	22.8+	16.2	-	-	130

Description. Shell medium size, equivalve, inequilateral, subtrigonal in outline, about twice as long as high, anterior margin round, posterior margin acute, postero-dorsal margin very long and arcuate, ventral margin arcuate, convex moderately, marginal carina running strongly from umbo to posterior edge; umbo orthogyrous, not prominent, located at about one-third the distance from the anterior end, apical angle about 130 degrees; surface marked with radial V-shaped and reversed V-shaped ribs and numerous concentric weak growth lines, with several wide and short radial ribs existing at the anterior part; V-shaped ribs present just below umbo, reversed V-shaped ribs present in antero-ventral area; several wide and strong radial ribs ornamenting postero-dorsal and postero-ventral areas, and about three wide reversed V-shaped ribs mark posterior edge; dental formula showing unionoid type; *4a 2a 2b 4b / 3a 3b*, with two stout pseudocardinal teeth and two long lamellar lateral teeth on LV, one feeble tiny pseudocardinal tooth and one long slender lateral tooth on RV; impression of internal surface reflecting radial ribs, umbonal area and posterior area marked with several wide radial ribs, posterior peripheral area ornamented with about four short radial ribs.

Remarks. Because of their transversely-elongate shell form, unionoid-type dental formula, and V-shaped ribs on the shell surface, the present specimens are classified as the genus *Nippononaia* (Suzuki, 1941). They are very similar to the illustrated specimens of *Nippononaia tetoriensis* (Maeda, 1962a, p.245-247, pl.38, figs.1-14) from the Lower Cretaceous Kuwajima Formation, Yanagidani, Shiramine area, Hakusan City, Ishikawa Prefecture, and the Okurodani, Shokawa area, Takayama City, Gifu Prefecture, in having a subtrigonal shell outline, elongate posterior area, V-shaped ribs below the umbonal area, several wide and stout radial ribs on the postero-dorsal area, and reversed V-shaped ribs along the posterior edge. The present specimens have reversed V-shaped ribs, consisting of three lines on antero-ventral half, although, these characters of ornamentation were not described by Maeda (1962a) on his specimens due to a different state of preservation.

Because of their very elongate shell outline, tapering posterior edge, numerous oblique ribs, and rounded umbo, the present specimens differ from the holotype of *Nippononaia ryosekiana* (Suzuki, 1941, p.411-413, text-figs.1-3), probably from the Lower Cretaceous Sebayashi Formation, Hachimanzawa, Kanna-machi, Gunma Prefecture. The present specimens also differ from the illustrated specimens of *Nippononaia sinensis* (Gu et al., 1976, p.360, pl.95, figs.23-28) from the Lower Cretaceous Fuxin and Jiufotang formations, west Liaoning Province, China, in having wide and oblique radial ribs on the posterior half of the valve. Because of its wide elliptical shell outline and strongly reversed V-shaped ribs on the posterior area, the holotype of *Nippononaia zhejiangensis* (Gu et al., 1976, p.361, pl.106, figs.11-14), from the Lower Cretaceous Guantou Formation, Zhejiang Province, China, is different from the present species. Because of the prominent umbo and wide apical angle (about 150 degrees), the present specimens also differ from the illustrated specimens of *Nippononaia yanjiensis* (Gu et al., 1976, p.361, pl.106, figs.20-16) from the Lower Cretaceous Tongfosi Formation, Jilin Province, China, in having a round and narrower apical angle: the former is about 130 degrees, while the latter is about 150 degrees. Finally, the illustrated specimens of *Nippononaia yunnanensis* (Gu et al., 1976, p.362, pl.107, fig.11), from the Lower Cretaceous Shinmen Formation, Hebei Province, China, differ from the present specimens in having a very elongate shell outline (L/H = 3.03), a linear plication running along the postero-dorsal area, and a wide apical angle (164 degrees).

Occurrence. Valanginian to Hauterivian mudstone beds of the Okurodani Formation at locality HD01(Yanagidani), Shiramine, Hakusan City, Ishikawa Prefecture, and locality 4 (KT003) (Kitadani), Katsuyama City, Fukui Prefecture, Japan.

Genus *Plicatounio* Kobayashi and Suzuki, 1936
Subgenus *Plicatounio* Ota, 1963, emended

Plicatounio (*Plicatounio*) *naktongensis* Kobayashi and Suzuki, 1936

Fig. 23 A - Q

1936 *Plicatounio naktongensis*; Kobayashi and Suzuki, p.252, pl.28, figs.1-4, 6-8.

1943 *Plicatounio naktongensis multiplicatus*: Suzuki, p.211, pl.16, figs.1-6.

1956 *Plicatounio naktongensis*; Kobayashi, p.80, pl.5, fig.3.

1959 *Plicatounio naktongensis*; Ota, p.15, pl.4, figs.4-8.

1962b *Plicatounio tetoriensis*; Maeda, p.348-349, pl.53, figs.5-7.

1962b *Plicatounio kobayashii*; Maeda, p.347-348, pl.53, figs.1-4.

1963 *Plicatounio* (*Plicatounio*) *naktongensis*; Ota, p.507, text-fig.1.

1990 *Plicatounio* (s.s.) *naktongensis multiplicatus*: Tamura, pl.5, figs.7,11.

1990 *Plicatounio* (s.s.) *naktongensis naktongensis*: Tamura, pl.5, figs.8-10.

1993 *Plicatounio* (*Plicatounio*) *naktongensis*; Matsukawa and Ido, fig.3-c.

1993 *Plicatounio* (*Plicatounio*) *multiplicatus*; Matsukawa and Ido, fig.3-b.

2009 *Plicatouinio naktongensis*; Matsuura, pls.2-8, figs.20, 21.

Material. 65 specimens (TGUSE-MM7423 to -MM7489, -MM7601, -MM7648) from the Okurodani Formation at localities M37 (KT000), M36 (KT001), M35 (KT002), and 2 (KT005), all Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan. These consist of 20 external casts of left valves, 20 external casts of right valves, 20 external casts of articulated valves, two external molds of a left valve, a single internal cast of a left valve, a single internal cast of right valve, and a single internal mold of a right valve. All specimens collected by M. Matsukawa, K. Ido.

Measurements (in mm except for L/H and D/L)

Specimen	L	H	T	D	L/H	D/L
TGUSE-MM7428	59.1	26.3	8.9	17.4	2.25	0.29
TGUSE-MM7429	79.6	26.5	4.3	18.4	3.00	0.23
TGUSE-MM7435	60.5	24.9	6.4	19.9	2.43	0.33
TGUSE-MM7437	54.1	21.9	7.6	15.4	2.47	0.28
TGUSE-MM7449	59.4	21.1	5.2	17.1	2.81	0.29
TGUSE-MM7455	55.1	20.8	7.0	15.8	2.65	0.29
TGUSE-MM7457	57.4	25.6	6.3	20.4	2.24	0.35
TGUSE-MM7459	44.9	22.4	7.3	18.8	2.01	0.42
TGUSE-MM7460	65.5	24.6	8.4	23.1	2.67	0.35
TGUSE-MM7461	63.9	24.9	9.2	16.4	2.56	0.26

Description. Shell medium to large, equivalve, inequilateral, elongate elliptical outline, strongly convex, test thick; anterior end sharply curving, ventral margin slightly arcuate and concave, postero-dorsal margin nearly straight, postero-ventral margin sinuate; surface of anterior half very smooth, marked with fine concentric growth lines, posterior half ornamented with about eight wide and obscure linear radial plicae running from umbonal area to ventral margin, these gradually disappearing from central area to anterior margin; very large and wide umbo, located at about one-third distance from the anterior end; pseudocardinal teeth long, posterior teeth strong, long and subparallel.

Remarks. Ota (1963) classified the genus *Plicatounio* into two subgenera *Plicatounio* and *Kwanmonia*, based on shell outline and features of the hinge. The former exhibits a very elongate shell outline while the latter presents a subtrigonal shell outline, so the present specimens belong to the subgenus *Plicatounio,* based on Ota (1963)'s criteria. The present specimens are very similar to the illustrated specimens of *Plicatounio naktongensis* (Kobayashi and Suzuki, 1936, p.252, pl.28, figs.1-4, 6-8) from Ryohori, Kinyo-men, Keisho-nan-do, South Korea, in having a broadly arcuate ventral margin, about seven wide and moderately elevated plicae radiating from the umbo to the posterior margin, and a very large umbo located at about one-third the distance from the anterior end. Suzuki (1943) established two subspecies, *P. naktongensis multiplicatus* and *P. naktongensis naktongensis* under the species *P. naktongensis*, as he was able to show that the former has fine radial ribs on the anterior slope, while the latter lack such radial ribs.

Two of the specimens at hand (TGUSE-MM7444,

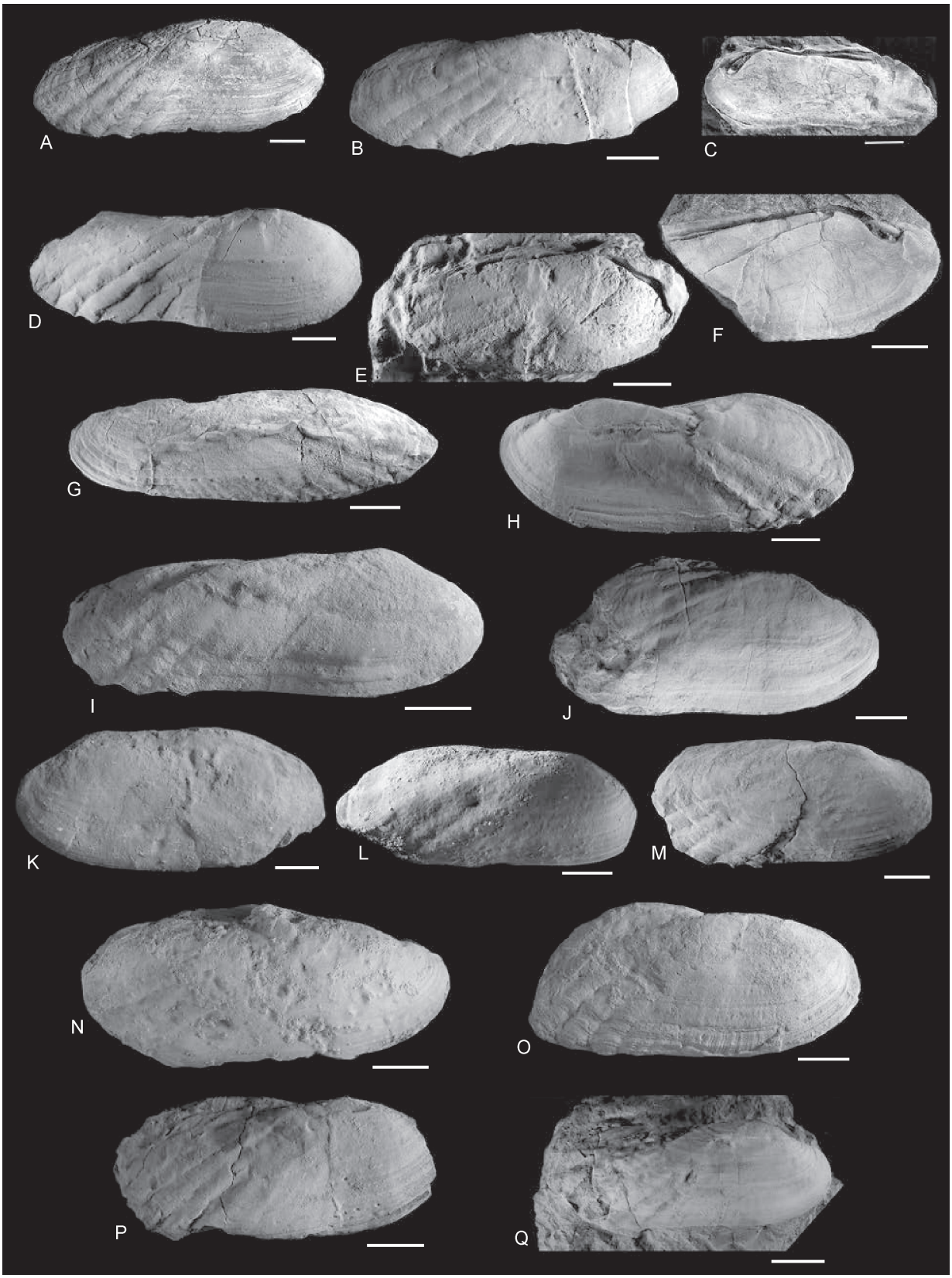

Fig.23. A-Q, *Plicatounio* (*Plicatounio*) *naktongensis* Kobayashi and Suzuki; A, TGUSE-MM7473, external cast of right valve, Okurodani Formation (loc. 2 (KT005)); B, TGUSE-MM7449, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); C, TGUSE-MM7648, internal cast of left valve, Okurodani Formation (loc. M36 (KT001)); D, TGUSE-MM7466, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); E, TGUSE-MM7439, internal cast of right valve, Okurodani Formation (loc. M35 (KT002)); F, TGUSE-MM7459, internal cast of right valve, Okurodani Formation (loc. M36 (KT001)); G, TGUSE-MM7453, external cast of left valve, Okurodani Formation (loc. M35 (KT002)); H, TGUSE-MM7457, external cast of left valve, Okurodani Formation (loc. M35 (KT002)); I, TGUSE-MM7472, external cast of articulated valves, Okurodani Formation (loc. M36 (KT001)); J, TGUSE-MM7434, external cast of right valve, Okurodani Formation (loc. M35 (KT002)); K, TGUSE-MM7430, external cast of articulated valves, Okurodani Formation (loc. M36 (KT001)); L, TGUSE-MM7437, external casts of articulated valves, Okurodani Formation (loc. M36 (KT001)); M, TGUSE-MM7457, external cast of right valve, Okurodani Formation (loc. M35 (KT002)); N, TGUSE-MM7435, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); O, TGUSE-MM7444, external casts of articulated valves, Okurodani Formation (loc. 2 (KT005)); P, TGUSE-MM7476, external cast of articulated valves, Okurodani Formation (loc. M36 (KT001)); Q, TGUSE-MM7455, external cast of right valve, Okurodani Formation (loc. M36 (KT001)). Scale bars show 1 cm.

-MM7473) have fine radial ribs and fine concentric growth lines on the anterior half; their surface ornamentations are well preserved. However, the surfaces of a number of the other specimens (TGUSE-MM7430, -7434, -7466, -7472, -7476) show deformed radial ribs and fine concentric deformed lines. Furthermore, they are gradually replaced by wide plicae on the posterior area. Therefore, the character of the radial ribs on the anterior area should not be used as classification for subspecies. Thus, the numbers of ribs should not be a criterion of classification for differentiating *P. naktongensis naktongensis* and *P. n. multiplicatus* and *P. naktongensis multiplicatus* should be treated as a junior synonym of *P. naktongensis*.

Maeda (1962b) established the new species *Plicatounio* (*Plicatounio*) *kobayashii*, based on four specimens from the Lower Cretaceous Okurodani Formation of the Tetori Group, Kitadani, Fukui Prefecture, because the umbos of these specimens are located more anteriorly than on the specimens of *Plicatounio* (*P.*) *naktongensis*. Maeda (1962b) also established the new species *Plicatounio* (*P.*) *tetoriensis*, based on six specimens, because their umbos are located more posteriorly than on the specimens of *Plicatounio* (*P.*) *naktongensis*. The ratio of the distance between the anterior end and the umbo to the shell length (D/L) of the present specimens exhibits a wide range (average = 0.29, max = 0.43, min = 0.23; N = 23), and the values of D/L for *Plicatounio* (*P.*) *kobayashii* (average = 0.32, max = 0.34, min = 0.29; N = 3) and *Plicatounio* (*P.*) *tetoriensis* (max = 0.31, min = 0.26; N = 2) fall within the range of values of the present specimens (Fig.24). Therefore, the position of the umbo cannot be used to differentiate *Plicatounio* (*P.*) *kobayashii* and *Plicatounio* (*P.*) *tetoriensis* from *Plicatounio naktongensis*, and *Plicatounio* (*P.*) *kobayashii* and *Plicatounio* (*P.*) *tetoriensis* should be treated as junior synonyms of *Plicatounio* (*P.*) *naktongensis*.

Because of their very large umbo, the illustrated specimens of *Plicatounio* (*P.*) *languidus* (Guo, 1985, p.191, pl.45, figs.7-8), from the Cretaceous Nanxin Formation, Yunnan Province, southwest China, differ from the present specimens. Based on the elliptical shell form and radial plicae on the posterior half, the present specimens are very similar to the illustrated specimen of the *Plicatounio* (*P.*) *yaoanensis* (Guo, 1985, p.190-191, pl.45, fig. 3), from the Cretaceous Malanggou Formation, southwest Yunnan Province, southwest China; however, the latter has more numerous radial plicae on the posterior half than does the former. The present specimens are also different from the illustrated specimens of *Plicatounio* (*P.*) *subtilis* (Guo, 1985, p.191, pl.45, figs.4-6) from the Lower Cretaceous Mangang Formation, southwest China, in that the latter shows a very elongate shell form.

Occurrence. Mudstone beds of the Okurodani Formation at localities M37 (KT000), M36 (KT001), M35 (KT002), and 2 (KT005), Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan.

Subfamily Hyriinae Ortmann, 1911

Remarks. Cox et al. (1969) incorporated the Subfamily Hyriinae into the Family Unionidae on the basis of characters of shell form. Garf and Cummings (2006) included the Subfamily Hyriinae in the Family Hyriidae in conformity with analysis of DNA. Kobayashi (1968) established the Subfamily Pseudohyriinae on the basis of the presence V-sculpture in the early ontogenetic stage.

Genus *Pseudohyria* MacNeil, 1936.

Remarks. The genus *Pseudohyria* was established by MacNeil (1936, p.1514-1515, pl.2, figs.1-3) based on the specimens from the Upper Cretaceous Irean Dabasu Formation, Inner Mongolia, China. He defined the new genus by a single cardinal tooth on the LV, and two cardinal teeth on the RV, and elevated radial ribs on the shell surface. Subsequently, Yang (1979) described specimens from the Lower Cretaceous Yeonhwadong Formation,

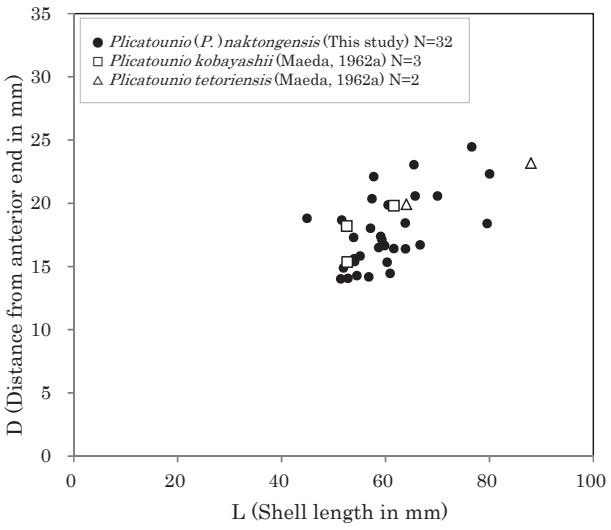

Fig.24. Relation of shell length (L) to distance from anterior end to umbo (D) in *Plicatounio kobayashii*, *Plicatounio tetoriensis*, and *Plicatounio* (*P.*) *naktongensis*.

Nagdong Subgroup, Gyeongsang Group in South Korea, as the new species *Pseudohyria matsumotoi*. He confirmed the following dental character in the species: three cardinal teeth on both the LV and RV. Then, Ogasawara (1988) described a specimen from the Lower Cretaceous Monomiyama Formation in northeast Japan as *Pseudohyria matsumotoi*, based on the presence of the two cardinal teeth on both the LV and RV. Subsequently, Tumpeesuwan and Tumpeesuwan (2010) described specimens from the Lower Cretaceous Sao Khua Formation, northeast Thailand, as the new species *Pseudohyria* (*Matsumotoina*) *somanai*, with three cardinal teeth on both the LV and RV. Although Tumpeesuwan and Tumpeesuwan (2010) utilized the subgenus name *Matsumotoina* of Guo (1982) for the Thailand specimens, Guo (1982) did not adequately describe the taxonomic characters in proposing the new subgenus, and also did not provide any illustrations or diagrams. As we cannot compare the subgenus of Guo (1982) with any specimens, the subgenus should be invalid and treated as *nomen dubium*; thus, the Thailand specimens should be treated as *Pseudohyria* (Table 11).

Pseudohyria aff. *matsumotoi* Yang, 1979

Fig. 25 A-Q

1988 *Pseudohyria matsumotoi*; Ogasawara, p.307-309, pl.1, figs.1-8, pl.2, figs.1-6, 9-10.
1990 *Pseudohyria matsumotoi*; Tamura, pl.8, figs.1.
1990 ?*Pseudohyria matsumotoi*; Tamura, pl.8, fig.3a,b.
1990 *Pseudohyria* cf. *matsumotoi*; Tamura, pl.8, fig.10.
1993 *Pseudohyria* ? sp.; Matsukawa and Ido, p.369, fig.3,h.
2009 *Pseudohyria matsumotoi*; Matsuura, pl.2-7, fig.37.

Material. 25 specimens (TGUSE-MM7490 to -MM7514) came from the Okurodani Formation at localities M37 (KT000) (TGUSE-MM7490 to -MM7492, -MM7499, -MM7505, -MM7507), M36 (KT001) (TGUSE-MM7493 to -MM7497, -MM7502 to -MM7504, -MM7506, -MM7508 to -MM7512, -MM7515), M35 (KT002) (TGUSE-MM7498, -MM7500, -MM7513), and 2 (KT005) (TGUSE-MM7501) , all Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan. They consist of 13 external casts of left valves, five external casts of right valves, six external casts of articulated valves, and a single external mold of a RV. All specimens were collected by Matsukawa, M. and Ido, K.

