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Carboniferous Primitive Fusulinaceans from the Koyama Limestone in Okayama Prefecture, western Japan

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Abstract : This paper treats of the Carboniferous fusulinacean zones of the Koyama Limestone in the so-called Kibi-Highland of central Chugoku in western Japan and the paleontological descriptions of sixteen species of *Millerella*, *Ozawainella*, *Eostaffella*, *Mediocris*, *Pseudostaffella*, *Profusulinella* and *Endothyra*, and the illustrations of nine species of Fusulinaceans and Endothyraceans. In this paper is also given the correlation with the fusulinacean zones of the Akiyoshi Limestone.

Key words : Carboniferous, Primitive fusulinacea, *Millerella*, *Ozawainella*, *Eostaffella*, *Mediocris*, *Pseudostaffella*, *Profusulinella*, *Endothyra*, Koyama Limestone, Okayama Prefecture

I. Introduction

The Carboniferous and Permian Koyama Limestone in the so-called Kibi-Highland of Okayama Prefecture, western Japan is well known among the Paleozoic students as well as the Atetsu and Taishaku ones. The stratigraphical and structural studies of the Koyama Limestone have been carried out by many Paleozoic students such as Ozawa (1925), Kobayashi (1950), Yoshimura (1961), Yokoyama et al. (1979) and Otoh (1985). However, the fusulinacean faunas, to make up the zonation of this limestone, have never been described from this limestone. We consider that the Carboniferous faunas should be described as the first step to set up the stratigraphy of the Koyama Limestone and based on it the geologic structure of this limestone could be made clear in the nearest future.

In this paper we described the following species such as *Millerella marblensis*, *M. bigemmicula*, *Ozawainella japonica*, *Eostaffella kanmerai*, *E. akiyoshiensis*, *E. shuhodoensis*, *E. mosquensis*, *E. ikensis*, *E. paraprisca*, *E.* sp. A, *Mediocris mediocris*, *M. breviscula*, *Pseudostaffella minuta*, *P. taishakuensis*, *Profusulinella toriyamai* and *Endothyra exilis*. Furthermore nine species are illustrated herein. The Carboniferous of the Koyama Limestone, based on this studies, is divided into four fusulinacean zones as stated below.