Table 11. Dental formula of *Pseudohyria* aff. *matsumotoi* (this study), *Pseudohyria gobiensis* (MacNeil, 1936), *Pseudohyria matsumotoi* (Yang, 1979), *Pseudohyria matsumotoi* (Ogasawara, 1988) and *Pseudohyria* (*Matsumotoina*) *somanai* (Tumpeesuwan and Tumpeesuwan, 2010).

Reference	Taxa	Dental Formula
MacNeil (1936)	Genus *Pseudohyria* (*Pseudohyria gobiensis*)	"a single of cardinal tooth on left valve, two cardinal teeth on right valve, lamellar teeth not well known, apparently short and curve"
This study	*Pseudohyria* aff. *matsumotoi*	*4, 2, 1'a, 1'b, P Ⅱ, P Ⅳ / 5, 3, 1a, 1b, P Ⅲ*
Yang (1979)	*Pseudohyria matsumotoi*	*4, 2, 1'a, P Ⅱ, P Ⅳ / (5), 3, 1a, 1b, P Ⅲ*
Ogasawara (1988)	*Pseudohyria matsumotoi*	*2, 1'a, P Ⅱ, P Ⅳ / 3, 1a, 1b, P Ⅲ*
Tumpeesuwan and Tumpeesuwan (2010)	*Pseudohyria* (*Matsumotoina*) *somanai*	*4, 2, 1'a, 1'b, P Ⅱ, P Ⅳ / 5, 3, 1a, 1b, P Ⅲ*

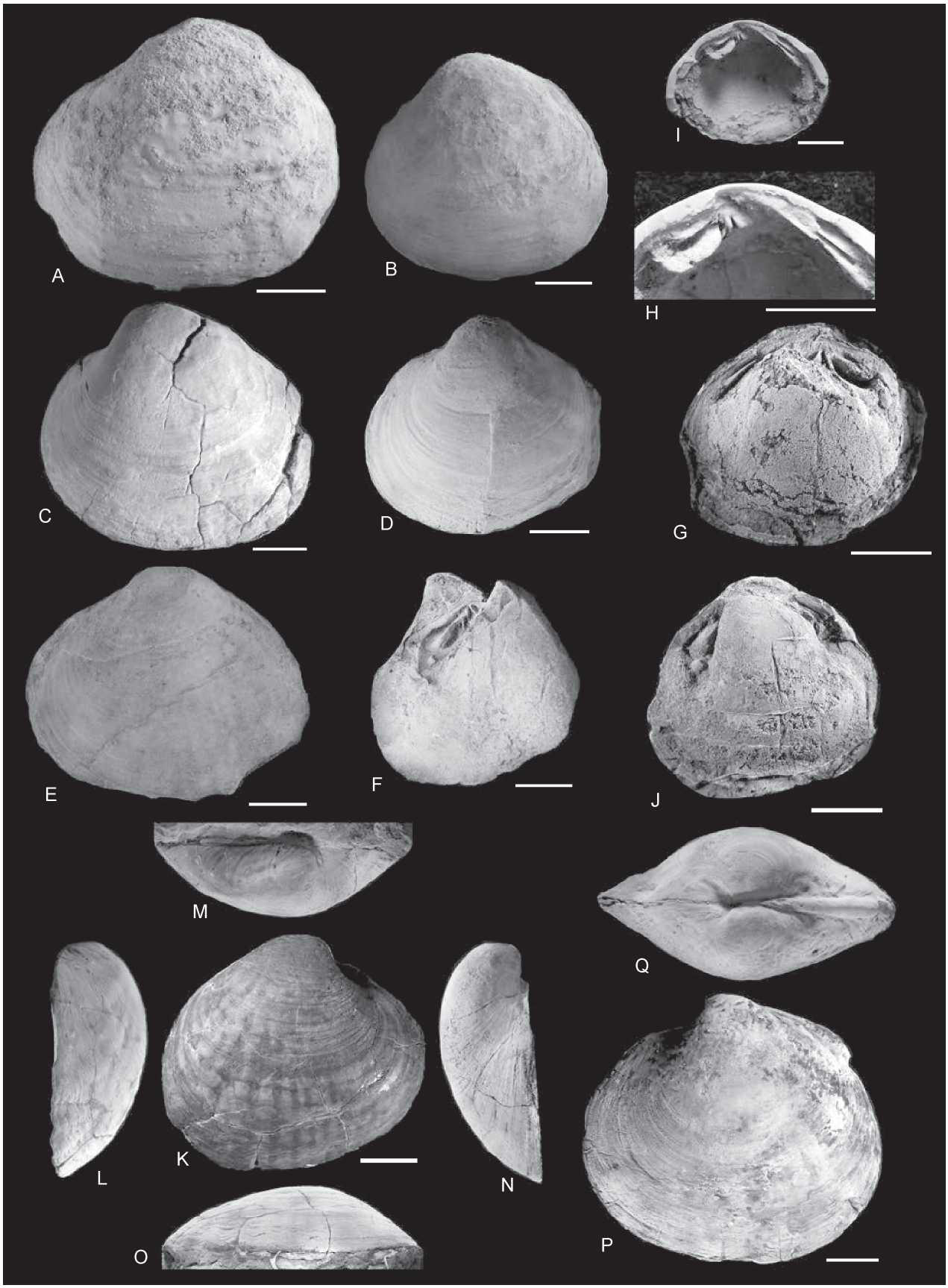

Fig.25. A-Q, *Pseudohyria aff. matsumotoi* Yang; A, TGUSE-MM7497, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); B, TGUSE-MM7498, external cast of left valve, Okurodani Formation (loc. M35 (KT002)); C, TGUSE-MM7492, external cast of right valve, Okurodani Formation (loc. M37 (KT000)); D, TGUSE-MM7491, external cast of left valve, Okurodani Formation (loc. M37 (KT000)); E, TGUSE-MM7494, external cast of left valve, Okurodani Formation (loc. M36 (KT001)); F, TGUSE-MM7505, internal cast of articulated valve, Okurodani Formation (loc. M37 (KT000)); G-I, TGUSE-MM7502, internal cast of right valve, Okurodani Formation (loc. M36 (KT001)); G, right view; H, rubber mold; I, hinge structure (rubber mold); J, TGUSE-MM7506, internal cast of left valve, the Okurodani Formation (loc. M36 (KT001)); K-O, TGUSE-MM7504, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); K, right view; L, posterior view; M, upper view; N, anterior view; O, ventral view; P,Q, TGUSE-MM7490, external cast of articulated valve, Okurodani Formation (loc. M37 (KT000)); P, left view; Q, upper view. Scale bars show 1 cm.

Measurements (in mm except for L/H)

Specimen	L	H	T	D	L/H
TGUSE-MM7490	56.2	50.0	13.7	21.1	1.12
TGUSE-MM7491	35.6	32.9	8.0	16.9	1.08
TGUSE-MM7493	31.2	30.9	8.1	12.4	1.01
TGUSE-MM7494	45.7	39.6	11.4	21.9	1.15
TGUSE-MM7496	34.6	31.5	10.8	18.8	1.10
TGUSE-MM7497	42.3	36.9	10.3	22.0	1.15
TGUSE-MM7498	40.8	38.0	13.6	18.9	1.07
TGUSE-MM7499	44.0	34.4	14.7	19.7	1.28
TGUSE-MM7503	25.6	23.3	5.6	12.6	1.10
TGUSE-MM7504	50.7	43.7	13.6	21.8	1.16
TGUSE-MM7506	32.3	28.6	6.4	16.7	1.13
TGUSE-MM7507	34.3	28.3	9.1	17.9	1.21
TGUSE-MM7508	39.2	35.3	6.8	20.5	1.11
TGUSE-MM7509	38.7	36.2	8.0	18.2	1.07
TGUSE-MM7514	32.6	32.1	10.8	12.9	1.01
TGUSE-MM7512	34.5	29.3	8.4	17.5	1.17
TGUSE-MM7510	40.5	36.4	11.5	21.4	1.11

Description. Shell medium size, equivalve, inequilateral, trigonal suboval form, postero-dorsal margin nearly straight, postero-ventral corner round, ventral margin broadly arcuate and slightly crenulate with radial grooves, anterior margin round, moderately convex; prominent umbo, prosogyrate, situated at about mid-point of shell length; surface smooth, about 10 shallow and wide radial grooves on posterior half, these grooves enlarging posteriorly, becoming gradually prominent toward postero-ventral side, interspaces between grooves wider than ribs anteriorly, indistinct near the umbo on the anterior half; concentric growth lines irregularl and showing wavy pattern at edge of ventral area; dental formula: *4 2 1'a 1'b PII PIV / 5 3 1a 1b PIII,* 4 stout, parallel to the antero-dorsal margin, 2 stout, subparallel to the antero-dorsal margin, 1'a low, small and trigonal in shape, nearly vertical, 1'b low, short and subtrigonal in form, P Ⅱ narrow and elongate, parallel to the postero-dorsal margin, a little longer than PIV, PIV narrow and elongate, parallel to the postero-dorsal margin, 5 low, about half the length of 3 and parallel to antero-dorsal margin, 3 stout and high, slightly arcuate, subparallel to the antero-dorsal margin, 1a low, short and bifurcating (shown on only one specimen, TGUSE-MM7503), nearly vertical, 1b low, short and wedge-shaped, P Ⅲ narrow and elongate, subparallel to the postero-dorsal margin; pallial line smooth; adductor scars suboval and subequal in size; ligament running from umbo to posterior end.

Remarks. The present specimens are very similar to the holotype of *Pseudohyria matsumotoi* (Yang, 1979, p.230-233, pl.28, figs.1-8), from the lower horizon of the Yeonhwadong Formation, Nagdong Subgroup, Gyeongsang Group, South Korea, in having about 10 strong radial grooves on the posterior half and slightly wavy concentric growth lines in the ventral area. However, the present specimens differ from the holotype in their dental formula, as the latter lacks 1'b on the left valve. So, we hesitate to identify the present specimens as *Pseudohyria matsumotoi*. Because its entire surface is marked with radial grooves, the illustrated specimens of *Pseudohyria gobiensis* (MacNeil, 1936, p.1515, pl.2, figs.1-3), from Iren Dabasu Formation, Iren Dabasu and Inner Mongolia, differ from the present species. Based on the angle of the postero-ventral corner, the present specimens of the species also differs from the illustrated specimens of *Pseudohyria somanai* (Tumpeesuwan and Tumpeesuwan, 2010, p.96-102, Fig.4, A-K) from the Lower Cretaceous Sao Khua Formation, Khorat Group, northeast Thailand; the angle of the former is rather angulate, while in the latter it is sharply angulate.

Occurrence. Mudstone beds of the Okurodani Formation at localities M37 (KT000), M36 (KT001), M35 (KT002), and 2 (KT005), Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan.

Order Trigonioida Dall, 1889

Superfamily Trigoniacea Lamarck, 1819

Family Trigoniidae Lamarck, 1819

Genus *Latitrigonia* Kobayashi in Kobayashi and Tamura, 1957

Remarks. Kobayashi (in Kobayashi and Tamura, 1957) established the genus *Latitrigonia* defined by very small, subquadrate or subcurcular outline, disk larger than area, parallel costae with nodes on disk, and transverse costellae on area. Then, Kobayashi (1957) identified three specimens from Yambarazaka, Izumi area, Ono City, Fukui Prefecture, in the Yambarazaka Formation, as *Latitrigonia tetoriensis*, sp. nov., and two specimens from the same locality as *Latitrigonia orbicularis* sp. nov. Afterward, Maeda (1963) identified four specimens from Tanimaya-dani, Izumi area, Ono City, Fukui Prefecture, in the Yamabarazaka Formation [=Kaizawa Formation of Matsukawa and Asahara (2010)],

as *Latitrigonia horii*, sp. nov. and an additional specimens as *Latitrigonia kasaii*, sp. nov. Kobayashi (1957) and Maeda (1963) used shell outline characters for identification of species of *Latitrigonia*, including roundly subquadrate, subcircular, subquadrate and subtrapezoidal shell form. The specimens from two localities in the Kaizara and Yamabarazaka formations probably show similar shell variation; however, we do not have certain evidence for such variation and therefore hesitate to treat these species as junior synonyms of *Latitrigonia tetoriensis*.

Latitrigonia tetoriensis Kobayashi, 1957

1957 *Latitrigonia tetoriensis*; Kobayashi, p.45, pl.1, figs.11-13.
1975 *Latitrigonia tetoriensis*; Hayami, p.103.
Occurrence. Yambarazaka Formation.

Latitrigonia orbicularis Kobayashi, 1957

1957 *Latitrigonia orbicularis*; Kobayashi, p.45, pl.1, figs.14, 15.
1975 *Latitrigonia orbicularis*; Hayami, p.104.
Occurrence. Yambarazaka Formation.

Latitrigonia horii Maeda, 1963

1963 *Latitrigonia horii*; Maeda, p.3, pl.1, figs.1-6.
Occurrence. Kaizara Formation.

Latitrigonia kasaii Maeda, 1963

1963 *Latitrigonia kasaii*; Maeda, p.4, pl.1, fig.5.
Occurrence. Kaizara Formation.

Genus *Ibotrigonia* Kobayashi in Kobayashi and Tamura, 1957

Ibotrigonia tetoriensis Maeda, 1963

1963 *Ibotrigonia tetoriensis*; Maeda, p.4-5, pl.1, figs.8, 9.
Remarks. Maeda (1963) identified two specimens from Taniyama-dani, Izumi area, Ono City, Fukui Prefecture, in the Yamabarazaka Formation [=Kaizara Formation of Matsukawa and Asahara (2010)], as *Ibotrigonia tetoriensis*.
Occurrence. Callovian Yambarazaka Formation.

Subfamily Myophorellinae Kobayashi, 1954

Remarks. Kobayashi (1954) proposed the Subfamily Myophorellinae based on Japanese Jurassic trigonians. Subsequently, Hayami (1975) changed the Subfamily Myophorellina of Kobayashi (1954) to Tribe Myophorellini without providing a reason. This change probably was caused by misspelling by Kobayashi (1954), because he originally wrote as "Subfamily Myophorelline" instead of "Myophorellinae".

Genus *Myophorella* Bayle, 1878
Subgenus *Promyophorella* Kobayashi and Tamura, 1955

Myophorella (*Promyophorella*) *imamurai* Kobayashi, 1956

Fig. 26 A-R

1956 *Myophorella* (*Promyophorella*) *imamurai*; Kobayashi, p.3, pl.1, fig.3.
1966 *Myophorella* (*Promyophorella*) *toyamensis*; Maeda and Kawabe, p.43, pl.1, figs.1-14.
1966 *Myophorella* (*Promyophorella*) *magawensis*; Maeda and Kawabe, p.47, pl.1, figs.15-19.
1966 *Myophorella* (*Promyophorella*) *tetoriensis*; Maeda and Kawabe, p.48, pl.1, figs.20-22.
1966 *Myophorella* (*Promyophorella*) *hidensis*; Maeda and Kawabe, p.46, pl.2, figs.1-29.

Material. 21 specimens (TGUSE-MM7772 to -MM7791, -MM7827) from localities Mg01 (TGUSE-MM7772 to -MM7774), Mg04 (TGUSE-MM7775), Mg05 (TGUSE-MM7776 to -MM7786), Mg06 (TGUSE-MM7787, -MM7788), and Mg07 (TGUSE-MM7789 to -MM7791, -MM7827), Magawa Formation, Arimine district, Toyama City, Toyama Prefecture, Japan They consist of a single external cast of a left valve, two external molds of left valves, a single internal mold of a left valve, a single external cast of a right valve, five external molds of right valves, two internal casts of right valves, a single internal mold of a right valve, three external molds of articulated valves, two internal casts of articulated valves, a pair of external molds and internal casts of left valves, and a pair of external molds and internal casts of articulated valves (K. Suzuki, A. Ishitoya, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.). Five specimens (KIK0024, -0393 to -0396)

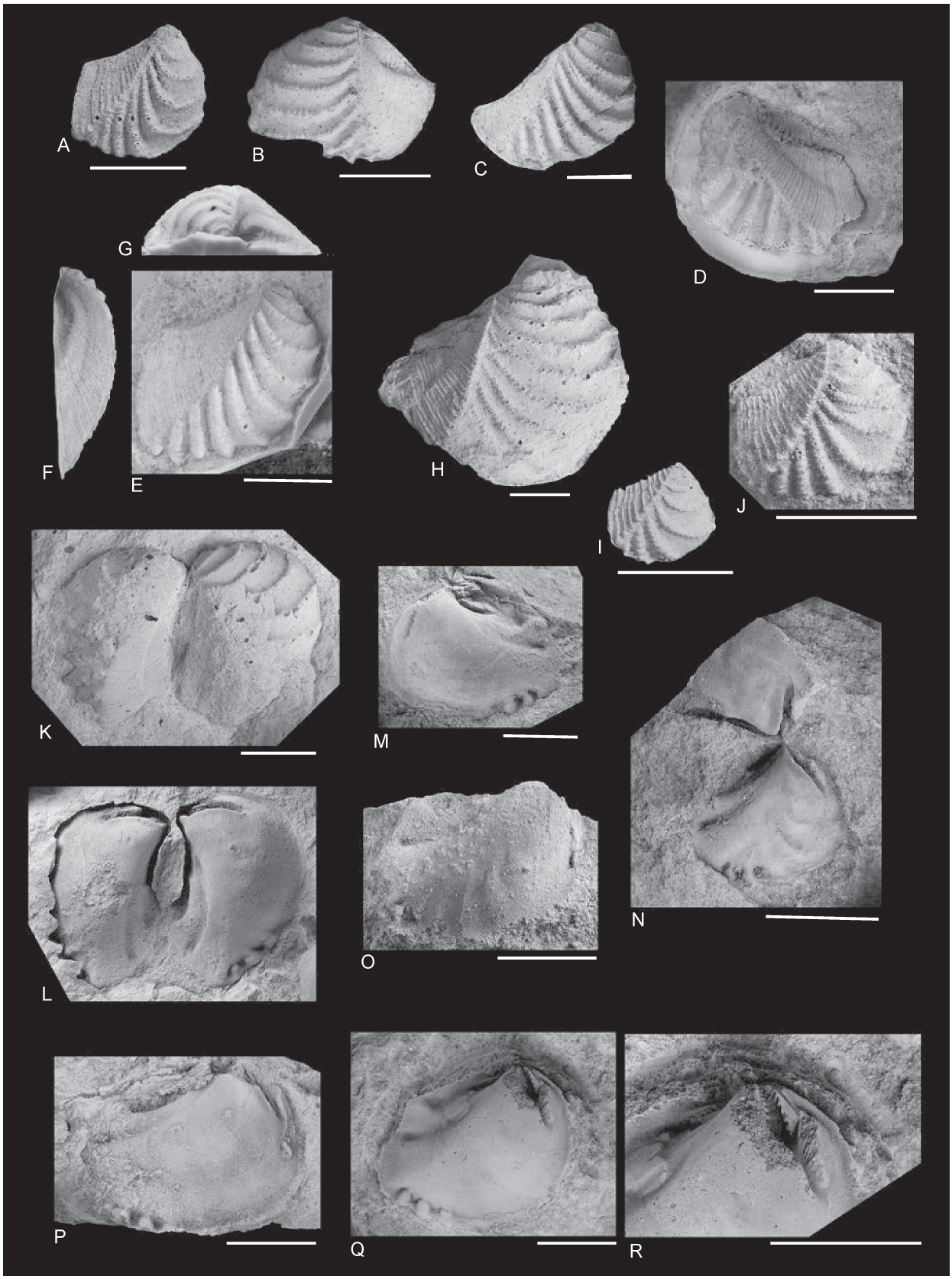

Fig.26. A-R, *Myophorella* (*Promyophorella*) *imamurai* Kobayashi; A, TGUSE-MM7789, external mold of right valve (rubber mold), Magawa Formation (loc. Mg07); B, TGUSE-MM7783, external mold of articulated valves (rubber mold), Magawa Formation (loc. Mg05); C, TGUSE-MM7779, external mold of right valve (rubber mold), Magawa Formation (loc. Mg05); D, TGUSE-MM7772, external mold of left valve (rubber mold), Magawa Formation (loc. Mg01); E-G, TGUSE-MM7827, external mold of right valve, Magawa Formation (loc. Mg07); E, right view (rubber mold); F, posterior view (rubber mold); G, upper view (rubber mold); H, KIK0024, external mold of right valve (rubber mold), Kiritani Formation; I, KIK0394, external mold of right valve (rubber mold), Kiritani Formation; J, TGUSE-MM7790, external mold of right valve (rubber mold), Magawa Formation (loc. Mg07); K,L, TGUSE-MM7788, external mold and internal casts of articulated valves, Magawa Formation (loc. Mg06); K, external cast (rubber mold); L, internal cast; M, TGUSE-MM7778, internal cast of left valve, Magawa Formation (loc. Mg05); N, TGUSE-MM7787, internal cast of articulated valves, Magawa Formation (loc. Mg06); O, TGUSE-MM7780, external mold of right valve (rubber mold), Magawa Formation (loc. Mg05); P, TGUSE-MM7777, internal cast of right valve, Magawa Formation (loc. Mg05); Q,R, TGUSE-MM7773, internal cast of right valve, Magawa Formation (loc. Mg01); Q, right view; R, hinge structure. Scale bars show 1 cm.

found at Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan, including a single external mold of a left valve, two external molds of right valves, and two external molds of articulated valves. All specimens are kept at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture (T. Yamaguchi, K. Yoshida, and T. Hamuro Coll.).

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7772	25.6	22.9	6.1	1.12
TGUSE-MM7773	28.0	23.5	6.5	1.19
TGUSE-MM7774	22.8	22.5	7.1	1.01
TGUSE-MM7777	23.0	18.2	4.2	1.26
TGUSE-MM7778	23.6	19.5	5.1	1.21
TGUSE-MM7779	23.0	21.1	4.4	1.09
TGUSE-MM7780	23.5	17.2	5.1	1.36
TGUSE-MM7781	14.1+	14.7+	-	-
TGUSE-MM7782	9.4	8.4	3.2	1.11
TGUSE-MM7783	20.4+	18.7+	-	-
TGUSE-MM7784	19.5	17.0	4.3	1.15
TGUSE-MM7785	16.9	15.1	4.3	1.12
TGUSE-MM7786	20.5	18.7	4.7	1.10
TGUSE-MM7787	14.4	13.1	4.2	1.10
TGUSE-MM7788	25.9	20.1	4.9	1.29
TGUSE-MM7789	14.7	13.1	-	1.12
TGUSE-MM7790	12.2	11.5	2.5	1.06
TGUSE-MM7791	26.5+	20.2+	4.9	-
KIK 0024	39.7	35.6+	6.8	-
KIK 0393	14.7	11.7+	2.4	-
KIK 0394	9.4	8.9	2.4	1.06
KIK 0395	13.4+	12.7+	2.7	-

Description. Shell small to medium in size, equivalve, strongly inequilateral, outline fairly variable but commonly trigonally ovate, gently convex, little longer than high; siphonal margin nearly straight; umbo slightly opisthogyrate, situated at one-third to one-fourth the distance from the anterior end; escutcheon shallow; body disk and area divided by slightly arcuate marginal carina; shallow median furrow existing on area; disk ornamented with about 10 tiny tuberculae on costae; area and escutcheon marked with numerous smooth transverse costellae; median groove strongly impressed on internal mold; ventral margin of internal mold marked with some strongly crenulate ornament; two subequal teeth marked with strong transverse ridges.

Remarks. The specimens are identified as *Myophorella* (*Promyophorella*) *imamurai* Kobayashi (Kobayashi, 1956, p.3, pl.1, fig.3) from the Upper Jurassic Kiritani Formation in having about 10 costae on the disk, fine oblique and transverse costellae on the area, a linear carina, and moderately arcuate carina dividing between area and disk. Maeda and Kawabe (1966) subsequently established four additional species, *Myophorella* (*P.*) *toyamensis, M.* (*P.*) *magawaensis, M.* (*P.*) *tetoriensis*, and *M.* (*P.*) *hidensis,* based on specimens from the Middle Oxfordian Magawa Formation exposed along the Magawa River at Arimine area in Toyama Prefecture, Japan. These species are classified by slightly different characters of shell outline, shape of costae on the disk, and tiny tubercles on the marginal carina. Specifically, *Myophorella* (*P.*) *toyamensis* is characterized by a subtrigonal shell outline, straight costae on the disk, and a tuberculate marginal carina, *M.* (*P.*) *hidensis* is categorized by a subtrigonal to subtrapezoid shell outline and arcuate costae on disk, *M.* (*P.*) *magawensis* is represented by a subtrigonal to subquadrate shell outline, arcuate costae on disk, and a tuberculate marginal carina, while *M.* (*P.*) *tetoriensis* is classed by its subtrigonal or ovate shell outline and arcuate costae on the disk.

One of the specimens (TGUSE-MM7789) of the present species is characterized by a subtrigonal shell outline, arcuate costae, and tuberculate marginal carina on the disk, representing characters of both *M.* (*P.*) *toyamensis* and *M.* (*P.*) *magawensis*. Another of the present specimens (TGUSE-MM7774) is characterized by a subtrigonal to subtrapezoid shell outline, straight costae, and tuberculate marginal carina on the disk, exhibiting features of the four species *M.* (*P.*) *toyamensis, M.* (*P.*) *magawaensis, M.* (*P.*) *hidensis*, and *M.* (*P.*) *tetoriensis*. One of the present specimens (TGUSE-MM7783) is also characterized by a subtrigonal to subtrapezoidal shell outline and straight costae, characters represent a five of both *M.* (*P.*) *toyamensis* and *M.* (*P.*) *hidensis*. Several of the present specimens (TGUSE-MM7784, TGUSE-MM7779) are characterized by subtrigonal to subquadrate shell outlines, and straight costae, features confirmed on both *M.* (*P.*) *toyamensis* and *M.* (*P.*) *magawaensis*. Finally, the specimen (TGUSE-MM7788) is characterized by a subtrigonal to subquadrate shell outline, arcuate costae, and tuberculate marginal carina on disk. The features of this specimen are characteristic of both *M.* (*P.*) *toyamensis*, and *M.* (*P.*) *magawaensis*. Therefore, the value of the classification of

the four species established by Maeda and Kawabe (1966) is a *nomen dubium*. According to the International Code of Zoological Nomenclature (Article 24), these four species are regarded as junior synonyms of *Myophorella* (*P.*) *imamurai.*

Because of their well-rounded marginal carina, the present specimens are distinct from the illustrated specimens of *Myophorella* (*P.*) *orientalis* (Maeda and Kawabe, 1966, p.51, pl.1, figs.1-22, pl.2, figs.1-14) from the Middle Jurassic Kaizara Formation of the Tetori Group, Izumi area, Ono city, Fukui Prefecture. The present specimens also differ from the illustrated specimen of *Myophorella saurini* (Kozai et al., 2006, pl.1, figs.29, 30) from the Lower Jurassic Klo Tho Formation, Umphang Group, Umphang area, northwestern Thailand, in possessing a narrow area wlth costae on the disk and decorated by small bead-like tubercles. Based on the smaller number of costae on the disk (about seven) and large tubercles on the costae on the disk, the present specimens differ from the illustrated specimen of the *Myophorella saurini* (Hayami, 1972, p.201-204, pl.34, figs.1-20, pl.38, fig.8) from the Lower Jurassic Loc.2 of Lo-Duc, north-northeast of Ho Chi-Minh City (Saigon), Vietnam.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine area in Toyama Prefecture, Japan (TGUSE-MM7772, -7791, and -7827). Sandstone beds of the Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area Toyama City in Toyama Prefecture, Japan (KIK 0024 and KIK 0393-0396).

Myophorella (*Promyophorella*) *orientalis* Kobayashi and Tamura, 1955

1957 *Myophorella* (*Promyophorella*) *orientalis*; Kobayashi, p.46, pl.1, figs.16-18.
1963 *Myophorella* (*Promyophorella*) *orientalis*; Maeda, p.6-7, pl.1, figs.11, 12.
1975 *Myophorella* (*Promyophorella*) *orientalis*; Hayami, p.110.

Remarks. Kobayashi (1957) identified severel fragmentary specimens from Yambarazaka, Izumi area, Ono City, Fukui Prefecture, in the Yambarazaka Formation, as *Myophorella* (*P.*) *orientalis*. Maeda (1963) subsequently identified several fragmentary specimens from Taniyama-dani, Izumi area, Ono City, Fukui Prefecture, in the Yambarazaka Formation [=Kaizara Formation in Matsukawa and Asahara (2010)], as *Myophorella* (*P.*) *orientalis.*

Occurrence. Yambarazaka Formation

Genus *Nipponitrigonia* Cox, 1952

Nipponitrigonia sagawai (Yehara, 1927)

Fig. 27 A-J

1927 *Trigonia sagawai*; Yehara, p.34, pl.3, figs.10a-10b.
1957 *Nipponitrigonia sagawai*; Kobayashi, p.53-54, pl.10, figs.2-11.
1962c *Nipponitrigonia sagawai*; Maeda, p.503-505, pl.1, figs.1-15.
1962c *Nipponitrigonia kobayashii*; Maeda, p.505-506, pl.2, figs.1-15, pl.3, figs.13-15.
1962c *Nipponitrigonia imamurai*; Maeda, p.506-507, pl.3, figs.1-12.
1962e *Nipponitrigonia furukawensis*; Maeda, p.274-275, pl.42, figs.1-15.
1963 *Nipponitrigonia kobayashii*; Maeda and Kawabe, p.57-58, pl.1, figs.2-8.
1975 *Nipponitrigonia sagawai sagawai*; Hayami, p.104.
1975 *Nipponitrigonia sagawai kobayashii*; Hayami, p.104.

Material. 64 specimens (KIK0016b, -0016c, -0021, -0022a, -0022b, -0316, -0317, -0319a, -0319b, -0319c, -0319d, -0319e, -0319f, -0319g, -0319h, -0319i, -0319j, -0319k, -0319l, -0319m, -0319n, -0319o, -0319p, -0319r, -0371, -0372b, -0383a, -0383b, -0383c, -0383d, -0383e, -0383f, -0383g, -0397, -0398, -0399c, -0400a, -0400b, -0401 to -KIK0404, -0405a, -0405b, -0406 to -KIK0409, -0410d, -0410c, -0410d, -0410e, -0411, -0412a, -0412b, -0412d, -0412e, -0413, -04141, -0415a, -0415b, -0416 to -KIK0419) from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. They consist of 10 external casts of left valves, seven external casts of right valves, 17 external molds of left valves, seven external molds of right valves, 17 internal casts of left valves, four internal casts of right valves, and two internal casts of articulated valves. All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture (A. Yamada, A. Sawayama, and T. Hamuro Coll.).

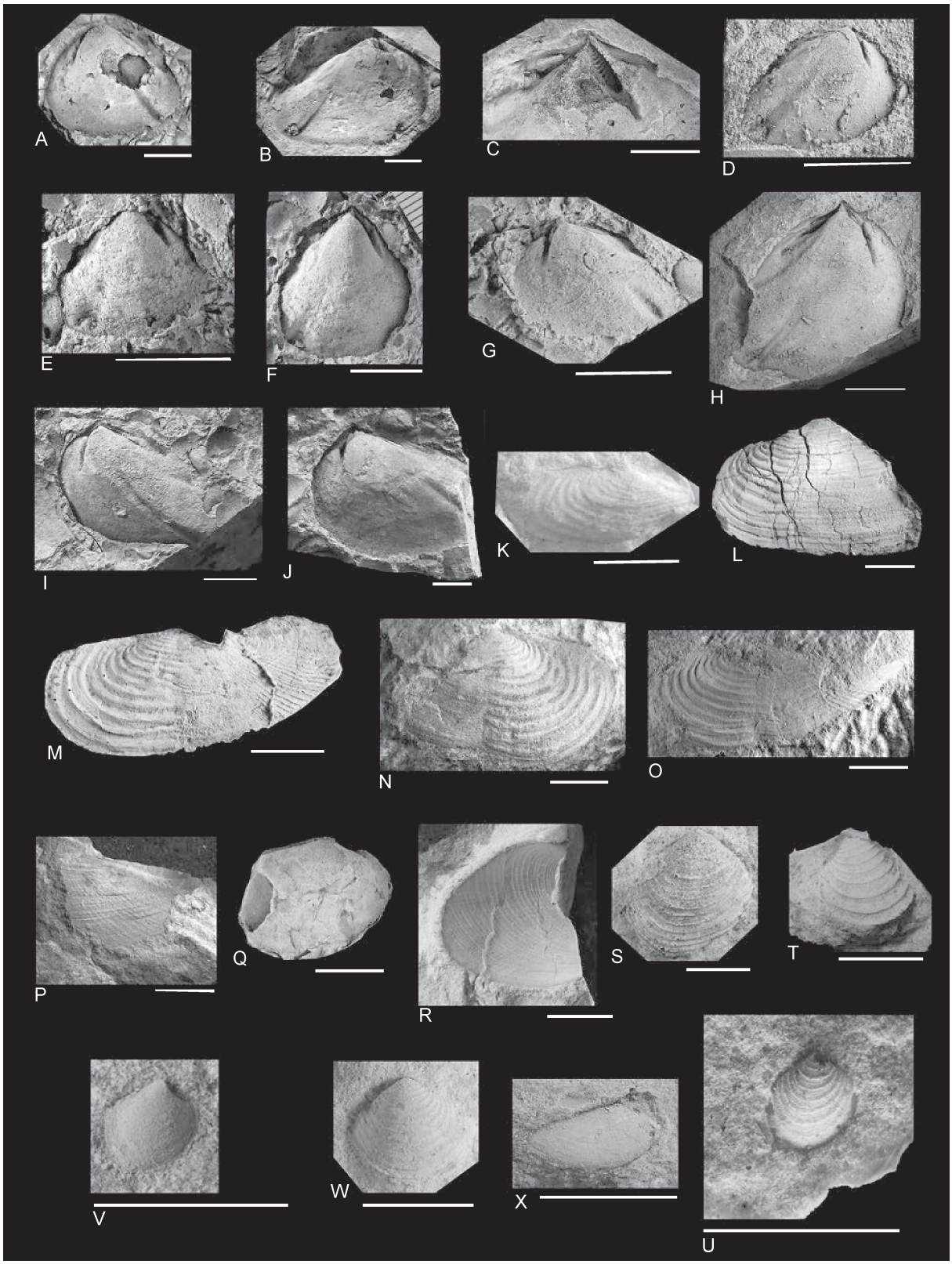

Fig.27. A-J, *Nipponitrigonia sagawai* (Yehara); A, KIK0021, internal cast of left valve, Kiritani Formation; B,C, KIK0022a, internal cast of right valve, Kiritani Formation; B, right view; C, hinge structure; D, KIK0317b, internal cast of right valve, Kiritani Formation; E, KIK0319n, internal cast of right valve, Kiritani Formation; F, KIK0319d, internal cast of right valve, Kiritani Formation; G, KIK0382r, internal cast of left valve, Kiritani Formation; H, KIK0400a, internal cast of right valve, Kiritani Formation; I, 252-(3), internal cast of left valve, Kiritani Formation (Yehara's specimen housed at Tenri High School); J, 251-(4), internal cast of left valve, Kiritani Formation (Yehara's specimen housed at Tenri High School); K, *Cercomya* (*Cercomya*) cf. *gurgitis* (Pictet and Campiche), TGUSE-MM7811, external cast of left valve (rubber mold), Magawa Formation (loc. Mg01); L-P, *Cercomya* (*Capillimya*) sp.; L, TGUSE-MM7815, external cast of left valve, Magawa Formation (loc. Mg01); M, TGUSE-MM7814, external cast of left valve (rubber mold), Magawa Formation (loc. Mg01); N, TGUSE-MM7816, external cast of right valve, Magawa Formation (loc. Mg01); O, TGUSE-MM7818, external cast of left valve, Magawa Formation (loc. Mg05); P, TGUSE-MM7817, external cast of left valve, Magawa Formation (loc. Mg01); Q, *Thracia*? sp.; KIK0414c, internal cast of right valve, Kiritani Formation; R, Bivalvia gen. et sp. indet. A, KIK0433, external cast of left valve, Kiritani Formation; S-W, Bivalvia gen. et sp. indet. B; S, TGUSE-MM7820, external cast of right valve (rubber mold), Magawa Formation (loc. Mg01); T, TGUSE-MM7823, external cast of left valve (rubber mold), Magawa Formation (loc. Mg01); U, TGUSE-MM7824, external cast of right valve (rubber mold), Magawa Formation (loc. Mg01); V, TGUSE-MM7819, external cast of right valve, Magawa Formation (loc. Mg01); W, TGUSE-MM7822, external cast of left valve (rubber mold), Magawa Formation (loc. Mg01); X, Bivalvia gen. et sp. indet. C, KIK0431, external cast of right valve, Kiritani Formation. Scale bars show 1 cm.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0016b	19.3	16.2	4.2	1.19	120
KIK0021	28.6	25.2	7.7	1.14	118
KIK0317	15.4	12.5	4.8	1.23	112
KIK0319r	17.6	13.5	3.1	1.30	128
KIK0383b	12.1	8.7	2.9	1.39	124
KIK0383c	19.4	14.9	3.1	1.30	118
KIK0397	29.3+	25.0	11.9	1.95	120
KIK0397	24.6	12.6	3.4	1.10	116
KIK0400a	32.7	30.3	6.1	1.08	112
KIK0400b	10.5	9.2	2.1	1.13	116
KIK0401	17.4	13.9	2.5	1.25	116
KIK0405b	17.5	14.4	3.3	1.21	120
KIK0406	34.3	27.8	7.7	1.23	116
KIK0407	18.8	17.0	4.0	1.11	118
KIK0408	33.1+	27.9	11.1	1.19+	118
KIK0409	33.9	25.4	6.1	1.33	116
KIK0410c	15.4	13.3	-	1.16	96
KIK0412a	20.3	15.3	5.1	1.33	124
KIK0412e	9.7	8.8	3.6	1.10	124
KIK0412d	9.5+	9.0	2.9	1.06+	106
KIK0415b	20.7	16.7	5.5	1.24	110
KIK0416	23.3	23.6	8.3	0.99	94
KIK0417	30.2+	29.3	8.4	1.03+	94
KIK0419	26.6	21.2	5.3	1.25	106

Description. Shell medium to small size, equivalve, inequilateral, trigonally suboval and subtrigonal, moderately convex, transversally elongate, shows wide variation (L/H ranging from 1.0 to 2.0, average = 1.27; N = 38); arcuate postero-dorsal margin; test thick; umbo prosogyrate, located at two-fifths distance from anterior end; apical angle ranging from 108 to 128 degrees (average = 118.9 degrees; N = 51); obtusely marginal carina running from above umbo to postero-ventral corner, which becomes smooth in later growth stages; surface smooth except near umbo, anterior side of umbo marked with few strong concentric costae; two main teeth having strong transverse ridges, ridges on main teeth (3a, 3b) of specimens (KIK 0022a and KIK 0400) number about 8; inner cast having two grooves on disk and area near marginal angulation.

Remarks. Maeda (1962c) classified trigonian specimens from Todani in Kiritani area, Toyama Prefecture as *Nipponitrigonia sagawai* (Yehara, 1927), *Nipponitrigonia kobayashii* sp. nov., and *Nipponitrigonia imamurai* sp. nov. He established the two new species on the following criteria:

(1) The specimens of *Nipponitrigonia sagawai* have a wide inter-space between costae.

(2) Specimens classified as *Nipponitrigonia imamurai* have different characters of the inner molds and costae near the anterior margin from those of *Nipponitrigonia kobayashii* and *Nipponitrigonia sagawai*.

However, inter-spaces between the costae of specimens described as both *N. kobayashii* and *N. imamurai* exhibit a gradual expansion tendency from the umbonal area to the ventral area (Table 12). Table 12 shows that the specimens described as *N. kobayashii* are larger than the specimens described as *N. sagawai*; the average shell length of the former specimens is 24.2 mm, while that of the latter specimens is 15.7 mm. This shows that larger specimens have wider inter-spaces between the costae, and smaller specimens have narrower inter-spaces between the costae. So, we can not differentiate to these two species using size of inter-space between costae as criterion, and *Nipponitrigonia kobayashii* (Maeda, 1962c) is regarded as a junior synonym of *N. sagawai* (Yehara).

Furthermore, since Maeda (1962c) did not specifically describe the characters of *N. imamurai*, we can not confirm the differences on the illustrated specimens (Maeda, 1962c, pl.3, figs.1-12). The specimens described as *N. imamurai* are characterized by an ovately trigonal shell outline and this character is also characteristic on the specimens described by Kobayashi (1957, pl.10, figs. 2-11) as *N. sagawai* from the Soma Group in Fukushima area, the Jurassic formation in Sakawa area, Kochi Prefecture, and the Ushioi and Kiritani formations in Toyama Prefecture. Therefore, the specimens described as *Nipponitrigonia imamurai* by Maeda (1962c) belong to *Nipponitrigonia sagawai* (Yehara, 1927) as a junior synonym.

Maeda (1962c) additionally classified specimens from the Sugizaki Formation, Hida City, Gifu Prefecture, as the new species *Nipponitrigonia furukawensis* (Maeda, 1962e, p.274-275, pl.42, figs.1-15) because they exhibit narrower inter-spaces between costae than the specimens described as *N. sagawai*, *N. kobayashii*, and *N. imamurai*. However, the specimens described as *N. furukawensis* are smaller than the specimens of *N. sagawai* from the Jurassic formation in Sakawa area, than specimens of *N. kobayashii* from the Kiritani and Magawa formations, as well as

specimens of *N. imamurai* from the Kiritani Formation; the average of shell length of *N. furukawensis*, *N. sagawai*, *N. kobayashii*, and *N. imamurai* is 12 mm, 15.7 mm, 24.2 mm, and 21.4 mm, respectively. Since the inter-space width between costae is related to narrowing of the shell toward the umbonal area, as discussed above, the smaller specimens described as *Nipponitrigonia furukawensis* have narrower inter-spaces between costae. Furthermore, the specimens described as *N. furukawensis* are characterized by an ovately trigonal shell outline, similar to *N. sagawai*. Thus, the specimens described as *Nipponitrigonia furukawensis* (Maeda, 1962e) should be assigned to *Nipponitrigonia sagawai* (Yehara, 1927) and the species *N. furukawensis* considered a junior synonym of *N. sagawai.*

Because of its ovately trigonal shell form, the specimens are different from the illustrated specimens of *Nipponitrigonia kikuchiana* (Yokoyama, 1891, p.363-365, pl.40, figs.4-6) from Tanono, Kamikatsu-town, Tokushima Prefecture. Incidentally, Yokoyama (1891) described the type locality of *Nipponitrigonia kikuchiana* as "Tanno;", this locality is now mapped as the Hoji Formation, but Yehara (1924) used "Tannono" on his geological map of the area (Yehara, 1924, pl.18).

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Genus *Vaugonia* Crickmay, 1930
Subgenus *Vaugonia* Cox et al. 1969

Vaugonia (*Vaugonia*) *yambarensis* Kobayashi, 1956

1956 *Vaugonia yambarensis*; Kobayashi, p.1,2, pl.1, figs.1a,b.
1963 *Vaugonia ariminensis*; Maeda and Kawabe, p.57, pl.1, fig.1.

Table 12. Comparison of width between costae of species *Nipponitrigonia* (Kobayashi, 1957; Maeda, 1962a; The present study).