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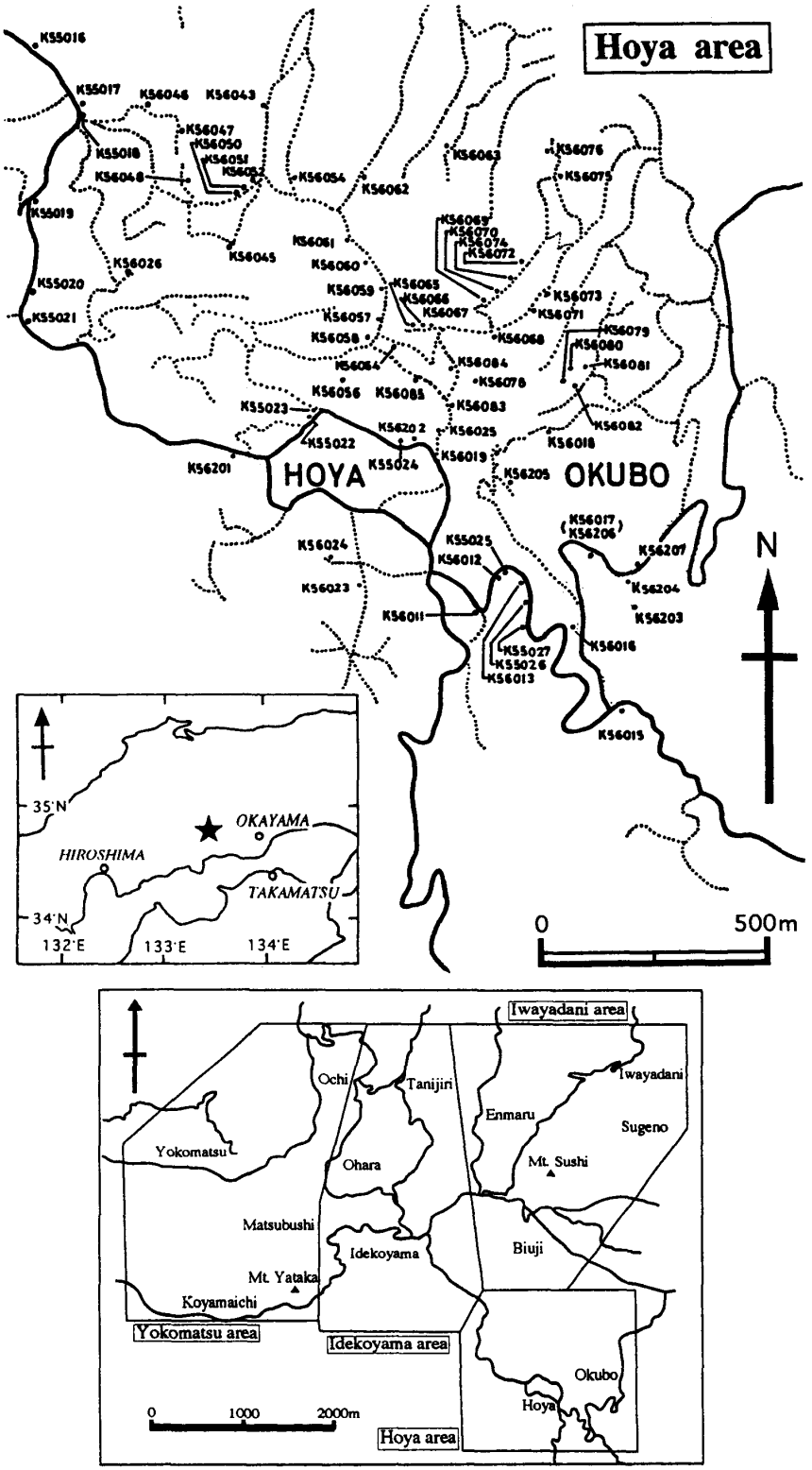


Figure 1. The location of the studied area and the microfossil localities of the Hoya area in the Koyama Limestone upland.

Table 1. The microfossil faunas of the Koyama Limestone in the Hoya area.

Species \ Locality	K55018	K55025	K56015	K56023	K56024	K56025	K56046	K56047	K56050	K56054	K56067	K56068	K56070	K56082	K56205	K55024	K56011	K56012	K56048	K56051	K56052	K56061	K56069	K56071	K56080	K56081	K56201	K55026	K56013	K56018	K56019	K56202	K55027	K56057	K56058	K56064	K56065	K56066	K56083	K56084	K56073	K56074
Endothyra similis	*				*																																					
E. irinae				*											*																											
E. exilis						*									*												*		*													
E. sp.	*		*	*	*		*	*	*	*	*	*	*	*	*			*	*	*		*	*		*	*			*			*					*					
Endothyranopsis sp.	*					*																																				
Endostaffella sp.		*	*				*	*	*		*		*										*																			
Planoendothyra sp.		*							*																		*															
Mediocris mediocris				*	*		*	*									*		*																							
M. breviscula		*	*						*	*	*	*		*							*																					
Eostaffella ikensis																		*									*															
E. akiyoshiensis																		*		*																							
E. kanmerai																*	*																										
E. mosquensis																		*									*															
E. paraprisca																*						*	*	*	*	*		*														
E. shuhodoensis																					*								*													
E. sp.A																											*					*										
Millerella marblensis																*					*																						
M. bigemicula																						*	*	*				*														
Ozawainella japonica																					*										*											
Pseudostaffella minuta																													*	*													
P. taishakuensis																														*		*										
Nankinella yokoyamai																																*										
Eoschubertella sp.																												*					*										
Profusulinella toriyamai																												*			*			*			*	*	*				
P. fusiformis																												*				*			*		*		*				
Fusulinella taishakuensis																																*				*		*				
F. sp.																																*		*	*	*	*		*	*		
Schubertella kingi																																									*	*	
Pseudoschwagerina sp.																																									*		
Schwagerina sp.																																										*	
Pseudofusulina sp.																																									*		
Parafusulina sp.																																											*