Taxa	Reference	Registered number	Length (mm)	Height (mm)	← umbonal area inter-space of between costae (mm) ventral area →									
					1	2	3	4	5	6	7	8	9	*average*
Nipponitrigonia sagawai	Kobayashi (1957)	pl.10, fig.5	30.17	28.85	1.9	1.5	1.5	1.5	1.5	1.5	1.6	1.9	2.2	***1.7***
		pl.10, fig.6	30.15	23.71	1.1	1.1	1.2	1.3	1.5	1.2	1.6	-	-	***1.3***
	Maeda (1962a)	pl.1, fig.1	15	10+	0.9	0.9	0.9	1.3	1.5	1.0	-	-	-	***1.1***
Nipponitrigonia kobayashii	Maeda (1962a)	pl.2, fig.4	23	16	1.2	1.2	1.4	1.8	2.2	1.8	1.9	-	-	***1.7***
		pl.2, fig.12	36	24+	1.6	1.4	1.7	2.1	1.5	2.0	2.1	-	-	***1.8***
Nipponitrigonia sagawai	This study	KIK0317	15.37	12.54	1.2	1.7	-	-	-	-	-	-	-	***1.5***
		KIK0400b	12.58	9.7	1.1	1.3	1.9	-	-	-	-	-	-	***1.5***
		KIK0411	17.92	11.88+	1.1	1.0	1.2	1.6	-	-	-	-	-	***1.2***
		KIK0412a	20.27	15.27	0.9	1.0	1.0	1.5	1.6	-	-	-	-	***1.1***
		KIK0412b	-	-	0.9	1.1	1.3	1.6	1.9	2.1	-	-	-	***1.2***
		KIK0412d	9.54+	9.02	0.6	0.8	-	-	-	-	-	-	-	***1.5***
		KIK0412e	9.74	8.84	0.7	0.8	1.0	1.3	1.5	-	-	-	-	***0.7***
		KIK0418	11.56+	10.63+	0.7	0.8	1.1	1.7	-	-	-	-	-	***1.0***

1975 *Vaugonia* (*Vaugonia*) *yambarensis*; Hayami, p.108.

Remarks. Kobayashi (1956) identified two specimens from Yambra, Izumi area, Ono City, Fukui Prefecture, in the Yambra Formation, as *Vaugonia yambarensis*. Then, Maeda and Kawabe (1963) identified one small specimen from Inonedani, Arinie area, Toyama City, Toyama Prefecture, in the Magawa sandstone and conglomerate [=Magawa Formation of Matsukawa et al. (2014a)] as *Vaugonia ariminensis* sp. nov. However, based on shell size, subovate outline, and number of costae, the specimen identified as *V. ariminensis* should be assigned to *V. yambarensis*. Afterward, Hayami (1975) classified the species to belong to the subgenus *Vaugonia* without reason. Based on Cox et al. (1969), the genus *Vaugonia* has two subgenera, *Vaugonia* and *Orthotrigonia*. Because of the costae on its late growth shell, the present material belongs to the subgenus *Vaugonia*.

Occurrence. Yambara Formation.

Vaugonia (*Vaugonia*) cf. *yambarensis* Kobayashi, 1956

Fig. 19 J

Material. A single specimen, KIK0023 from Todani, Toyama City, Toyama Prefecture, Japan. The specimen is an external mold of a left valve, which lacks one-third of shell in postero-dorsal area. The specimen is kept at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture (M. Wakabayashi Coll.).

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
KIK 0023	23.3+	25.5+	11.4	-

Description. Shell medium size, strongly inequilateral, posterior margin curved, strongly convex; distinct marginal carina, slightly arcuate; area marked with numerous costellae; disk ornamented with tiny tuberculate costae (not less than 9 costae), four costae tending in the direction of the dorsal area forming a V-shape, others nearly straight.

Remarks. Since the present specimen is characterized by V-shaped costae which persist to late growth stage, it belongs to the subgenus *Vaugonia*, as defined by Cox et al. (1969). The present specimen is similar to the illustrated specimens of *Vaugonia yambarensis* (Kobayashi, 1956, p.1-2, pl.1, figs.1a-b) from the Yambara conglomeratic sandstone [Yambara Formation of Matsukawa et al. (2006)], Tetori Group, Kuzuryugawa region, Fukui Prefecture, Japan, in having a V-shaped tuberculate costae, arcuate slender marginal carina, and enlarged posterior area. However, the present specimen lacks dorsal and posterior areas, so the specimen is identified as *Vaugonia* (*V.*) cf. *yambarensis*.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Vaugonia (*Vaugonia*) *fukuiensis* Maeda, 1962

1962d *Vaugonia fukuiensis*; Maeda, p.515, 516, pl.1, figs.1-16.

1975 *Vaugonia* (*Vaugonia*) *fukuiensis*; Hayami, p.108.

Remarks. Maeda (1962d) identified 23 specimens from Aradani, Nishidani area, Ono City, Fukui Prefecure, in the Yambarazaka Formation, as *Vaugonia fukuiensis*. Afterward, Hayami (1975) assigned the species to belong to the subgenus *Vaugonia* without proriding reasons.

Occurrence. Callovian Yambarazaka Formation.

Vaugonia (*Vaugonia*) *kuzuryueneis* Maeda, 1963

1963 *Vaugonia kuzuryueneis*; Maeda, p.5, 6, pl.1, fig.10.

Remarks. Maeda (1963) identified a sinlge fragmentary specimen from Taniyama-dani, Izumi area, Ono City, Fukui Prefecture, in the Yamabarazaka Formation [=Kaizara Formation in Matsukawa and Asahara (2010)], as *Vaugonia kuzuryueneis* sp. nov. Because of costae on the late growth shell, this species belongs to subgenus *Vaugonia*. The species differs from *Vaugonia* (*V.*) *fukuiensis* in having an obtuse angle of the costae on the disc.

Occurrence. Kaizara Formation.

Family Trigonioididae Cox, 1952

Genus *Trigonioides* Kobayashi and Suzuki, 1936

Trigonioides (*Wakinoa*) *tetoriensis* Maeda, 1963

Fig. 28 A - X

1963 *Trigonioides tetoriensis*; Maeda, p.81-83, pl.12, figs.1-9.

1963 *Trigonioides kitadaniensis*; Maeda, p.83-85, pl.12, figs.10-16.

1970 *Wakinoa tetoriensis*; Tamura, pl.1, figs. 9-14.

1993 *Trigonioides* (*Wakinoa*) *tetoriensis*; Matsukawa and Ido, fig.3 g.

2009 *Trigonioides* (*Wakinoa*) *tetoriensis*; Matsuura, pl.2-7, fig.36.

Material. 17 specimens from the Okurodani Formation at localities M36 (KT001) (TGUSE-MM7558, -MM7561, -MM7566), M35 (KT002) (TGUSE-MM7553 to -MM7557, -MM7559, -MM7560, -MM7562, -MM7563, -MM7565, -MM7567), and 4 (KT003) (TGUSE-MM7564, -MM7610, -MM7611), Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan. All specimens collected by M. Matsukawa and K. Ido. They consist of six external casts of left valves, nine external casts of right valves, and two external casts of articulated valves.

Measurements (in mm excepts for L/H)

Specimen	L	H	T	L/H	T/L
TGUSE-MM7553	38.3	28.6	9.9	1.34	0.26
TGUSE-MM7554	37.3	27.4	10.3	1.36	0.28
TGUSE-MM7555	34.0	24.5	8.6	1.39	0.25
TGUSE-MM7557	33.6	26.5	8.1	1.27	0.24
TGUSE-MM7558	31.3	22.8	8.9	1.37	0.28
TGUSE-MM7562	34.6	26.3	9.9	1.32	-
TGUSE-MM7563	20.2	15.4	6.8	1.31	0.28
TGUSE-MM7565	29.5	22.5	7.6	1.31	0.34
TGUSE-MM7566	31.1	25.8	6.3	1.21	0.26

Description. Shell medium size, subtrigonal form, equivalve, inequilateral; strongly convex, ratio of shell length to thickness (T/L) ranging from 0.20 to 0.34 (average = 0.26); posterior ridge prominent, nearly rectilinear, running from near bottom of umbo to postero-ventral corner; umbo large, round, slightly prosogyrate, located at about two-fifths distance from anterior end; surface of ventral area marked with concentric ribs, anterior area impressed by about five reversed V-shaped ribs from umbonal area to center of ventral margin, embossed by about six V-shaped sculptures, the angle of V-shaped ribs varying from 10 to 20 degrees at center area; postero-ventral corner area decorated with about seven reversed V-shaped ribs; hinge plate wide, dental formula as follows: *4 2 1' PⅡ PⅣ / 5 3 1 PⅠ PⅢ* ; 4 elongate, arcuate, crenulated on anterior side; 2 strong, elongate, slightly arcuate, crenulate on anterior and posterior sides; 1' adjoining 2, few vertical crenulations; PⅡ long, slightly arcuate, crenulated; PⅣ very long and narrow, a little arcuate, crenulated; 5 strong, ridge-like, elongate, crenulated; 3 elongate, crenulated; 1 adjoining 3, few vertical crenulations; PⅠ very long, narrow, slightly arcuate, crenulated; PⅢ along margin of shell, narrow, shorter than PI; internal surface very smooth, pallial line smooth, anterior and posterior adductor scars almost same size, anterior one with trigonal form, posterior one with subtrigonal form, short radial oblique ribs along ventral margin.

Remarks. The specimens are characterized by V-shaped ornamentation of the surface and crenulated strong lateral teeth. These shapes are confirmed in the types of both *Trigonioides tetoriensis* (Maeda, 1963, p.81-83, pl.12, figs.1-9) and *T. kitadaniensis* (Maeda, 1963, p.83-85, pl.12, figs.10-16), both from Okurodani Formation, Tetori Group, Kitadani, Katsuyama City, Fukui Prefecture, Japan; Maeda (1963) described those as distinct species based on the differences in the ratio of shell length to height (L/H). The values of L/H for *Trigonioides tetoriensis* (Maeda, 1963) range from 1.43 to 1.50 (average = 1.46; N = 2) while for *Trigonioides kitadaniensis* (Maeda, 1963) they vary from 1.37 to 2.00 (average = 1.57; N = 6); the values of L/H of *Trigonioides kitadaniensis* thus fall within the range of values for *Trigonioides tetoriensis*. The values of L/H of the present topotype specimens range from 1.21 to 1.50 (average = 1.34; N = 15). Based on these values of L/H, the present specimens fall within the range of both *Trigonioides tetoriensis* and *Trigonioides kitadaniensis*, so the L/H values of ratio of all specimens from Kitadani, including Maeda's and ours, range from 1.37 to 2.00. This means that all of these specimens must belong to the same species. Based on the International Code of Zoological Nomenclature (Article 24), *Trigonioides kitadaniensis* should thus be regarded as a junior synonym of *T. tetoriensis*. Hayami (1975) incorporated *Trigonioides kitadaniensis* as a junior synonym of *Trigonioides* (*Wakinoa*) *tetoriensis*, but did not provide a reason. We follow Hayami (1975) in assigning the specimens to *Trigonioides* (*Wakinoa*) *tetoriensis*.

Comparison. The present specimens are different from the illustrated specimens of *Trigonioides* (*Wakinoa*) *wakinoensis wakinoensis* (Ota, 1959, p.107, pl.11, figs.1-7)

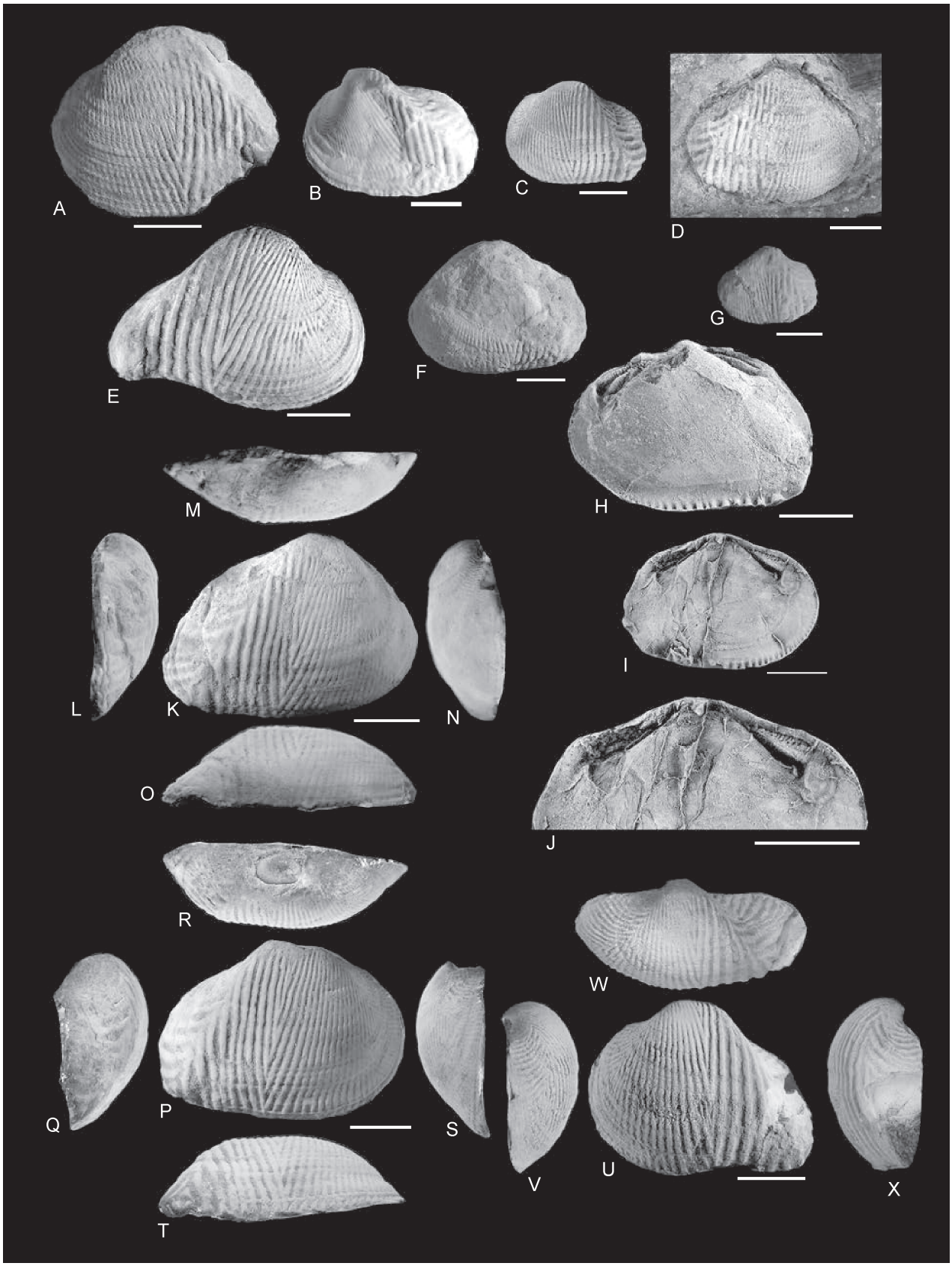

Fig.28. A-X, *Trigonioides* (*Wakinoa*) *tetoriensis* Maeda; A, TGUSE-MM7561, external cast of articulated valves, Okurodani Formation (loc. M36 (KT001)); B, TGUSE-MM7557, external cast of left valve, Okurodani Formation (loc. M35 (KT002)); C, TGUSE-MM7610, external cast of left valve, Okurodani Formation (loc. 4 (KT003)); D, TGUSE-MM7566, external cast of right valve, Okurodani Formation (loc. M36 (KT001)); E, TGUSE-MM7611, external cast of left valve, Okurodani Formation (loc. 4 (KT003)); F, TGUSE-MM7562, external cast of left valve, Okurodani Formation (loc. M35 (KT002)); G, TGUSE-MM7563, external cast of right valve, Okurodani Formation (loc. M35 (KT002)); H, TGUSE-MM7558, internal cast of left valve, Okurodani Formation (loc. M36 (KT001)); I,J, TGUSE-MM7557, internal cast of left valve, Okurodani Formation (loc. M35 (KT002)); I, left view; J, hinge structure; K-O, TGUSE-MM7554, external cast of right valve, Okurodani Formation (loc. M35 (KT002)); K, right view; L, posterior view; M, upper view; N, anterior view; O, ventral view; P-T, TGUSE-MM7553, external cast of right valve, Okurodani Formation (loc. M35 (KT002)); P, right view; Q, posterior view; R, upper view; S, anterior view; T, ventral view; U-X, TGUSE-MM7564, external cast of left valve, Okurodani Formation (loc. 4 (KT003)); U, right view; V, anterior view; W, upper view; X, posterior view. Scale bars show 1 cm.

from the Lower Cretaceous Wakino Formation, Rikimaru, Miyawaka City (the former Wakamiya-machi), Fukuoka Prefecture, as the former is characterized by a subtrigonal shell outline (average of L/H 1.34; N = 11), while the latter is characterized by a subquadrate one (L/H 2.14; the value from Ota, 1959, pl.11, fig.1, holotype). The present specimens also differ from the illustrated specimens of *Trigonioides* (*Wakinoa*) *wakinoensis intermedius* (Hase, 1960, p.316, pl.37, figs.5-9, pl.38, figs.2, 3), from the Lower Cretaceous Wakamiya Formation, Kwanmon Group, Takibe area, Yamaguchi Prefecture, Japan, in that the former has several V-shaped ribs from the umbonal area to the ventral margin, and a subtrigonal form, while the latter has about two V-shaped ribs, in the umbonal area only, as well as a subquadrate shell outline.

Occurrence. Mudstone beds of the Okurodani Formation at localities M36 (KT001), M35 (KT002), and 4 (KT003), Kitadani, along Sugiyamagawa River, Katsuyama City, Fukui Prefecture, Japan.

Subclass Heterodonta Neumayr, 1884
Order Veneroida H. Adams and A. Adams, 1856
Superfamily Luciniacea Fleming, 1828
Family Fimbriidae Nicol, 1950
Genus *Fimbria* Megerle von Mühlfeld, 1811

Fimbria sp.

Fig. 19 K, L

Material. Five specimens (KIK0025, -0420 to -0423) from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. These consist of three internal casts of right valves, a single external cast of a right valve, and a single external cast of a left valve (T. Hamuro Coll.). All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK 0025	27.2+	22.6+	6.1	-	146
KIK 0422	13.9	10.6	1.8	1.31	130
KIK 0423	24.6	17.4	4.4	1.42	140

Description. Shell medium size, transversely elliptical form, subequilateral, shell length greater than height, moderately convex; test very thick; umbo a little prosogyrous; two cardinal and a lateral teeth on right valve (A Ⅲ, 3a, 3b), posterior lateral tooth remote; surface ornamented with concentric growth lines and weak radial ribs, forming reticulate sculpture; inner ventral margin crenulate.

Remarks. The present specimens are similar to the illustrated specimens of *Fimbria somensis* (Hayami, 1961, p.120-121, pl.16, figs.11-13) from the Middle Jurassic Yamagami Formation, Soma City, Fukushima Prefecture, in having a subovate shell form, concentric ribs, and lucinoid denticles. However, the thickness of the test of the present specimens is greater than that of the specimens of *Fimbria somensis*.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Order Veneroida H.Adams and A.Adams, 1856
Superfamily Cardiacea Lamarck, 1809
Family Cardiidae Lamarck, 1809
Subfamily Protocardiinae Keen, 1951
Genus *Protocardia* von Beyrich, 1845

Protocardia sp.

Fig. 19 M-U

Material. 12 specimens (TGUSE-MM7792 to -MM7803) from locality Mg01, consisting of four internal casts of left valves, six internal casts of right valves, and two internal casts of articulated valves (K. Suzuki, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.)

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7792	8.5	8.4	2.8	1.02
TGUSE-MM7793	15.2	10.3	3.9	1.48
TGUSE-MM7794	9.9	7.7	3.0	1.29
TGUSE-MM7795	8.0	6.3	2.4	1.28
TGUSE-MM7796	9.5	8.3	2.3	1.15
TGUSE-MM7798	14.2	12.2	4.3	1.17
TGUSE-MM7799	6.0	4.1	1.7	1.46
TGUSE-MM7801	9.5	7.3	-	1.31
TGUSE-MM7802	3.8	3.2	1.1	1.21
TGUSE-MM7803	6.1	5.1	0.8	1.19

Description. Shell very small size, equivalve, inequilateral, subtrianglar in outline, faintly carinate in posterior part, longer than high, strong inflated, test thin; posterior margin obliquely truncated; umbo prominent, prosogyrate, and positioned centrally; posterior area obscurely delimited from disk, fairly concave; surface ornamented with numerous fine concentric ribs and weak and sparse radial ribs; adductor scars subequal in size, subelliptical; pallial line entire with small sinus at posterior adductor scar.

Remarks. Because of the prosogyrate and central umbo, carinate posterior area, and their radial and concentric ribs at posterior area and disk, the specimens belong to the genus *Protocardia* (Cox et al., 1969). The illustrated specimens of *Protocardia* (*P.*) *kurumensis* (Hayami, 1958, p.194-195, pl.28, figs.5-8), from the Lower Jurassic Kuruma Group, are characterized by stout radial and concentric ribs on their surface and fine crenulations in the posterior part of the inner ventral margin, whereas the radial concentric ribs of the present specimens are weak and crenulation in the posterior part of the inner ventral margin is not confirmed. The illustrated specimens of *Protocardia morii* (Hayami, 1960b, p.17-20, pl.3, figs.11-15), from the Jurassic-Cretaceous transitional Tategami Formation of the Jusanhama Group, Japan, differ from the present specimens in their suborbicular in outline and distinctly numerous concentric ribs with radial riblets. The present specimens are different from the illustrated specimens of the *Protocardia hiraigaensis* (Hayami, 1965, p.119-120, pl.15, figs.8-10), from the Aptian Hiraiga Formation of the Miyako Group, in that they have a trigonal outline, while that of *P. hiraigaensis* is suborbicular.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine in Toyama Prefecture, Japan.

Protocardia ? sp.

1959b *Protocardia* sp.; Hayami, p.158, pl.13, fig.11.

Remarks. Hayami (1959b) identified seven specimens from Mitarai, Shokawa area, Takayama City, Gifu Prefecture, in the Mitarai Formation, as *Protocardia* sp. Based on Cox et al. (1969), the genus *Protocardia* is defined by a posterior slope with radial ribs and the remainder of shell with concentric ribs. However, the concentric ribs are not confirmed on our material due to poor preservation. so, we assign the present specimens to *Protocardia* ?

Superfamily Solenacea Lamarck, 1809
Family Cultellidae Davies, 1935

Cultellidae gen. et sp. indet.

Fig. 19 X, Y

Material. Three specimens (TGUSE-MM7343, -MM7804, -MM7805) collected from mudstone beds of the Izuki Formation at locality IZ04 (TGUSE-MM7343) and sandy mudstone beds of the Magawa Formation at locality Mg01 (TGUSE-MM7804 and 7805). These consist of a single external cast of articulated open valves, and two specimens of external casts of left valves (K. Suzuki, A. Ishitoya, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.).

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7343	-	-	-	-
TGUSE-MM7804	26.0	8.3	2.0	3.15
TGUSE-MM7805	14.9	5.0	1.4	2.98

Descriptive remarks. The specimens are characterized by a rectangular and compressed shell, with beak located at one-third distance from the anterior end. This suggests the specimens belong to the Family Cultellidae, as defined by Cox et al. (1969). Since the character of the strong internal ribs used for classification at the genus level is not seen, we can not discuss the infra-taxonomic level of these materials.

Occurrence. Mudstone beds of the Izuki Formation (IZ04) Itsuki, Ono City, Fukui Prefecture, Japan (Matsukawa and Ido, 1993) and muddy sandstone beds of the Middle Oxfordian Magawa Formation (Mg01) along Magawa River at Arimine area in Toyma Prefecture, Japan.

Superfamily Tellinacea de Blainville, 1814
Family Tancrediidae Meek, 1864
Genus *Tancredia* Lycett, 1850
Subgenus *Tancredia* Cox et al., 1969

Tancredia (*Tancredia*) sp.

Fig. 19 V, W

Material. Twelve specimens (KIK0016c, -0382j, -0383j, -0398, -0399a, -0399b, -0424a, -0424b, -0425, -0426a, -0426b, -0427 to -0429) from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. These consist of seven internal casts of left valves, three internal casts of right valves, a single external cast of a left valve, and a single external cast of a right valve (T. Hamuro Coll.). All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0016c	18.4	13.9	2.2	1.33	124
KIK0382j	18.2	12.2	1.6	1.49	120
KIK0399a	17.6	11.2	2.9	1.58	130
KIK0399b	20.2	15.7	6.4	1.29	126
KIK0424a	16.5	12.3	3.6	1.34	130
KIK0424b	17.0	11.4	2.6	1.50	148
KIK0425	20.3	13.2	2.2	1.54	126
KIK0426a	21.2+	14.4	3.9	1.47+	120
KIK0426b	21.9	15.6+	4.6	-	130
KIK0427	14.3	10.5	2.2	1.36	120
KIK0428	15.7	12.8	-	1.23	-
KIK0429	9.9+	8.2	-	1.22+	-

Description. Shell medium size, equivalve, very inequilateral, subtrigonal form, prosogyrate, anterior side elongate and subangular, posterior side truncated, length longer than height, ratio of shell length to height ranging from 1.23 to 1.58 (average = 1.41; N = 9); ridge running along the posterior slope; umbo located at about four-sevenths distance from anterior end; apical angle ranging from 120 to 148 degrees (average = 127.4 degrees; N = 10); surface marked with numerous very fine concentric growth lines; hinge formula consists of two small cardinal teeth on each valve, distinguishable posterior lateral teeth on each valve (*2 4b P Ⅱ /3a 3b P Ⅰ P Ⅲ*); pallial line without pallial sinus; two adductor scars forming suboval.

Remarks. Based on their more elongate shell length (L/H = 2.0) and one cardinal tooth on each valve, the present specimens differ from the illustrated specimen of *Tancredia rostrata* (Tamura, 1959, p.117, pl.12, fig.23), from the Upper Jurassic Sakamaoto Formation, Kumamoto Prefecture, Japan. The present specimens also differ from the illustrated specimen of *Tancredia* sp. (Gu et al., 1997, p.189, pl.26, figs.14,15), from the middle - lower part of the Yunshan Formation, Baoqing district, Heilongjiang Province, China, in their shorter shell length and untapering anterior end. The present specimens are also different from the illustrated specimens of *Tancredia* (*Paratancredia*) *latoniformis* (Hayami, 1972, p.207-208, pl.35, figs.5-7), from the Lower Jurassic Loc.2 of Lo-Duc, north-northeast of Ho Chi-Minh City (Saigon),Vietnam, in the location of the umbo and the apical angle. The location of the umbo on the former species is about four-sevenths of the shell length from the anterior end, and it possesses a sloping posterior ridge and wider apical angle (about 127.4 degrees), whereas in the latter species the location of the umbo is two-thirds distance of the shell length from the anterior end, and it lacks the posterior sloping ridge and has a narrower apical angle (about 105 degrees).

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Superfamily Arcticacea Newton, 1891
Family Arctidae Newton, 1891
Genus *Isocyprina* Röder, 1882

Isocyprina sp.

Fig. 19 Z

Material. Three specimens (KIK0027a, -0027c, -0414b), from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan, include a single internal cast and external mold of a right valve, and two internal casts of left valves (T. Hamuro Coll.). All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0027a	13.8	14.0	4.0	0.99	-
KIK0027c	14.9+	14.8	5.8	1.01+	120
KIK0414b	17.9+	16.9	6.4	1.06+	120

Description. Shell small, equivalve, inequilateral, trigonally suboval, well inflated with weak posterior carina;

umbo prominent, prosogyrate, located at nearly center of shell length; apical angle about 120 degrees; hinge formula *A Ⅱ 2 4b P Ⅱ / A Ⅲ A Ⅰ 3b P Ⅰ* (KIK0027c), 2 undifferentiated from A; surface ornamented with fine concentric growth lines; pallial line entire without pallial sinus; adductor muscle scars suboval and subequal.

Remarks. The present specimens are different from the illustrated specimens of *Isocyprina shizuhamensis* (Hayami, 1959e, p.67-68, pl.5, figs.29-31), from the Middle Jurassic Aratozaki Formation, Shizukawa area, Miyagi Prefecture, Japan, in having a well inflated shell and a prominent umbo. The ratio of shell length to thickness of the present specimens is 3.4, while in *Isocyprina sizuhamensis* it ranges from 5.4 to 5.8 (Hayami, 1959e).

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Family Neomiodontidae Casey, 1955
Genus *Crenotrapezium* Hayami, 1958

Crenotrapezium kobayashii (Maeda, 1959)

1959 *Polymesoda* (*Isodomella*) *kobayashii*; Meda, p. 158-159, pl. 17, fig.s 1-11.
1975 *Crenotrapezium* ? *kobayashii*; Hayami, p.141.

Remarks. Maeda (1959) identified specimens from Tochio, Kamitakara area, Takayama City, Gifu Prefectre, in the Tochio Formation (Matsukawa et al., 2007) as *Plymesoda* (*Isodomella*) *kobayashii* sp. nov. (Chiba University, not registered). Afterward, Hayamai (1975) classified the species as belonging to the genus *Crenotrapezium* without proriding reasoning. The cuniform outline of the specimen suggests that the specimens belong to the genus *Crenotrapezium.*

Subfamily Neomiodontinae Casey, 1955

Genus *Neomyrene* gen. nov.

Derivation of name. *Neo* and *Myrene* meaning new *Myrene*.

Remarks. Kobayashi and Suzuki (1937) identified specimens from the Tetori Group (Izuki Formation) as *Corbicula tetoriensis* based on the presence of three cardinal teeth and defined the specimen UMUT MM7014 as the paratype of the species. Subsequently, Suzuki and Oyama (1943) classified *C. tetoriensis* as *C.* (*Mesocorbicula*) *tetoriensis*, because the umbo of *C. tetoriensis* is different from the living *Corbicula leana* in having a prosogyrous form. Casey (1955) established the new genus *Myrene* for neomiodontids with dental formula *AI A Ⅲ 3a 3b 5b P Ⅰ / A0 A Ⅱ 2b 4b P0 P Ⅱ*. Ohta (1973) subsequently described the dental formula of the paratype of *C. tetoriensis* as *AI A Ⅲ 3a 3b 5b PI* (*P Ⅲ*) */ A0 A Ⅱ 2b 4b P0 P Ⅱ*, and he established the new subgenus *Mesocorbicula* under the genus *Myrene*, based on the specimens of *C.* (*M.*) *tetoriensis*. Ohta (1973) pointed out that these specimens have three cardinal teeth on the RV and two cardinal teeth on the LV, so they should belong to the genus *Myrene*. Although the genus *Myrene* (Casey, 1955) does not have a right lateral tooth P Ⅲ, Ohta (1973) assigned specimens having P Ⅲ to the genus *Myrene*, and he described the specimens UMUT MM7008 (holotype), UMUT MM7011 (paratype), GF. T65001to -T65003, -T65005, and -T65010 from the type locality Izuki Formation, and GF. T632, -T635, -T650, -T65030, and -T65031 from Yanagidani, Shiramine, Hakusan City, Ishikawa Prefecture (probably Kuwajima Formation) all as *Myrene* (*Mesocorbicula*) *tetoriensis* (Kobayashi and Suzuki). However, since these specimens all have the right lateral tooth, they can not be included in the genus *Myrene*. So, the specimens are suitable to be assigned to the new genus *Neomyrene*.

Neomyrene tetoriensis (Kobayashi and Suzuki, 1937)

Fig. 29 A-PP

Type specimen. Holotype (UMUT MM7008) housed at the University Museum, the University of Tokyo.

Type locality. Itsuki at Ono City, Fukui Prefecture, Japan.

1937 *Corbicula tetoriensis* Kobayashi and Suzuki, p.46, text-fig.2, pl.4, figs.7-15, pl.5, figs.1-7.
1937 *Corbicula amagasiraensis*; Kobayashi and Suzuki, p. 45-46, pl.5, figs.8-12.
1943 *Corbicula* (*Mesocorbicula*) *tetoriensis*; Suzuki and Oyama, p.143.
1973 *Myrene* (*Mesocorbicula*) *tetoriensis*; Ohta, p.260, pl.3, fig.18, pl.4, figs.1-12.
1973 *Neomiodon*? *amagasiraensis*; Ohta, p.264, pl.3, figs. 13-17.
1975 *Neomiodon*? *amagasiraensis*; Hayami, p.141.

1975 *Myrene* (*Mesocorbicula*) *tetoriensis*; Hayami, p.141, pl.8, fig.1.

1990 *Myrene* (*Mesocorbicula*) *tetoriensis*; Tamura, pl.12, figs.5-7.

1993 *Myrene* (*Mesocorbicula*) *tetoriensis*; Matsukawa and Ido, fig.3 k, l.

2006 *Myrene* (*Mesocorbicula*) *tetoriensis*; Matsukawa et al., p.214, fig.10.

2009 *Myrene* (*Mesocorbicula*) *tetoriensis*; Matsuura, pl.2-7, figs.23-31.

2013 *Myrene tetoriensis*; Nishida et al., p.242, Table 1, p.244, Table 2, p.244, fig.3A, B.

Type specimen. Holotype (UMUT MM7008) housed at the University Museum, the University of Tokyo.

Type locality. Itsuki at Ono City, Fukui Prefecture, Japan.

Material. UMUT MM 7008 (holotype; illustrated by Kobayashi and Suzuki, 1937, p.46-47, pl.4, figs.9a, 9b), from the Tetori Group (probably the Izuki Formation) in Itsuki, Ono City, Fukui Prefecture, Japan. About 900 specimens were collected from the Izuki Formation at localities IZ01, IZ02, IZ03, IZ04, IZ05, IZ06, IZ09, IZ10, and IZ13 (Itsuki, Ono City, Fukui Prefecture, Japan; from the Ushimaru Formation at localities US10A, US10D, and US10E (Makido, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999); from the Otaniyama Formation at localities OK19 (same locality as OT01; Matsukawa and Ido, 1993) and OK52A-F (OK19 upper of the Okurodani; Matsukawa and Ido, 1993, OK52 along Ogamigo river; Matsukawa et al., 1996,) Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Ido, 1993); from the Okurodani Formation at localities OK13, OK17, and OK22A (Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999); from the Kuwajima Formation at localities M18, M19, 9, M4, M2, M6, M5, and 44 (M18 and M19, Todani, Kuwajima, 9, M4, M2, M6, M5, and 44, Seto, Hakusan City, Ishikawa Prefecture, Japan; Matsukawa and Ido, 1993); from the Taie Formation at localities KR-01, KR-05, TE-01, ON-01, Heb-01, and SZ-01 (KR-01 and KR-05 Kurouchi, Inagoe District, TE-01, ON-01, and Heb-01, Taie, Furukawa District, Takayama City, Gifu Prefecture, Japan; Matsukawa and Fukui, 2009), and from muddy sandstone beds of the Amagodani Formation located at UT-1, UT-3, and TY-1 (Kannnondani, Ono City, Fukui Prefecture, Japan; Matsukawa and Asahara, 2010) and at OS10A, OS10D, OS10E1, OS10G, OS10H and OS14 (Oshirakawa, Hakusui Lake, Oshirakawa region, Shirakawa Village, Gifu Prefecture, Japan; Matsukawa et al., 1999). We selected 27 specimens for study from the Izuki Formation at localities IZ03 (TGUSE-MM5758, -MM5766, -MM5777, -MM5786, -MM5925, -MM5947, -MM5950, -MM7246, -MM7602, -MM7606), IZ05 (TGUSE-MM7131, -MM7327, -MM7371, -MM7375, -MM7379, -MM7381, -MM7385, -MM7409, -MM7412, -MM7605, -MM7640), IZ06 (TGUSE-MM5854), IZ09 (TGUSE-MM5742), and IZ10 (TGUSE-MM7650), as well as from the Okurodani Formation at locality OK13 (TGUSE-MM7636 to -MM7638). These consist of three external casts of left valves, seven external casts of right valves, 12 external casts of articulated valves, three internal casts of articulated valves, and two concretions with many specimens.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
TGUSE-MM5742	16.4	12.4	4.6	1.32	126
TGUSE-MM5758	26.7	22.1	8.5	1.20	96
TGUSE-MM5766	24.1	20.3	6.1	1.19	110
TGUSE-MM5777	20.5	17.9	7.4	1.15	94
TGUSE-MM5854	12.0	10.2	4.0	1.18	110
TGUSE-MM5925	27.6	22.6	7.8	1.22	100
TGUSE-MM5947	22.6	16.7	5.7	1.35	116
TGUSE-MM5950	28.1	21.3	5.7	1.32	108
TGUSE-MM7131	21.4	17.8	4.0	1.20	94
TGUSE-MM7246	20.3	15.7	6.9	1.30	104
TGUSE-MM7327	28.6	27.2	8.7	1.05	90
TGUSE-MM7371	27.8	21.2	7.6	1.31	106
TGUSE-MM7379	24.6	19.3	-	1.28	114
TGUSE-MM7381	30.0	22.8	8.6	1.32	106
TGUSE-MM7385	22.3	18.5	8.0	1.20	110
TGUSE-MM7409	29.4	24.3	-	1.21	110
TGUSE-MM7412	30.8	26.4	7.8	1.17	88
TGUSE-MM7602	23.8	18.1	7.9	1.31	100
TGUSE-MM7605	31.0	26.7	9.4	1.16	96
TGUSE-MM7606	19.9	15.2	6.7	1.31	108
TGUSE-MM7636	26.5	21.7	5.5	1.22	116
TGUSE-MM7637	29.8	25.4	7.2	1.17	110
TGUSE-MM7638	-	16.7	-	-	120
TGUSE-MM7640	23.5	20.3	7.7	1.16	106
TGUSE-MM7650	35.0	30.0	9.8	1.17	-

Description. Shell small, equivalve, inequilateral, subtrigonal shell form, moderately convex; anterior margin

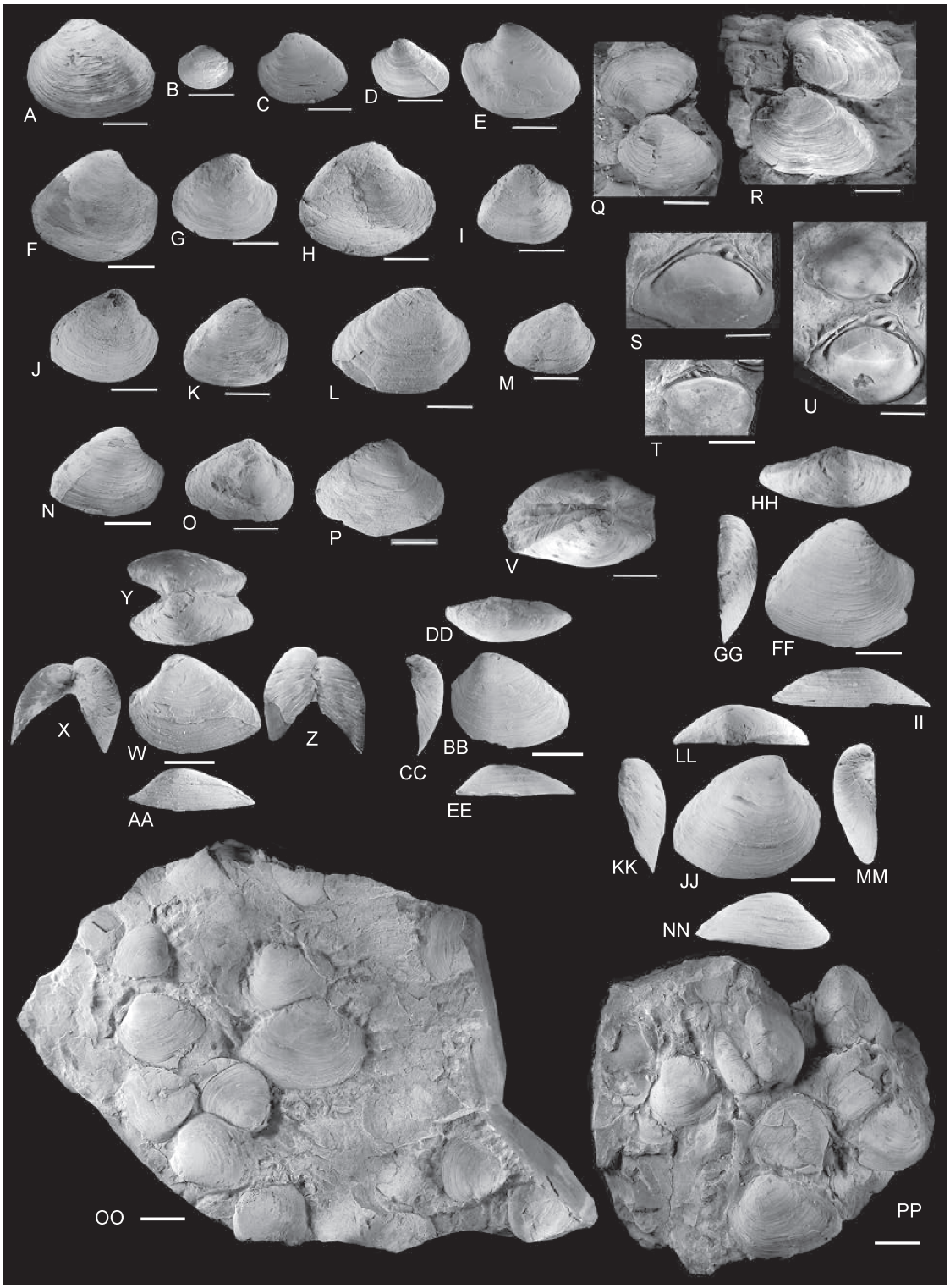

Fig.29. A-PP, *Neomyrene tetoriensis* (Kobayashi and Suzuki) gen. nov.; A, TGUSE-MM5925, external cast of left valve, Ushimaru Formation (loc. US10D); B, TGUSE-MM5854, external cast of articulated valves, Izuki Formation (loc. IZ06); C, TGUSE-MM7606, external cast of left valve, Formation (loc. IZ13); D, TGUSE-MM5742, external cast of articulated valves, Izuki Formation (loc. IZ09); E, UMUT MM7008, holotype, external cast of left valve, Izuki Formation; F, TGUSE-MM7327, external cast of articulated valves, Izuki Formation (loc. IZ04); G, TGUSE-MM7131, external cast of right valve, Izuki Formation (loc. IZ05); H, TGUSE-MM7409, external cast of articulated valves, Izuki Formation (loc. IZ05); I, TGUSE-MM5777, external cast of right valve, Izuki Formation (loc. IZ03); J, TGUSE-MM7385, external cast of articulated valves, Izuki Formation (loc. IZ05); K, TGUSE-MM5766, external cast of right valve, Izuki Formation (loc. IZ03); L, TGUSE-MM7381, external cast of right valve, Izuki Formation (loc. IZ05); M, TGUSE-MM7246, external cast of articulated valves, Izuki Formation (loc. IZ03); N, TGUSE-MM5758, external cast of right valve, Izuki Formation (loc. IZ03); O, TGUSE-MM7379, external cast of articulated valves, Izuki Formation (loc. IZ05); P, TGUSE-MM7371, external cast of articulated valves, Izuki Formation (loc. IZ05); Q, TGUSE-MM5947, external cast of articulated valves, Formation (loc. IZ03); R, TGUSE-MM5950, external cast of articulated valves, Izuki Formation (loc. IZ03); S, TGUSE-MM7637, internal cast of right valve, Okurodani Formation (loc. OK13); T, TGUSE-MM7638, internal cast of right valve, Okurodani Formation (loc. OK22); U, TGUSE-MM7636, internal cast of articulated valves, Okurodani Formation (loc. OK13); V, TGUSE-MM7650, external cast of articulated valves, Izuki Formation (loc. IZ10); W-AA, TGUSE-MM7602, external cast of articulated valves, Izuki Formation (loc. IZ03); W, left view; X, anterior view; Y, upper view; Z, posterior view; AA, ventral view; BB-EE, TGUSE-MM7640, external cast of left valve, Izuki Formation (loc. IZ05); BB, left view; CC, anterior view; DD, upper view; EE, ventral view; FF-II, TGUSE-MM7412, external cast of right valve, Izuki Formation (loc. IZ05); FF, right view; GG, posterior view; HH, upper view; II, ventral view; JJ-NN, TGUSE-MM7605, external cast of articulated valves, Izuki Formation (loc. IZ05); JJ, right view; KK, posterior view; LL, upper view; MM, anterior view; NN, ventral view; OO, TGUSE-MM7375, bedding plane accumulation of *Neomyrene tetoriensis* valves; PP, TGUSE-MM5786, bedding plane accumulation of *Neomyrene tetoriensis* valves. Scale bars show 1 cm.

round, ventral margin arcuate, posterior end slightly acute, postero-dorsal margin slightly round, faint marginal carina running from umbo to posterior end; surface smooth, marked with numerous fine concentric growth lines; test thin; prominent umbo, prothogyrate, located at about two-fifths of shell length from anterior end; dental formula (Fig. 30) *A Ⅰ A Ⅲ 3a 3b 5b P Ⅰ P Ⅲ / A0 A Ⅱ 2b 4b P0 P Ⅱ*; AI narrow, long and arcuate; A Ⅲ very thin, long and connecting to 3a; 3a small raindrop form and subparallel to anterior margin; 3b large stout, trigonal form, dorsal area connecting to 3a and located just below umbo; 5b weak, thin, arcuate and subparallel to posterior margin; P Ⅰ very narrow, long arcuate and little higher than P Ⅲ; P Ⅲ very long, thin, along posterior shell margin and subparallel with PI; A0 very thin, long, arcuate and along edge of hinge plate; A Ⅱ thin, long and subparallel with A0; 2 slender with subtrigonal form and subparallel to anterior margin; 4b stout, subtrigonal; P0 long, narrow and subparallel with P Ⅱ; P Ⅱ long, slightly arcuate; broad escutcheon, narrow lunule; anterior and posterior adductor muscle scars nearly same size, anterior one exhibiting subcircular, posterior one subtrigonal; pallial line smooth.