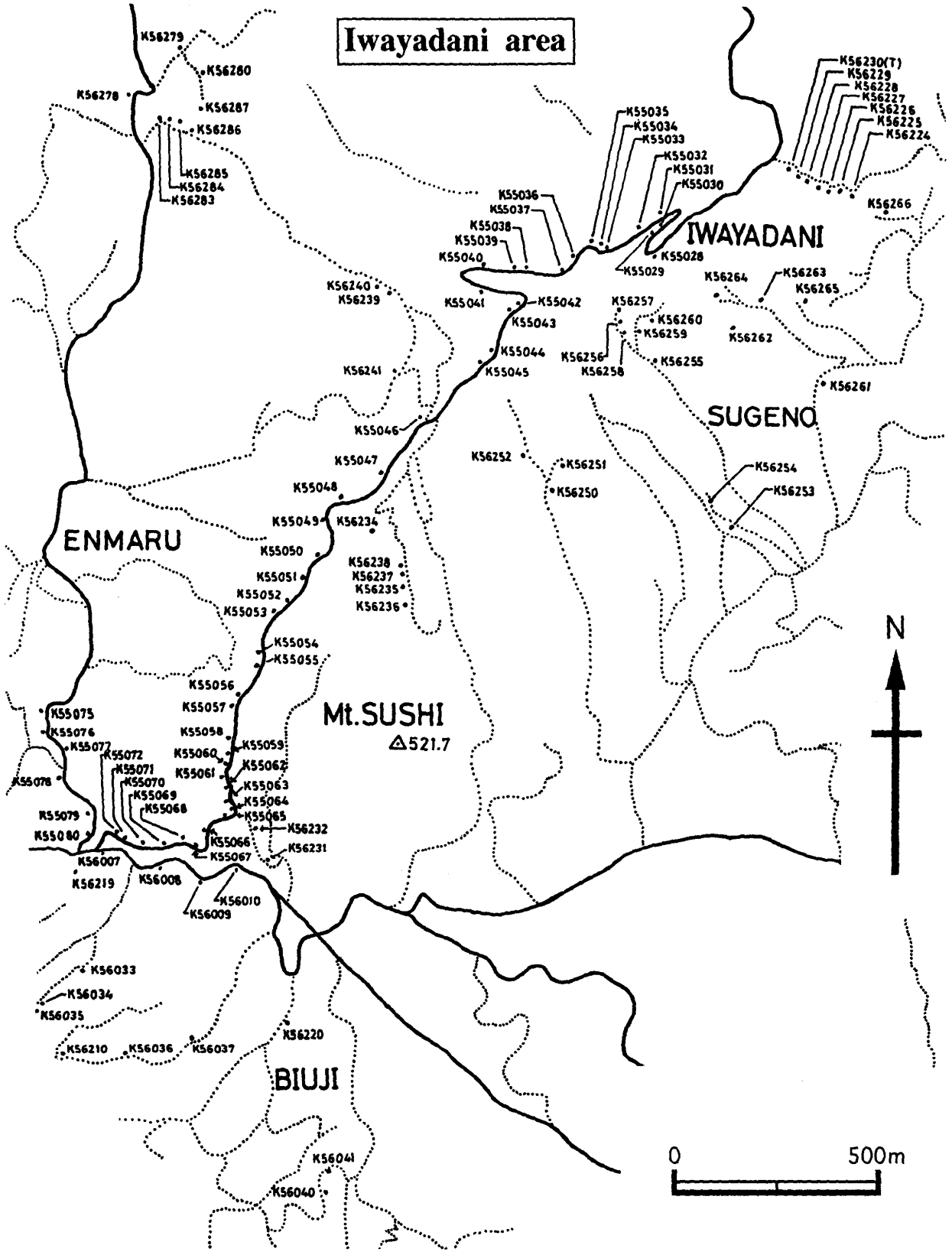


Figure 2. The microfossil localities of the Iwayadani area in the Koyama Limestone upland.

Table 2. The microfossil faunas of the Koyama Limestone in the Iwayadani area.

Species \ Locality	K55035	K55037	K55038	K55056	K55058	K55060	K55064	K55069	K55071	K55075	K55077	K55079	K56033	K56230	K56284	K56286	K55040	K55042	K55048	K55051	K55052	K55053	K55055	K55065	K56008	K56035	K56225	K56228	K56239	K56241	K56258	K55043	K55045	K55047	K55054	K56010	K56252	K56259	K56263	K56250	K56251	K56260	K56036	K56235	K56236	K56238	K56264
Endothyra similis										*					*																																
E. irinae										*					*																																
E. exilis		*							*				*																																	
E. sp.	*	*	*	*	*	*	*	*	*	*	*	*		*		*		*	*	*	*	*	*	*	*	*		*		*	*			*	*						*						
Endothyranopsis sp.			*	*					*																																						
Endostaffella sp.	*	*			*			*																																						
Planoendothyra sp.											*		*				*																														
Mediocris mediocris	*	*		*								*													*																					
M. breviscula		*	*			*	*	*	*		*	*	*	*	*	*							*	*	*	*																				
Eostaffella ikensis																		*			*									*																
E. akiyoshiensis																				*			*		*								*														
E. kanmerai																				*	*	*	*	*									*														
E. mosquensis																			*	*	*						*		*																		
E. paraprisca																	*	*	*	*		*						*		*					*												
E. shuhodoensis																		*						*					*																	
E. sp.A																	*	*								*	*				*																
Millerella marblensis																		*		*											*																
M. bigemicula																	*	*	*														*														
Ozawainella japonica																			*		*	*											*														
Pseudostaffella minuta																																	*		*	*											
P. taishakuensis																																*		*													
Nankinella yokoyamai																																		*													
Eoschubertella sp.																																*	*													
Profusulinella toriyamai																																	*													
P. fusiformis																																*	*													
Fusulinella taishakuensis																																														
F. sp.																																														
Schubertella kingi																																														
Pseudoschwagerina sp.																																														
Schwagerina sp.																																														
Pseudofusulina sp.																																														
Parafusulina sp.																																														