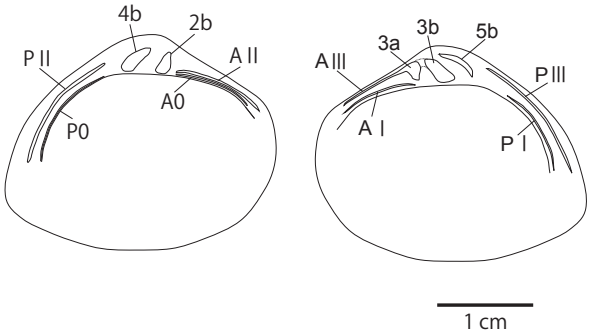

Fig.30. Dental formula of *Neomyrene tetoriensis* (Kobayashi and Suzuki) gen. nov. (TGUSE-MM7636).

Remarks. Kobayashi and Suzuki (1937) mentioned that the specimens from the Izuki Formation are variable in outline, and interpreted that the variation in shell outline is related to stage of growth, although they did not assess this relation quantitatively. Matsukawa and Ido (1993) discussed variation of shell form of *Myrene tetoriensis* from the Ushimaru, Otaniyama, Izuki, Okurodani, and Kuwajima formations of the Tetori Group and classified the wide shape-type as phenotype C and the tall shape-type as phenotype J. Living *Corbicula fluminea* in the Minho estuary of northwest Portugal exhibit significant variation in shell shape, including elongate, short, and rounded shell forms (Sousa et al., 2007); these are all classified in the same species based on genetic analysis. Zhou et al. (2011) showed that elongate forms of *C. fluminea* live in high flow-rate water currents in the Yellow, Huaihe, Hanshiui, Yangtze, and Xijiang rivers of China, while short and rounded forms of the species live in low flow-rate water currents. Thus, based on the study of recent *Corbicula fluminea*, shell outline variation of *Neomyrene tetoriensis* was probably controlled by water current velocity. We similarly conclude that the various forms of *Neomyrene tetoriensis* are best classified as the same species.

Kobayashi and Suzuki (1937) identified small specimens from Amagashira-dani, Otani, former Kamianama-village, Izumi area, Ono City, Fukui Prefecture, in conglomerate sandstone of Amagashira as *Corbicula amagasiraensis*. Subsequently, Ohta (1973) classified the type specimens of *Corbicula amagasiraensis* as well as specimens from weathered conglomeratic sandstone of the Shimoanama Formation of the Kuzuryu Subgroup at loc. T501, Amagashira-dani, Nagano, Ono City, Fukui Prefecture, as *Neomiodon*? *amagasiraensis*. Since PIII is observed on specimen UMUT MM 07007e, and Ohta (1973) described that 5b is faintly observable on paratype UMUT MM 07007d, specimens described as *Corbicula amagasiraensis* can be classified as *Neomyrene tetoriensis*. Small specimens described as *Corbicula amagasiraensis* by Kobayashi and Suzuki (1937) probably represent the juvenile stage of the present species.

Ohta (1973) placed fossil locality T501 in the lower part of the Yambara Formation, although specimen described by Ohta (1973) came from the Shimoanama Formation of the Kuzuryu Subgroup. Based on Kawai et al. (1957), the Shimoanama Formation consists of the Kamiwakago, Kaizara and Yambarazaka members in ascending order, but there is no description of the Yambara Formation as a stratigraphic unit in the Shimoanama Formation. Concerning the Yambara Formation, Maeda (1961) divided the Itoshiro Subgroup into four units, the Yambara conglomerate, and the Ashidani, Obuchi, and Izuki formations in ascending order. Ohta (1973) placed locality T501 on his stratigraphic column (fig.2 in Ohta, 1973), referred from Maeda's (1961) stratigraphy. So, reference to the Shimoanama Formation of the Kuzuryu Group by Ohta (1973) is incorrect.

Occurrence. Mudstone of the Izuki Formation at

localities IZ01, IZ02, IZ03, IZ04, IZ05, IZ06, IZ09, IZ10, and IZ13 (Itsuki, Ono City, Fukui Prefecture, Japan; Matsukawa and Ido, 1993); Mudstone beds of the Ushimaru Formation at localities US10A, US10D, and US10E (Makido, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999); mudstone of the Numamachi Formation at locality KJ-02, Numamachi, Hida-Furukawa region (Matsukawa et al., 2007); medium-grained sandstone beds of the Otaniyama Formation at localities OK52C and OK19 (OK52C along the Ogamigo River; Matsukawa et al., 1996; OK19 upper part of the Okurodani Formation; Matsukawa and Ido, 1993), Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa et al., 1999); very fine-grained muddy sandstone beds of the Kuwajima Formation at localities M18 (same locality as KWJ-01), M19 (same locality as KWJ-02), 9 (same locality as KWJ-03), M4 (same locality as KWJ-04), M2 (same locality as KWJ-06), M6 (same locality as KWJ-10), M5 (same locality as KWJ-11), and 44 (same locality as KWJ-12) (M18 and M19, Kuwajima, 9, M4, M2, M6, M5, and 44, Seto, Hakusan City, Ishikawa Prefecture, Japan; Matsukawa et al., 2006; KWJ-01, KWJ-02, KWJ-03, KWJ-04, KWJ-06, KWJ-10, KWJ-11 and KWJ-12; Matsukawa and Ido, 1993); mudstone of the Okurodani Formation at localities OK13, OK17c, and OK22A (Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999), OS10A, OS10D, OS10E1, OS10G, OS10H and OS14 (Oshirakawa, Hakusui Lake, Oshirakawa region, Shirakawa Village, Gifu Prefecture, Japan; Mudstone of the Taie Formation at localities KR-01, KR-05, TE-01, ON-01, Heb-01 and Sz-01 (KR-01 and KR-05 Kurouchi, Inagoe District, TE-01, ON-01 and Heb-01 Taie, Furukawa District, Takayama City, Gifu Prefecture, Japan; Matsukawa and Fukui, 2009); and muddy sandstone beds of the Amagodani Formation located at UT-1, UT-3 and TY-1 (Kannondani, Ono City, Fukui Prefecture, Japan; Matsukawa and Asahara, 2010).

Superfamily Corbiculacea Gray, 1847
Family Corbiculide Gray, 1847
Genus *Tetoria* Kobayashi and Suzuki, 1937

Remarks. Kobayashi and Suzuki (1937) classified specimens from the Tetori Group (probably＝Taie Formation of Matsukawa and Fukui, 2009), at Kurouchi, Hida City, Gifu Prefecture, as *Batissa yokoyamai*, because some specimens have long lateral teeth and a smooth surface. Suzuki and Oyama (1943) revised *Batissa yokoyamai* and *B. antiqua* to *Corbicula* (*Tetoria*) *yokoyamai* and *C.* (*T.*) *antiqua*, respectively, because these taxa are characterized by a pallial sinus. Subsequently, Ota (1965) followed Suzuki and Oyama's (1943) opinion that the specimens classified as the genus *Batissa* have a deep pallial sinus, so they assigned these specimens to the new genus *Tetoria*, defined by radial threads (cracks) on the shell surface. However, the "radial threads" were subsequently determined by Hayami (1965) and Tamura (1977) to be cracks related to secondary deformation. In summary, Ota (1965) established to the two subgenera *Tetoria* and *Paracorbicula* under the genus *Tetoria* based on the idea that the former has radial threads while the latter does not; as the 'radial threads' are produced by secondary deformation, however, these subgeneric names are considered invalid.

Tetoria yokoyamai (Kobayashi and Suzuki, 1937)

Fig. 31 A-T

1937 *Batissa yokoyamai*; Kobayashi and Suzuki, p.44-45, pl.4, figs.3-6.
1943 *Corbicula* (*Tetoria*) *yokoyamai*; Suzuki and Oyama, p.141,147.
1965 *Tetoria* (*Tetoria*) *yokoyamai*; Ota, p.166-168.
1975 *Tetoria* (*Tetoria*) *yokoyamai*; Hayami, p.142, pl.8, fig.2.
1982 *Tetoria* (*Tetoria*) *yokoyamai*; Ohta, p.109, figs.5-10.
1990 *Tetoria yokoyamai*; Tamura, pl.12,figs.8,9.
1993 *Tetoria* (*Tetoria*) *yokoyamai*; Matsukawa and Ido, p.369, fig.3n.
2009 *Tetoria yokoyamai*; Matsuura, pl.2-7, figs.32-35.
2007 *Tetoria* (*Tetoria*) *yokoyamai*; Matsukawa et al., p.428, fig.6.10.

Material. UMUT MM 7004 (holotype), illustrated by Kobayashi and Suzuki (1937, p.44-45, pl.4, figs.3-6), from the Tetori Group [probably＝Taie Formation of Matsukawa and Fukui (2009)] in Kurouchi, Hida City, Gifu Prefecture. 134 specimens are housed in the Department of Environmental Science, Tokyo Gakugei University. They consist of 29 external casts of left valves, 26 external casts of right valves, 17 external casts of articulated valves, 24

internal casts of left valves, 24 internal casts of right valves, two internal casts of articulated valves, seven external molds of left valves, and five external molds of right valves (M. Matsukawa, K. Ido, K. Nakada, M. Fukui, T. Asahara, and K. Koarai Coll.) These specimens come from mudstone of the Izuki Formation at localities IZ03 (TGUSE-MM5381,-MM5382, -MM5384, -MM5387, -MM5396, -MM5404 to -MM5409), IZ04 (TGUSE-MM5317 to -MM5331, -MM5333, -MM5334, -MM5335a, -MM5335b, -MM5337, -MM5338a, -MM5338b, -MM5339 to –MM5347, -MM5348a, -MM5348b, -MM5378 to –MM5380, -MM7568 to -MM7590, -MM7593 to –MM7599), IZ05 (TGUSE-MM5332, -MM5386, -MM5393, -MM5413), IZ06 (TGUSE-MM5383, -MM5395, -MM5403, -MM5410, -MM5411), IZ10 (TGUSE-MM5394, -MM5414) and IZ13 (TGUSE-MM5336, -MM5385, -MM5388, -MM5389, -MM5391, -MM5392, -MM5397 to –MM5402, -MM5412, -MM5415, -MM5416, -MM5617a, -MM5617b, -MM5418), Itsuki, Ono City, Fukui Prefecture, Japan (Matsukawa and Ido, 1993); mudstone of the Ushimaru Formation at localities US10A (TGUSE-MM5354a, -MM5355c, -MM5359c, -MM5359d, -MM5360a, -MM5360b, -MM5360c, -MM5360d, -MM5360e, -MM5363a, -MM5363b, -MM5371a), US10D (TGUSE-MM5356, -MM5357b, -MM5358k), US10E (TGUSE-MM5368b), US21A (TGUSE-MM5370), US21B (TGUSE-MM5377), US21E (TGUSE-MM5369), US21L (TGUSE-MM5361a, -MM5361b, -MM5361c), US23 (TGUSE-MM5362a, -MM5362b), and US23L (TGUSE-MM5364, -MM5365, -MM5366a, -MM5366b, -MM5367, -MM5372, -MM5373a, -MM5373b, -MM5374, -MM5375, -MM5376a, -MM5376b), Makido, Takayama City, Gifu Prefecture, Japan (Matsukawa and Nakada, 1999); mudstone of the Okurodani Formation at localities OK11 (TGUSE-MM5316), OK13 (TGUSE-MM5554), OK17B (TGUSE-MM5313, -MM5314), OK21 (TGUSE-MM5315), and OK22 (TGUSE-MM5312) (OK11and OK17 Okurodani, OK21 and OK22 Kobudani, Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999); and mudstone of the Taie Formation at localities Heb-01 (TGUSE-MM5349, -MM5351, -MM5352), ON-01 (TGUSE-MM5350), and SZ-01 (TGUSE-MM5353), Furukawa District, Takayama City, Gifu Prefecture, Japan (Matsukawa and Fukui, 2009); muddy sandstone beds of the Amagodani Formation at locality UT-01 (TGUSE-MM5302 to -MM5311), Kannondani, Ono City, Fukui Prefecture, Japan (Matsukawa and Asahara, 2010).

Measurements (in mm except for L/H and Number of cracks)

Specimen	L	H	T	L/H	Number of cracks	
					radial	all
TGUSE-MM5320	41.8	39.5	8.3	1.06	7	17
TGUSE-MM5324	33.1	33.6	11.1	0.99	5	13
TGUSE-MM5330	33.9	34.0	8.6	1.00	2	4
TGUSE-MM5332	39.6	40.4	8.3	0.98	9	12
TGUSE-MM5334	29.6	32.6	7.4	0.91	2	2
TGUSE-MM5337	66.9	61.1	17.6	1.09	16	26
TGUSE-MM5339	39.0	36.7	9.1	1.06	5	7
TGUSE-MM5341	41.5	37.4	7.8	1.11	5	16
TGUSE-MM5342	38.8	38.5	11.7	1.01	1	12
TGUSE-MM5349	12.1	11.8	2.6	1.03	3	5
TGUSE-MM5378	61.3	57.9	12.5	1.06	5	29
TGUSE-MM5379	37.1	38.3	9.7	0.97	4	21
TGUSE-MM5380	34.4	35.6	8.8	0.96	0	3
TGUSE-MM5388	27.3	26.0	5.6	1.05	2	10
TGUSE-MM5389	20.8	19.9	4.1	1.04	1	4

Description. Shell medium to large, equivalve, subequilateral, suborbicular, moderately convex; umbo slightly prominent, orthogyrate, located at almost mid-point of shell length; surface smooth, ornamented with numerous fine concentric growth lines; test thick; dental formula *AⅡ 2a 2b 4b PⅡ/AⅢ AⅠ 3a 1 3b PⅠ PⅡ*; lateral teeth long, curved, posterior lateral teeth shorter than anterior teeth; anterior and posterior adductor muscle scars nearly same size, anterior one subcircular, posterior one subtriangular; pallial sinus fairly deep, wedge shaped, gradually narrowing.

Remarks. Because of their suborbicular shell form, fine concentric growth lines, very deep pallial sinus, and cyrenoid-type dentition, the present specimens belong to the genus *Tetoria*, as defined by Ota (1965). The specimens are further identified as *Tetoria yokoyamai* (Kobayashi and Suzuki; 1937, p.44-45, pl.4, figs.3-6) in having shells a little longer than high, and the umbo located at about the center of the shell length.

The present specimens differ from the holotype of *Tetoria yoshimoensis* (Ota, 1965, p.168-170, pl.12, figs.1-22, pl.13, figs.1-13), from the Lower Cretaceous Yoshimo Formation, Shimonoseki City, Yamaguchi Prefecture, because the latter is characterized by a prosogyrate umbo, thin test, with the umbo located at a point from the median to about one-third the distance from the anterior end. The

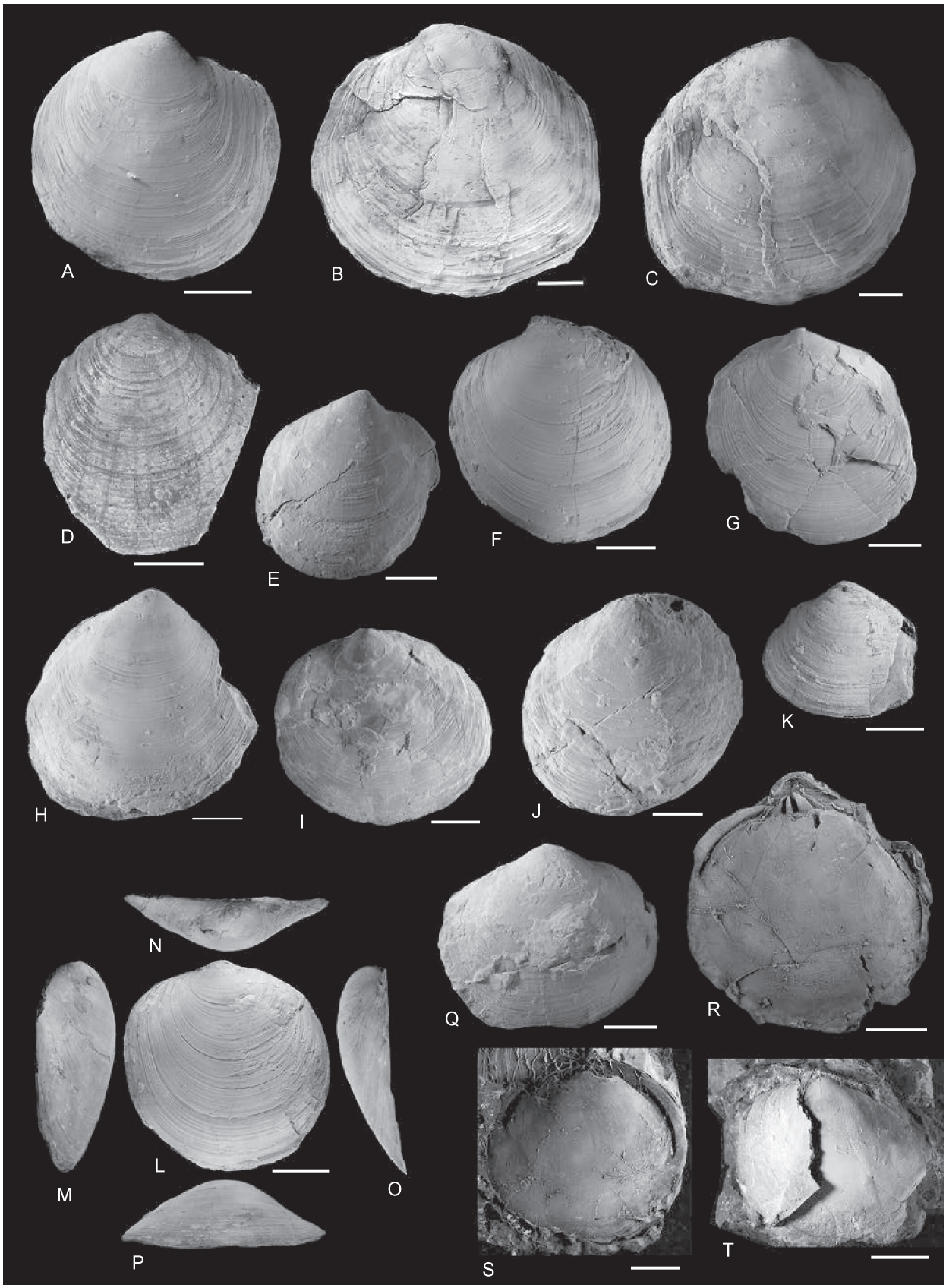

Fig.31. A-T, *Tetoria yokoyamai* (Kobayashi and Suzuki); A, TGUSE-MM5380, external cast of right valve, Formation (loc. IZ04); B,C, TGUSE-MM5378, external cast of articulated valves, Izuki Formation (loc. IZ04); B, left view; C, right view; D, UMUT MM7004, holotype, external cast of right valve, Kurouchi (probably=Taie Formation of Matsukawa and Fukui, 2009); E, TGUSE-MM7575, external cast of right valve, Izuki Formation (loc. IZ04); F, TGUSE-MM5379, external cast of left valve, Izuki Formation (loc. IZ04); G, TGUSE-MM7577, external cast of left valve, Izuki Formation (loc. IZ04); H, TGUSE-MM7589, external cast of right valve, Izuki Formation (loc. IZ04); I, TGUSE-MM7584, external cast of left valve, Izuki Formation (loc. IZ04); J, TGUSE-MM7585, external cast of right valve, Izuki Formation (loc. IZ04); K, TGUSE-MM5554, external cast of left valve, Okurodani Formation (loc. OK13); L-P, TGUSE-MM7594, external cast of right valve, Izuki Formation (loc. IZ04); L, left view; M, anterior view; N, upper view; O, posterior view; P, ventral view; Q, TGUSE-MM7572, external cast of right valve, Izuki Formation (loc. IZ04); R, TGUSE-MM7591, internal cast of left valve, Izuki Formation (loc. IZ05); S, TGUSE-MM5379, internal cast of left valve, Izuki Formation (loc. IZ04); T, TGUSE-MM5396, internal and partly external cast of left valve, Izuki Formation (loc. IZ03). Scale bars Show 1 cm.

present specimens differ from the illustrated specimens of *Tetoria sanchuensis* (Yabe et al., 1926, p.53, pl.12, figs.8-10, 17), from Lower Cretaceous Shiroi Formation, the Sanchu Cretaceous, Shiroi, Ueno Village, Gunma Prefecture, in that the latter is characterized by a trigonal ovate shell form, a prominent umbo, and strong convexity. The present specimens differ from the holotype of *Tetoria koshigoensis* (Ohta, 1982, p.112-113, pl.1, figs.11-19), from the Lower Cretaceous Upper Member of the Koshigoe Formation, Haidateyama Group, Koshigoe, Honjio, Saiki City, Ohita Prefecture, in having a more rounded shell, a smaller umbo, a thicker test, and a more centrally located umbo. Based on the shell form, the present specimens differ from the holotype of *Tetoria yatsushiroensis* (Ohta, 1982, p.115, pl.2, figs.1-6) from the Lower Cretaceous Yatsushiro Formation, Joguzan, Yatsushiro City, Kumamoto Prefecture, due to the latter's suborbicular shell form.