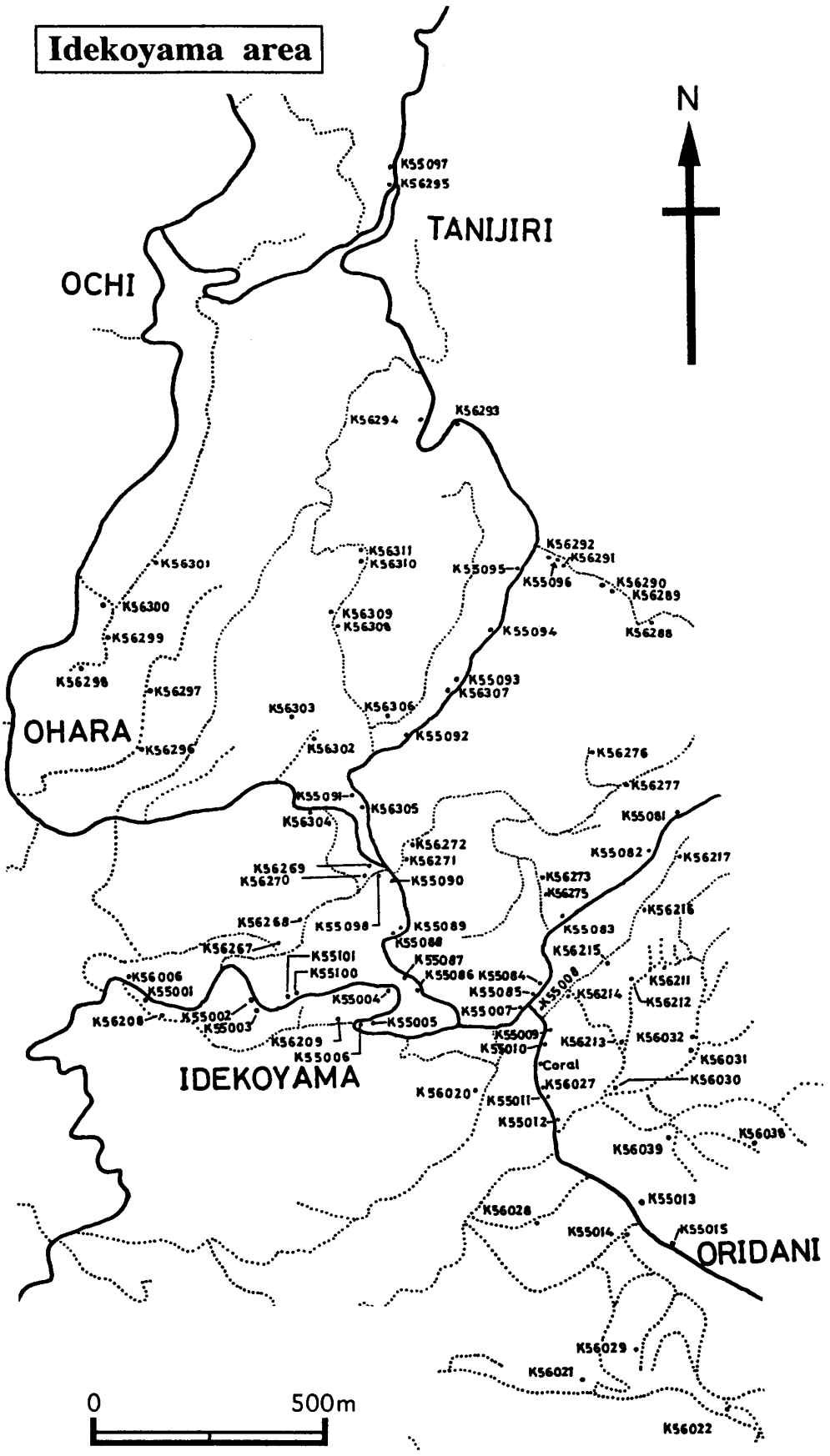


Figure 3. The microfossil localities of the Idekoyama area in the Koyama Limestone upland.

Table 3. The microfossil faunas of the Koyama Limestone in the Idekoyama area.

Species \ Locality	K55005	K55006	K55007	K55013	K55014	K55081	K55082	K55083	K55084	K55091	K55092	K55093	K55095	K55096	K55097	K56020	K56027	K56030	K56031	K56032	K56208	K56209	K56211	K56216	K56272	K56288	K56290	K56291	K56294	K56301	K56305	K56308	K56310	K55008	K55010	K55011	K55012	K55100	K55101	K56270	K55004	K55086	K55087	K55089	K55098
Endothyra similis	*	*										*						*		*																									
E. irinae								*									*			*																									
E. exilis											*					*																				*	*	*						
E. sp.	*	*	*	*	*		*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*		*			*			
Endothyranopsis sp.											*	*					*		*										*							*									
Endostaffella sp.				*							*									*			*	*	*			*	*															
Planoendothyra sp.							*																										*				*								
Mediocris mediocris						*	*	*	*	*	*			*	*	*	*	*	*	*		*		*				*	*			*	*		*	*								
M. breviscula		*	*		*	*	*	*					*		*						*				*		*			*					*	*								
Eostaffella ikensis															*																						*						*		
E. akiyoshiensis																																		*	*		*	*							
E. kanmerai																																		*				*			*		*		
E. mosquensis																																				*		*							
E. paraprisca																																			*			*				*			
E. shuhodoensis																																		*				*							
E. sp.A																																						*			*				
Millerella marblensis																																						*				*			
M. bigemicula																																							*			*	*		
Ozawainella japonica																																						*							
Pseudostaffella minuta																																						*				*			
P. taishakuensis																																									*				*
Nankinella yokoyamai																																										*	*		
Eoschubertella sp.																																										*	*		