Maeda (1959) identified spescimens from Tochio, Kamitakara area, Takayama City, Gifu Prefecture in the Tochio Formation (Matsukawa et al., 2007)as *Paracorbicula sanchuensis*. Medium in shell size, subcircular in outline, with thick test, long lateral teeth, and deeply sinuate pallial line suggest the specimens can be identified as *Tetoria yokoyamai*.

Occurrence. Mudstone of the Izuki Formation at localities IZ04, IZ05, and IZ13 (Itsuki, Ono City, Fukui Prefecture, Japan; Matsukawa and Ido, 1993); Tithonian to Berriasian, mudstone of the Ushimaru Formation at localities US10A, US10D, US10E, US21A, US21B, US21E, US21L, and US23L (Makido, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999); Mudstone of the Okurodani Formation at localities OK11, OK13, OK17, OK21, and OK22 (OK11, OK13 and OK17 Okurodani, OK21 and OK22 Kobudani; Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999), OS10A, OS10D, OS10E1, OS10G, OS10H and OS14 (Oshirakawa, Lake Hakusui, Oshirakawa Region, Shirakawa Village, Gifu Prefecture, Japan; Matsukawa et al., 1999); Muddy sandstone beds of the Amagodani Formation located at UT-01 (Kannondani, Ono City, Fukui Prefecture, Japan; Matsukawa and Asahara, 2010).

Family Pisidiidae Gray, 1857
Genus *Sphaerium* Scopoli, 1777

Sphaerium coreanicum (Kobayashi and Suzuki, 1936)

Fig. 32 A-J

1936 *Corbicula* (*Leptesthes* ?) *coreanica*; Kobayashi and Suzuki, p.255-256, pl.29, figs.1-7.
1980 *Sphaerium coreanicum*; Ma, p.121, pl.5, figs.22,23,25, 29.
1984 *Sphaerium coreanicum*; Gu et al., p.170, pl.45, figs.17-19.
1990 *Sphaerium coreanicum*; Tamura, p.34-41, pl.13, figs.1-54, pl.14, figs.1-10, pl.15, figs.1-10, pl.16, figs.A,C,F,G,H,I.
1997 *Sphaerium coreanicum*; Gu et al., p.215-216, pl.32, figs. 16-18.

Material. 23 blocks (TGUSE-MM7612, -MM7613, -MM7615 to -MM7635), comprising many shells, are housed in the Department of Environmental Science, Tokyo Gakugei University. These blocks were collected from the Izuki Formation (IZ02), the Okurodani Formation (OK17, OK22B, OK31), and the Izuki Formation (IZ02). Most blocks comprise many specimens, about nine specimens per cm^2 at the surface. The total number of specimens can be estimated at approximately 1,600 specimens. Most of the specimens are overlapping, so only four external casts of left valves and eight external casts of right valves can be measured for shell length and height. All specimens were collected by M. Matsukawa and K. Ido.

Measurements (in mm except for L/H and D/L)

Specimen	L	H	D	L/H	D/L
TGUSE-MM7619a	4.5	3.5	2.2	1.31	0.50
TGUSE-MM7620a	5.1	4.0	2.1	1.29	0.41
TGUSE-MM7620b	6.0	3.9	3.2	1.54	0.53
TGUSE-MM7621a	4.7	3.1	2.0	1.53	0.42
TGUSE-MM7621b	4.8	2.7	2.3	1.80	0.48
TGUSE-MM7621c	4.8	3.6	2.3	1.34	0.48
TGUSE-MM7621d	5.8	4.4	2.4	1.30	0.42
TGUSE-MM7622a	4.3	3.1	2.7	1.41	0.63
TGUSE-MM7622b	5.1	2.9	2.4	1.73	0.48
TGUSE-MM7623a	6.2	5.5	3.1	1.12	0.49
TGUSE-MM7624a	4.1	2.5	2.0	1.62	0.49
TGUSE-MM7624b	4.5	2.8	2.3	1.63	0.51

Description. Shell very small (length ranging from 4.1 to 6.2 mm, average = 4.99 mm), equivalve, inequilateral, moderate convex, shell length longer than height, shell outline subelliptical, oval, subquadrate, or elongate

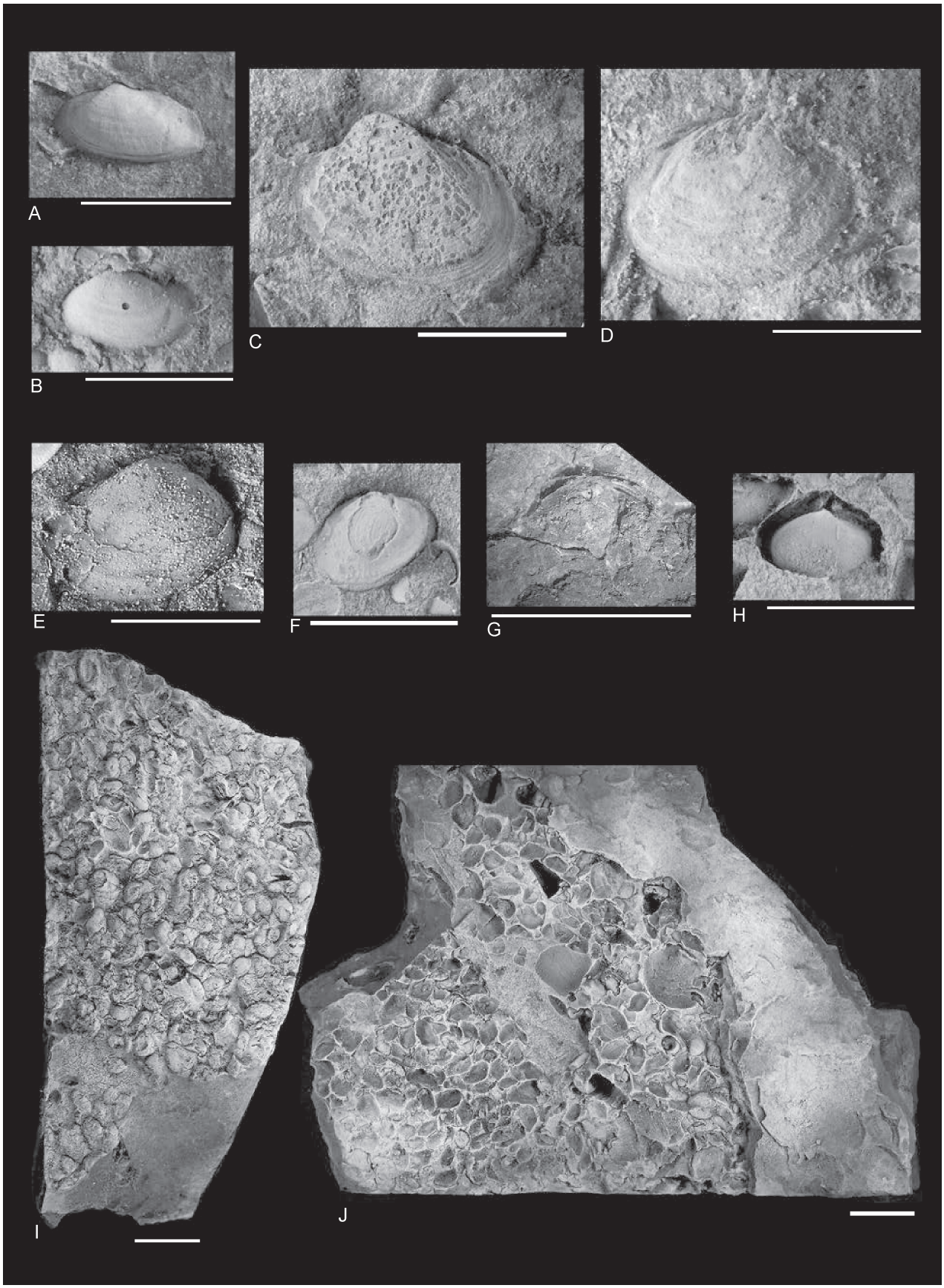

Fig.32. A-J, *Sphaerium coreanicum* Kobayashi and Suzuki; A, TGUSE-MM7622d, external cast of left valve, Okurodani Formation (loc. OK17B); B, TGUSE-MM7622a, external cast of right valve, Okurodani Formation (loc. OK17B); C, TGUSE-MM7630, external cast of left valve, Okurodani Formation (loc. OK31); D, TGUSE-MM7628, external cast of right valve, Okurodani Formation (loc. OK31); E, TGUSE-MM7621b, external cast of right valve, Okurodani Formation (loc. OK17B); F, TGUSE-MM7629a, external cast of right valve, Okurodani Formation (loc. OK17B); G, TGUSE-MM7624c, internal cast of right valve, Okurodani Formation (loc. OK17C); H, TGUSE-MM7619, internal cast of right valve, Okurodani Formation (loc. OK22); I, TGUSE-MM7624, bedding plane accumulation of *Sphaerium coreanicum* valves, Okurodani Formation (loc. OK17C); J, TGUSE-MM7635, bedding plane accumulation of *Sphaerium coreanicum* valves, Okurodani Formation (loc. OK13). Scale bars show A-H 5 mm, I and J 1 cm.

elliptical, wide range of variation in shell outline (L/H ranging from 1.12 to 1.80; average 1.47); umbo located at about mid-point of shell length (D/L ranging from 0.41 to 0.63; average 0.49), slightly prosgyrate, dental formula two cardinal teeth and two anterior lateral teeth on right valve (TGUSE-MM7619), probably two cardinal teeth on left valve, based on presence of two sockets on right valve, posterior lateral teeth on right valve and lateral teeth on left valve unconfirmed; surface very smooth, marked with fine concentric growth lines.

Comparison. Shell outline is highly variable in the present species. Specimens with an oval outline are similar to the illustrated specimens of *Sphaerium anderssoni* (Suzuki, 1943b, p.53-54, 62-63, pl.4, figs.1-4) from the Kongozan Formation, Husin Group, between Seikamon (Tsinghomen) and Reito (Lingtung), in the Husin coal field, northeast China. However, the present specimens are smaller than those of *Sphaerium anderssoni* (range of shell length is 13.0 to 14.5 in mm; shell height is 8.0 to 11.5 in mm). Although Hase (1960) established the two subgenera *Sphaerium anderssoni anderssoni* and *S. anderssoni jeholense* based on variations in shell form (elongate elliptical form for *S. anderssoni anderssoni* and subcircular form for *S. anderssoni jeholense*), these variations in shell outline are found in the species of Kobayashi and Suzuki (1936). So, classification of the species and subspecies on the basis of shell form can not be undertaken, and we are reluctant to classify specimens on this basis.

Hase (1960) described *Sphaerium anderssoni anderssoni* (p.319-321, pl.37, figs.12-15; pl.38, figs.4-8, 9-23) from the Sengoku Formation, Kwanmon Group, Wakino area, Fukuoka Prefecture; from the Nyoraida Formation, Kwanmon Group, Yurino area, Fukuoka Prefecture; from the lower and upper Wakamiya Formation, Kwanmon Group, Yurino and Kokura-Yahta areas, Fukuoka Prefecture, and the Shimonoseki, Toyonishi, and Asa areas, Yamaguchi Prefecture; from the Shiohama Formation, Kwanmon Group, Kokura-Yahata area, Fukuoka Prefecture; and from the Yamaji Shale of the Inakura Formation, Kwanmon Group, Inakura area, Okayama Prefecture. The specimens of the *Sphaerium anderssoni anderssoni* are characterized by large shell size (shell length: range from 6.5 to 19 mm, average = 10.0 mm; N = 25; shell height: range from 4 to 11 mm, average = 6.5 mm; N = 25) and inequilateral shell form with a well-rounded anterior margin and a broadly rounded or truncated posterior one. The present specimens are smaller than the specimens of *Sphaerium anderssoni anderssoni*.

Occurrence. Mudstone of the Izuki Formation at localities IZ02 (Itsuki, Ono City, Fukui Prefecture, Japan; Matsukawa and Ido, 1993); Mudstone beds of the Okurodani Formation at localities OK17 (Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999), OK22B (Kobudani, Shokawa, Takayama City, Gifu Prefecture, Japan; Matsukawa and Nakada, 1999).

Subclass Anomalodesmata Dall, 1889
Order Pholadomyoida Newell, 1965
Superfamily Pholodomyacea Gray, 1847
Family Pleuromyidae Dall, 1900
Genus *Pleuromya* Agassiz, 1842

Pleuromya ? sp.

Fig. 19 AA

Material. A single specimen (TGUSE-MM7806) was found from the locality Mg06. The specimen is an external cast of articulated valves. Part of the test remains at the anterior end (K. Suzuki, A. Ishitoya, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.)

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7806	23.4	14.4	3.2	1.63

Description. Shell medium size, inequilateral, trapeziform, transversely elongate, gently convex; shell length about twice the height; test very thin; umbo rising a little above the hinge line, located at two-fifths of the shell length from the anterior end; apical angle 125 degrees; surface marked with irregularly spaced concentric ribs.

Remarks. The present specimen is very similar to the specimens of *Pleuromya baoqingensis* (Matsukawa and Fukui, 2009, p.624, Fig.6, I-P) from the Lower Cretaceous Inagoe Formation, Japan, in having a transversely-elongate shell outline with the umbo situated toward the anterior end, and irregular concentric ribs. Because they have the umbo located at about the center of the shell length, the specimens of *Pleuromya baoqingensis* illustrated by Gu et al. (1997, p.233-234, pl.13, fig.21, pl.18, figs.1-3), from the

Lower Cretaceous Yunshan Formation of the Longzhaogou Group in eastern Heilongjiang Province, China, differ from the present specimens. Furthermore, the specimen at hand is a single valve, so we can not confirm the overlap of the right and left valves. Therefore, the specimen is tentatively identified as *Pleuromya* ? sp.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine area in Toyama Prefecture, Japan.

Superfamily Pandracea Rafinesque, 1815
Family Laternulidae Hedley, 1918
Genus *Cercomya* Agassiz, 1843
Subgenus *Cercomya* Agassiz, 1843

Cercomya (*Cercomya*) cf. *gurgitis* (Pictet and Campiche, 1865)

Fig. 27 K

Material. Seven specimens (TGUSE-MM7807to -MM7813) come from locality Mg01. They consist of four external casts of left valves, a single internal cast of a left valve, a single external cast of articulated valves, and a single external mold of articulated valves (K. Suzuki, A. Ishitoya, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.).

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7808	12.6+	06.7	2.2	1.89+
TGUSE-MM7811	19.7+	10.5	1.7	1.88+
TGUSE-MM7812	13.5	05.4	-	2.50

Description. Shell medium to small, equivalve, strongly inequilateral, nuculaniform, transversely elongate, slightly upcurved and tapering posterior end; moderately convex; apical angle about 140 degrees; umbo protruding minimally, opisthogyrate, located at two-thirds the distance from the posterior end; eventuate hinge; surface marked with strongly concentric folds, with fine growth lines between concentric folds.

Remarks. Because of their nuculaniform shape and slightly upcurved attenuating posterior end, the specimens belong to the genus *Cercomya*, as defined by Cox et al. (1969). Since the surface of the shells is ornamented by clearly concentric folds, the specimens are furthermore classified into the subgenus *Cercomya* of by Cox et al. (1969). The present specimens have a very inequilateral transversal-elongate form, tapering gradually posteriorly, and surface ornamentation, and these characters are the same as on the illustrated specimens of *Cercomya* (*Cercomya*) *gurgitis* (Pictet and Campiche) by Hayami (1966, p.166-167, pl.24, figs.8-10), from the Lower Cretaceous Hiraiga Formation, Miyako Group, Japan. However, the present specimens do not preserve all of the tapered posterior end, so they are identified as *Cercomya* (*Cercomya*) cf. *gurgitis* (Pictet and Campiche).

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine in Toyama Prefecture, Japan.

Subgenus *Capillimya* Crickmay, 1936

Cercomya (*Capillimya*) sp.

Fig. 27 L-P

Material. Five specimens (TGUSE-MM7814-7818) were collected from localities Mg01 and Mg05. They consist of an external cast and external mold of a left valve, three external casts of left valves, and a single external cast of articulated valves (K. Suzuki, A. Ishitoya, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.)

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7814	43.0	15.6	2.8	2.76
TGUSE-MM7815	-	27.8	10.4	-
TGUSE-MM7816	39.1+	23.3	4.2	1.68+
TGUSE-MM7818	40.8+	16.7	3.7	2.45+

Description. Shell medium size, subequivalve, inequilateral, transversely elongate, nuculaniform, moderately convex; test very thin; orthogyrate umbo situated at almost center of length, slightly protruding; apical angle about 135 degrees; very shallow furrow from under umbo to ventral margin; two strong keels on postero-dorsal corner; posterior margin with narrow gape; surface ornamented with concentric folds and faint radial striae on postero-ventral sector, this ornamentation forms subtle reticulate pattern, with numerous very fine growth lines spaced between concentric folds.

Remarks. Because of their elongate nuculaniform shape, narrow posterior gape, and reticulate ornamentation of concentric folds, the specimens are recognized as the genus *Cercomya*, as defined by Cox et al. (1969). In addition, the faint radial striae present in the postero-ventral sector indicate the specimens belong to the subgenus *Capillimya*, as defined by Crickmay (1936). The present specimens do not preserve the posterior margin, so we can not confirm the shape of the posterior area; consequently, the specimens are identified as *Cercomya* (*Capillimya*) sp. The present specimens are different from the illustrated specimen of *Cercomya* (*Capillimya*) *peruviana* Cox (Scholz et al., 2008, p.304, figs.6 D-F), from the Lower Jurassic Sierra de Santa Rosa Formation, northwestern Sonora, Mexico, in having an upcurved tapering posterior area. Because of their strong radial threads, the illustrated specimens of *Cercomya* (*Capillimya*) *peruviana* Cox, from the Middle Jurassic Rio Grande Formation, Nasca area, Peru (Cox, 1956, p.1185-1186, pl.128, fig.7), also differ from the present specimens.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine in Toyama Prefecture, Japan.

Family Thraciidae Stoliczka, 1870
Genus *Thracia* Sowerby, 1823

Thracia ? sp.

Fig. 27 Q

Material. A single specimen (KIK0414c) from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. The specimen is an internal cast of the right valve (T. Hamuro Coll.) and is housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
KIK 0414 c	23.5+	17.1	7.1	1.37+

Descriptive remarks. The specimen is a medium size shell, oblong, inequilateral, moderately convex, with shell length longer than height (L/H = 1.37+); posterior end broadly truncated; obtuse carina runs from umbo to postero-ventral area; hinge line nearly straight; umbo is submesial and a little opisthogyrate; hinge is edent. Because of the oblong shell outline, truncated posterior end, blunt carina from umbo to posterior margin, and edentulous hinge, the present specimen should be classified with the genus *Thracia* (Cox et al., 1969). However, the definitive characters of the genus *Thracia* – left valve larger than right valve and left valve overlapping the right valve (Cox et al., 1969) – can not be confirmed on the present specimen, so we classify it as the genus *Thracia* ?.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Order Unknown

Unio ? *ogamigoensis* Kobayashi and Suzuki, 1937

Fig. 22 CC

1937 *Unio ogamigoensis*; Kobayashi and Suzuki, p.41, pl.4, fig.16.

Material. UMUT MM7001 (holotype; illustrated by Kobayashi and Suzuki, 1937, p.41, pl.4, fig.16), from the Lower Cretaceous Okurodani Formation (Matsukawa et al. 2003a), Ogamigo, Shokawa area, Takayama City, Gifu Prefecture, Japan. The specimen is an almost complete external mold of articulated open valves, internal cast partly exposed and posterior area of RV lacking.

Description. Shell medium size (L=56mm, H=19mm), transversely oblong outline, equivalve, inequilateral, gently convex; anterior margin round, ventral margin nearly straight, posterior margin acute, postero-dorsal margin straight; umbo, located at about one-third from anterior end; surface smooth, marked with numerous fine concentric growth lines; hinge structures preserved incompletely on holotype, a single stout, short and oblique pseudocardinal tooth located along antero-dorsal margin, a lamellar tooth preserved only near the dorsal area on RV, hinge structures on LV unpreserved; anterior adductor scar oblong.