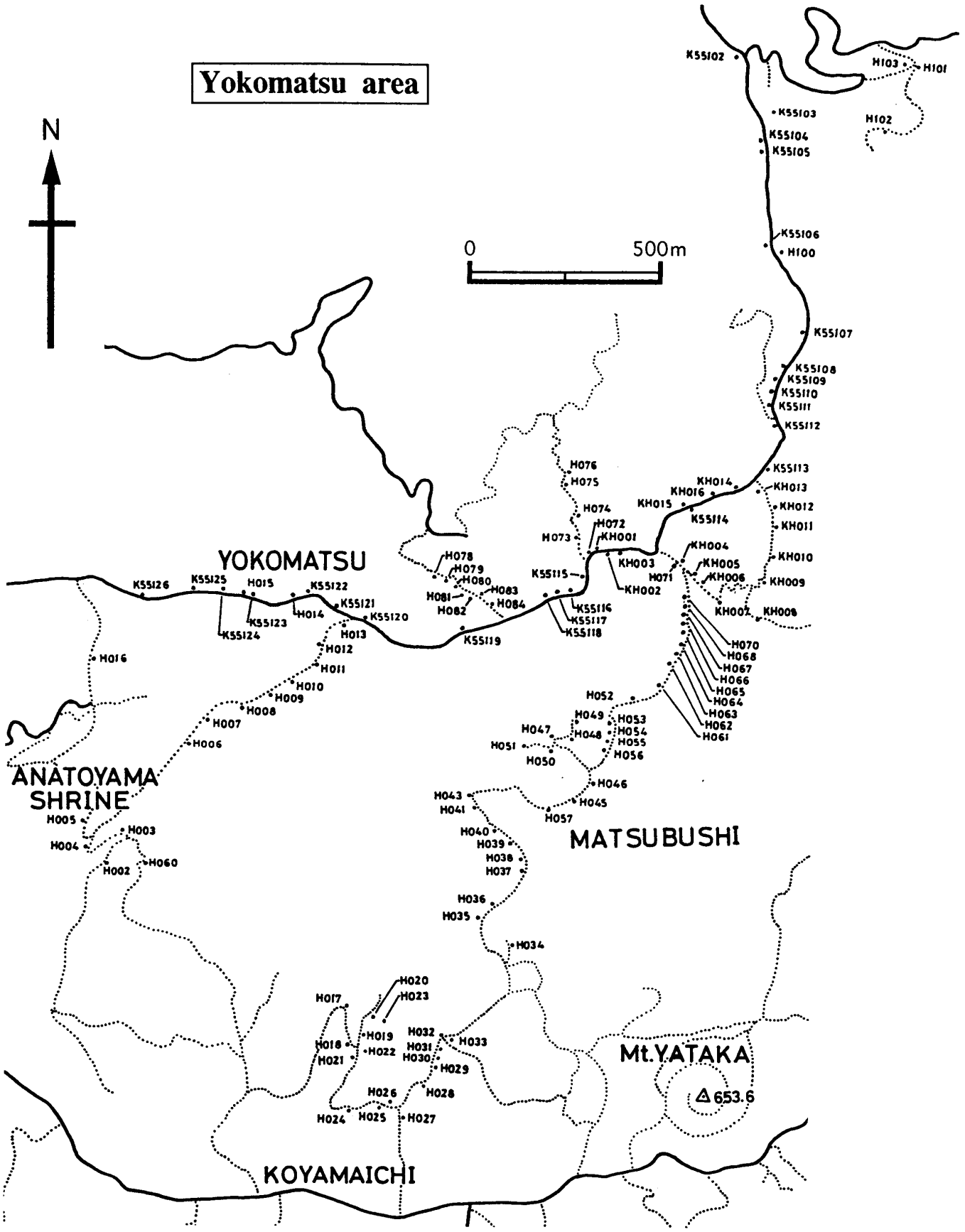


Figure 4. The microfossil localities of the Yokomatsu area in the Koyama Limestone upland.

Table 4. The microfossil faunas of the Koyama Limestone in the Yokomatsu area.