Remarks. The species is characterized by a transversally oblong outline, short pseudocardinal tooth and a single lateral tooth. Based on Fleming (1828), the genus *Unio* is defined by a crenulated cardinal tooth, elongates laminae tooth and transverse shell. The present species has a pseudocardinal tooth, but crenulated characters on the

pseudocardinal tooth are not confirmed. To date, only the type specimen of the species has been collected, although we tried to obtain additional topotype specimens. This rare occurrence probably reflects a rare species. We hesitate to assign the present specimen to the genus *Unio*, so, we treat it as *Unio* ? *ogamigoensis*. The present specimen is different from specimens of the *Archaeounio kagaensis* decribed above; the former is characterized by an elongate elliptical shell outline (L/H=3.0), while the latter is characterized by transversely, oval and subtrigonal shell outlines; values of L/H range from 1.11 to 2.36. The present species is different shell outline from *Cuneopsis kihongi* (Yang, 1984, p.17-20, pl.1, figs.1-22) from the Lower Cretaceous Myogog Formation, Nagdong Subgroup of the Gyongsang Group, South Korea, because the former species is transversely elongate, but the latter species is triangular in outline.

Occurrence. Okurodani Formation (Matsukawa et al., 2003a), Okurodani, Shokawa, Takayama City, Gifu Prefecture, Japan, horizon and locality are unknown.

Bivalvia gen. et sp. indet. A

Fig. 27 R

Material. Two specimens (KIK0433, -0434) from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. Both are external casts with about one-half of the shell remaining (T. Hamuro Coll.), and are only portions of the valves, so we are unable to assess whether these are the left or right valves. All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0433	22.4+	22.8+	-	-	-

Descriptive remarks. Small medium size, subovate form, moderately convex; surface marked with regular numerous fine concentric growth lines and faintly radial ribs; test thin. The present specimens are similar to the illustrated specimens of *Fimbria somensis* (Hayami, 1961, p.120-121, pl.16, figs.11-13), from the Middle Jurassic Yamagami Formation, Soma City, Fukushima Prefecture, in having a subovate shell form and concentric ribs. However, the thickness of the test of the present specimens is thinner than on specimens of *Fimbria somensis*. Furthermore, the present specimens' hinge formula is not preserved, so we classify them as Bivalvia gen. et sp. indet.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

Bivalve gen. et sp. indet. B

Fig. 27 S-W

Material. Six specimens (TGUSE-MM7819 to -MM7824) were found at locality Mg01. They consist of a single external mold of a left valve, three external molds of right valves, a single external cast of a right valve, and a single internal cast of a right valve (K. Suzuki, A. Ishitoya, Y. Fujimoto, M. Matsukawa, and K. Koarai Coll.).

Measurements (in mm except for L/H)

Specimen	L	H	T	L/H
TGUSE-MM7819	4.7	5.1	1.6	0.93
TGUSE-MM7820	20.4	19.6	3.8	1.04
TGUSE-MM7821	12.6	9.5+	3.2	-
TGUSE-MM7823	12.3+	11.0	4.1	1.11+
TGUSE-MM7824	4.5	5.6	1.8	0.81

Descriptive remarks. The specimens are characterized by very small shell, equivalve, inequilateral, subtrigonal ovate form, prominent umbo located at near the center of the shell length, narrow and short lunule, strong concentric ribs and very fine growth lines between concentric ribs, and weak lateral teeth. The specimens are very similar to the illustrated specimens of *Astarte* (*Trautscholdia*) *minor* Nagao (Hayami, 1965, p.91, pl.8, figs.19-22), from the Lower Cretaceous (Aptian) Hiraiga Formation, Japan, in having a very small and ovate shell, strong concentric ribs, and weak lateral teeth. However, since the character of the dentition for superfamily Crassatellacea is not observed in the present specimens, we are reluctant to discuss the precise taxonomic position of these materials.

Occurrence. Muddy sandstone beds of the Middle Oxfordian Magawa Formation along Magawa River at Arimine area in Toyma Prefecture, Japan.

Bivalvia gen. et sp. indet. C

Fig. 27 X

Material. Three specimens (KIK0430 to -0432) from Todani, Yatsuo area, Toyama City, Toyama Prefecture, Japan. They consist of a single external cast of a left valve, a single right valve, and a single internal mold of a left valve (T. Hamuro Coll.). All specimens are housed at the Kaiinkan (Yatsuo Fossil Museum), Toyama City, Toyama Prefecture.

Measurements (in mm except for L/H and Apical angle)

Specimen	L	H	T	L/H	Apical angle (°)
KIK0430	12.0	4.3	1.9	2.76	156
KIK0431	10.1	5.0	1.1	2.16	-

Descriptive remarks. The specimens are small shells, strongly inequilateral with very elongate transversally tapering form; ratio of shell length to height is 2.76 (KIK0430); postero-dorsal margin nearly straight, posterior end pointed; ventral margin arcuate; anterior margin curved, and antero-dorsal margin almost straight; obtuse linear ridge on posterior slope; test very thin; umbo round, located at about one-fourth distance of shell length from anterior end; apical angle 154 degrees (KIK0430); surface marked with fine concentric growth lines.

The present specimens are similar to the illustrated specimens of *Corbula* (*Cuneocorbula* ?) *longicostata* (Gu et al., 1997, p.221-222, pl.13, figs.8-14, 23-26), from the Lower Cretaceous Yunshan Formation, Baoqing district, China, in having a tapered shape and obtuse ridge on the posterior slope. However, as the character of the hinge structure for order Myoida type is not observed, we are unable to assess the precise taxonomic position of the specimens.

Occurrence. Sandstone beds of the Middle Oxfordian Kiritani Formation at Todani, tributary of Kubusugawa River at Yatsuo area, Toyama City in Toyama Prefecture, Japan.

III. The sum total of species described systematically from the Tetori Group

The upper Mesozoic Tetori Group of Japan yields rich assemblages of bivalve fossils suggestirg shallow marine, brackish water, and freshwater environments. About 80 years ago, Kobayashi and Suzuki (1937) described five bivalve species of the genera *Unio*, *Batissa* and *Corbicula* as well as three gastropod species from the "Tetori Series" (present Tetori Group) of Japan. Since then, Kobayashi (1954, 1956, 1957), Hayami (1959a, c, 1960a), Maeda (1959, 1962a, b, c, d, 1963), Maeda and Kawabe (1963, 1966), Ota (1973), Isaji (1993), Komatsu et al. (2003), and Matsukawa and Fukui (2009) have described 49 additional species of marine and nonmarine bivalves. In this contribution, we have systematically described 24 additional species, including two new species, from both the Middle Jurassic Kiritani and Magawa formations, and 8 species, including three new species and three new genera, from other formations of the Tetori Group, and have provided a systematic summay of all bivalve taxa known from the Tetori Group. As the result, 81 bivalve species are now known from the Tetori Group (Table 13). Among the 81 species, 65 belong to 30 genera of marine bivalves, and 16 belong to 13 genera of nonmarine bivalves. The great majority of the bivalve species are regarded as endemic species, the known distributions of which are restricted to Japan and its immediately adjacent areas of southeast Asia. Biostratigraphic durations of those species are almost always short, as constrained by three marine transgressions and regressions which are recorded in the Tetori Group (Fig. 33).

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Fig. 33. Biostratigraphic distribution of marine and nonmarine species from the Tetori Group.

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Table 13. List of bivalve taxa from the Tetori Group, Japan. Abbreviation in References; KS : Kobayashi and Suzuki (1937), K: Kobayashi (1956, 1957) and Kobayashi and Tamura (1955), MD: Maeda (1959, 1962, 1963), H: Hayami (1959a, b, 1960a), IG: Isaji (1993), KT: Komatsu et al. (2003), MF: Matsukawa and Fukui (2009), and No abbreviation: this paper.

	Superfamily	Family	Subfamily	Genus
1	Nuculacea Gray, 1824	Nuculidae Gray, 1824		*Palaeonucula* Quenstedt, 1930
2				
3				
4	Nuclanacea H. Adams and A. Adams, 1858	Milletiidae H. Adams and A. Adams, 1858		*Paleoneilo* Hall and Whitfield, 1869
5		Nuculanidae H. Adams and A. Adams, 1858		*Nuculana* Link, 1807
6				
7				
8	Solemyacea H. Adams and A. Adams, 1857	Solemyidae H. Adams and A. Adams, 1857		*Solemya* Lamarck, 1818
9	Mytilacea Rafinesque, 1815	Mytilidae Rafinesque, 1815	Mytilinae Rafinesque, 1815	*Mytilus* Linné, 1758
10				
11				*Brachidontes* Swainson, 1840
12			Modiolinae Keen, 1958	*Modiolus* Lamarck, 1799
13				
14				
15				
16	Pinnacea Leach, 1819	Pinnidae Leach, 1819		*Pinna* Linné, 1758
17				
18	Pteriacea Gray, 1847	Inoceramidae Giebel, 1852		*Inoceramus* Sowerby, 1814
19				
20				
21				
22				
23		Uncertain		
24		Oxytomidae Ichikawa, 1958		*Oxytoma* Meek, 1864
25				
26	Pectinacea Rafinesque, 1815	Entoliidae Korobkov, 1960		*Entolium* Meek, 1865
27		Pectinidae, Rafinesque, 1815		*Camptonectes* Agassiz in Meek, 1864
28				*Chlamys* Röding, 1798
29	Limacea Rafinesque, 1815	Limidae Rafinesque, 1815		
30				
31				
32	Ostreacea Rafinesque, 1815	Gryphaeidae Vyalov, 1936	Exogyrinae Vyalov, 1936	
33		Ostreidae Rafinesque, 1815	Ostreinae Rafinesque, 1815	
34	Arcticacea Newton, 1891	Arcticidae Newton, 1891		*Anisocardioides* Gu, 1984 (in Gu et al., 1984)
35	Unionacea Fleming, 1828	Unionidae Fleming, 1828	Unioninae Fleming, 1828	*Unio* Philipsson, 1788
36				
37				*Tetoriunio* gen. nov.
38				*Nagdongia* Yang, 1975
39				*Archaeounio* gen. nov.
40		Trigonioididae Cox, 1952		*Nippononaia* Suzuki, 1941
41				
42				*Plicatounio* Kobayashi and Suzuki, 1936
43			Hyriinae Ortmann, 1911	*Pseudohyria* MacNeil, 1936
44	Trigoniacea Lamarck, 1819	Trigoniidae Lamarck, 1819		*Latitrigonia* Kobayashi, 1957
45				
46				
47				
48				*Ibotrigonia* Kobayashi in Kobayashi and Tamura, 1957
49			Myophorellinae Kobayashi, 1954	*Myophorella* Bayle, 1878
50				
51				*Nipponitrigonia* Cox, 1952
52				*Vaugonia* Crickmay, 1930
53				
54				
55				
56		Trigonioididae Cox, 1952		*Trigonioides* Kobayashi and Suzuki, 1936
57	Luciniacea Fleming, 1828	Fimbriidae Nicol, 1950		*Fimbria* Megerle von Mühlfeld, 1811
58	Cradiacea Lamarck, 1809	Cardiidae Lamrck, 1809	Protocardiidae Keen, 1951	*Protocardia* von Beyrich, 1845
59				
60	Solenacea Lamarck, 1809	Cultellidae Davies, 1935		

Subgenus	Species	Ref.	Occurrence Formation in Japan		
	Palaeonucula makitoensis (Hayami, 1959)	**H**	Magawa Fm.	Mitarai Fm.	
	P. cf. *makitoensis* (Hayami, 1959)		Kititani Fm.		
	P. sp.	**H**	Mitarai Fm.		
	Paleoneilo ? sp.	**H**	Mitarai Fm.		
Nuculana Link, 1807	*Nuculana* (*Nuculana*) sp. A		Kiritani Fm.		
	N. (*N*.) sp. B		Kiritani Fm.		
Praesaccella Cox, 1940	*N*. (*Praesaccella*) sp.		Kiritani Fm.		
	Solemya suprajurensi s Hayami, 1959	**H**	Mitarai Fm.		
	Mytilus sp.		Kititani Fm.		
	M. ? sp.	**MF**	Inagoe Fm.		
	Brachidontes ? sp.	**H**	Mitarai Fm.		
Modiolus Lamarck, 1799	*Modiolus* (*Modiolus*) *magatama* Hayami, 1959		Magawa Fm.		
	M. (*M*.) *maedae* Hayami, 1959	**H**	Mitarai Fm.		
	M. (*M*.) *setiniae* Hayami, 1972		Magawa Fm.		
	M. (*M*.) *toyamensis* , sp. nov.		Magawa Fm.	Kiritani Fm.	
Pinna Linné, 1758	*Pinna* (*Pinna*) aff. *sandsfootensis* Arkell, 1933-1934	**H**	Miratai Fm.		
	P. (*P*.) *ariminensis* sp. nov		Magawa Fm.		
Inoceramus Sowerby, 1814	*Inoceramus* (*Inoceramus*) *maedae* Hayami, 1960	**H MF**	Mitarai Fm.	Izuki Fm.	
Mytiloides Brongniart, 1822	*I*. (*Mytiloides*) *hamadae* Hayami, 1960	**H**	Kaizara Fm.		
	I. (*M*. ?) sp.A		Kaizara Fm.		
	I. (*M*. ?) sp.B		Kiritani Fm.		
	I. ? *naganoensis* Hayami, 1960	**H**	Kiazara Fm.		
	I. ? *furukawensis* Hayami, 1960				
Oxytoma Meek, 1864	*Oxytoma* (*Oxytoma*) *tetoriensis* Hayami, 1959	**H**	Mitarai Fm.		
	O. sp.	**MF**	Inagoe Fm.		
	Entolium inequivalve Hayami, 1959	**H**	Magawa Fm.	Mitarai Fm	
	Camptonectes ? sp.	**H**	Mitarai Fm.		
Chlamys Röding, 1798	*Chlamys* (*Chlamys*) *mitaraiensis* Hayami, 1959	**H**	Mitarai Fm.		
	C. (*C*.) cf. *mitaraiensis* Hayami, 1959		Magawa Fm.	Mitarai Fm.	
	Limatula ? *iwayae* Hayami, 1959	**H**	Mitarai Fm		
	Limidae gen. et sp. indet.	**MF**	Inagoe Fm.		
	Exogyrinae gen. et sp. indet.	**MF**	Inagoe Fm.		
	Ostreinae gen. et sp. indet.	**MF**	Inagoe Fm.		
	Anisocardioides hulinensis Gu, 1984	**MF**	Taie Fm.	Inagoe Fm.	
	Unio antiqua (Kobayashi and Suzuki, 1937)	**KS MF**	Izuki Fm.	Okurodani Fm.	Taie Fm.
	U. cf. *longus* (Zhu, 1976)		Okurodani Fm.		
	Tetoriunio okurodaniensis (Komatsu et al., 2003) emend.	**KT**	Okurodani Fm.		
	Nagdongia soni Yang, 1975		Okurodani Fm.		
	Archaeounio kagaensis sp. nov.		Izuki Fm.	Kuwajima Fm.	Okurodani Fm.
	Nippononaia ryosekiana (Suzuki, 1941)	**IG**	Okurodani Fm.	Okura Fm.	
	N. *tetoriensis* Maeda, 1962	**MD**	Okurodani Fm.		
Plicatounio Ota, 1963 emend.	*Plicatounio* (*Plicatouino*) *naktongensis* Kobayashi and Suzuki, 1936		Okurodani Fm.		
	Pseudohyria aff. *matsumotoi* Yang, 1979		Okurodani Fm.		
	Latitrigonia tetoriensis Kobayashi, 1957	**K**	Yambarazaka Fm.		
	L. *orbicularis* Kobayashi, 1957	**K**	Yambarazaka Fm.		
	L. *horii* Maeda, 1963	**MD**	Kaizara Fm.		
	L. *kasaii* Maeda, 1963	**MD**	Kaizara Fm.		
	Ibotrigonia tetoriensis Maeda, 1963	**MD**	Kaizara Fm.		
Promyophorella Kobayashi and Tamura, 1955	*Myophorella* (*Promyophorella*) *imamurai* Kobayashi, 1956	**K**	Kiritani Fm.	Magawa Fm.	
	M. (*P*.) *orientalis* Kobayashi and Tamura, 1955	**K, MD**	Kaizara Fm.	Yambarazaka Fm.	
	Nipponitrigonia sagawai (Yehara, 1927)		Kiritani Fm.		
Vaugonia Crickmay, 1930	*Vaugonia* (*Vaugonia*) *yambarensis* Kobayashi, 1956	**K**	Yambara Fm.		
	V. (*V*.) cf. *yambarensis* Kobayashi, 1956	**K**	Kiritani Fm.		
	V. (*V*.) *fukuiensis* Maeda, 1962	**MD**	Yambarazaka Fm.		
	V. (*V*.) *kuzuryueneis* Maeda, 1963	**MD**	Kaizara Fm.		
	Trigonioides (*Wakinoa*) *tetoriensis* Maeda, 1963	**MD**	Okurodani Fm.		
	Fimbria sp.		Kiritani Fm.		
	Protocardia sp.		Magawa Fm.		
	P. ? sp.	**H**	Mitarai Fm.		
	Cultellidae gen. et sp. indet.		Magawa Fm.	Izuki Fm.	

	Superfamily	Family	Subfamily	Genus
60	Solenacea Lamarck, 1809	Cultellidae Davies, 1935		
61	Tellinacea de Blainville, 1814	Tancrediidae Meek, 1864		*Tancredia* Lycett, 1850
62	Arcticacea Newton, 1891	Arctidae Newton, 1891		*Isocyprina* Röder, 1882
63		Neomiodontidae Casey, 1955	Neomiodontinae Casey, 1955	*Crenotrapezium* Hayami, 1958
64				*Neomyrene* gen. nov.
65	Corbiculacea Gray, 1847	Corbiculide Gray, 1847		*Tetoria* Kobayashi and Suzuki, 1937
66				
67		Pisidiidae Gray, 1857		*Sphaerium* Scopoli, 1777
68			Corbulinae Lamarck, 1818	*Corbula* Bruguière, 1797
69	Pholodomyacea Gray, 1847	Pholadomyidae Gray, 1847		*Pachymya* J. de C. Sowerby, 1826
70				*Tetorimya* Hayami, 1959
71		Pleuromyidae Dall, 1900		*Pleuromya* Agassiz, 1842
72				
73				
74	Pandracea Rafinesque, 1815	Laternulidae Hedley, 1918		*Cercomya* Agassiz, 1843
75				
76		Thraciidae Stolicka, 1870		*Thracia* Sowerby, 1823
77				
78	Unknown	Unknown	Unknown	Unknown
79				
80				
81				

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Subgenus	Species	Ref.	Occurrence Formation in Japan		
	Cultellidae gen. et sp. indet.		Magawa Fm.	Izuki Fm.	
Tancredia Lycett, 1850	*Tancredia* (*Tancredia*) sp.		Kiritani Fm.		
	Isocyprina sp.		Kiritani Fm.		
	Crenotrapezium kobayashii (Maeda, 1959)	**MD**	Tochio Fm.		
	Neomyrene tetoriensis (Kobayashi and Suzuki, 1937)	**KS MF**	Yambara Fm.	Izuki Fm.	Ushimaru Fm.
			Numamachi Fm.	Otaniyama Fm.	Kuwajima Fm.
			Okurodani Fm.	Taie Fm.	Amagodani Fm.
	Tetoria yokoyamai (Kobayashi and Suzuki, 1937)	**KS MF**	Izuki Fm.	Ushimaru Fm.	Tochio Fm.
			Okurodani Fm.	Taie Fm.	Amagodani Fm.
	Filosina ? sp.	**MF**	Inagoe Fm.		
	Sphaerium coreanicum (Kobayashi and Suzuki, 1936)		Izuki Fm.	Okurodani Fm.	
	Corbula (*Eoursivivas* ?) aff. *matsumotoi* Hase, 1960	**MF**	Inagoe Fm.		
Arcomya Roemer, 1839	*Pachymya* (*Arcomya*) *longzhaogouensis* Yu and Li, 1982	**MF**	Inagoe Fm.		
	Tetorimya carinata Hayami, 1959	**H**	Mitarai Fm.		
	Pleuromya hidensis Hayami, 1959	**H**	Mitarai Fm.		
	P. baoqingensis (Yu and Li, 1982) (in Li and Yu, 1982)	**MF**	Inagoe Fm.		
	P. ? sp.		Magawa Fm.		
Cercomya Agassiz, 1843	*Cercomya* (*Cercomya*) cf. *gurgitis* (Pictet and Campiche, 1865)		Magawa Fm.		
Capillimya Crickmay, 1936	*C.* (*Capillimya*) sp.		Magawa Fm.		
	Thracia shokawensis Hayami, 1959	**H MF**	Mitarai Fm.	Inagoe Fm.	
	T. ? sp.		Kiritani Fm.		
Unknown	*Unio* ? *ogamigoensis* Kobayashi and Suzuki, 1937	**KS**	Okurodani Fm.		
	Bivalvia gen. et sp. indet. A		Kiritani Fm.		
	Bivalvia gen. et sp. indet. B		Magawa Fm.		
	Bivalvia gen. et sp. indet. C		Kiritani Fm.		

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本邦の後期中生代の手取層群の二枚貝化石

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環境科学分野

要　旨

後期中生代の手取層群が分布する全域から産出する非海生・海生二枚貝化石の分類を再検討した。Kobayashi and Suzuki（1937）が二枚貝化石５種を記載して以来，今日まで48種が記載されてきた。この論文では，桐谷層と真川層から得られた２新種を含む24種とその他の地層から得られた８種の二枚貝化石を記載した。また，これまで手取層群から得られ，記載された二枚貝化石の分類に関して現状をまとめ，属種名はコメントを付けて修正，現代化した。その結果，81種が手取層群から得られることが示された。81種の中の30属65種は海生二枚貝で，13属16種はは非海生二枚貝である。殆どの種は，日本と日本周辺地域から知られる地域固有種と判断される。そして，それら各種の生層序分布は，３回の海進と海退により断たれたと解釈した。

キーワード:　後期中生代，手取層群，海生二枚貝，非海生二枚貝

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