Species \ Locality	H015	H019	H020	H026	H027	H043	H051	KH006	KH011	H006	H010	H022	H033	H037	H040	H055	H056	H065	H066	H067	H068	KH004	K55106	K55107	K55110	K55117	K55121	H007	H045	H062	H071	H072	H078	H082	H083	K55115	K55116	K55119	K55120	K55123	H008	K55111	H052	KH009	KH012	KH016	K55104
Endothyra similis									*												*																								
E. irinae				*		*							*																																	
E. exilis								*		*																													*							
E. sp.	*	*	*	*	*	*	*	*	*	*		*		*	*	*	*		*	*									*											*							
Endothyranopsis sp.				*					*																																					
Endostaffella sp.		*				*	*						*		*	*					*								*																	
Planoendothyra sp.						*			*																																					
Mediocris mediocris		*		*	*	*						*			*																															
M. breviscula	*		*							*	*	*	*	*	*							*								*															
Eostaffella ikensis															*	*				*					*														*						
E. akiyoshiensis										*				*				*	*					*	*		*	*					*					*	*					
E. kanmerai													*	*		*			*	*					*		*	*				*							*					
E. mosquensis														*							*			*																					
E. paraprisca											*							*	*						*								*												
E. shuhodoensis																	*					*	*										*					*	*					
E. sp.A																*				*				*									*					*						
Millerella marblensis												*		*			*		*						*	*							*	*		*	*						
M. bigemicula											*			*				*					*			*	*						*		*				*				
Ozawainella japonica																									*			*	*			*		*					*					
Pseudostaffella minuta																												*		*			*	*	*				*					
P. taishakuensis																													*			*		*	*									
Nankinella yokoyamai																															*	*						*						
Eoschubertella sp.																																				*	*			*					
Profusulinella toriyamai																															*			*				*			*			
P. fusiformis																														*				*					*	*				
Fusulinella taishakuensis																																									*			*	
F. sp.																																										*				
Schubertella kingi																																												*	*	
Pseudoschwagerina sp.																																										*	*			*
Schwagerina sp.																																											*	*		*
Pseudofusulina sp.																																											*	*	*	

II. Brief summary of Carboniferous fusulinacean zones

The Carboniferous of the Koyama Limestone is divided into four fusulinacean zones as follows: *Endothyra-Mediocris* Zone, *Eostaffella-Millerella* Zone, *Pseudostaffella-Profusulinella* Zone and *Fusulinella* Zone in ascending order. The Koyama Limestone, however, is lacking both *Fusulina* and *Triticites* Zones and the Permian *Pseudoschwagerina-Parafusulina* Zone unconformably overlies the *Fusulinella* Zone. Of this limestone, the lower part is composed of the Carboniferous basic volcanic rocks and the Carboniferous limestones mainly consist of micrite limestones and the Permian generally sparite limestones.

The *Endothyra-Mediocris* Zone is generally composed of biomicritic limestones and its thickness ranges 60 to 100 m. This zone is characterized by *Endothyra similis* Rauzer-Chernousova, *E. irinae* Reitlinger, *E. exilis* Rauzer-Chernousova, *E.* sp., *Planoendothyra* sp., *Mediocris mediocris* Rozovskaya and *M. breviscula* (Ganelina). The *Endothyra-Mediocris* Zone of Koyama can be correlated with the *Endothyra* Zone to the *Mediocris mediocris* Zone of Akiyoshi (Matsusue, 1992).

The *Eostaffella-Millerella* Zone, whose thickness is estimated at 50 to 100 m, is mainly made up by biomicrite and partly by biosparite. The present zone is characterized by *Eostaffella ikensis* Vissarionova, *E. akiyoshiensis* Sada, *E. kanmerai* (Igo), *E. mosquensis* Vissarionova, *E. paraprisca* Durkina, *E. shuhodoensis* Sada, *E.* sp. A, *Millerella marblensis* Thompson, *M. bigemmicula* Igo and *Ozawainella japonica* Sada, and may be correlated with the *Eostaffella mosquensis* Zone to the *Millerella yowarensis* Zone of Akiyoshi (Matsusue, 1992).

The *Pseudostaffella-Profusulinella* Zone is generally composed of biomicrite and partly of biosparite, and measures about 80 m thick. This zone is mainly characterized by *Pseudostaffella minuta* Sada, *P. taishakuensis* Sada, *Nankinella yokoyamai* Sada, *Eoschubertella* sp., *Profusulinella toriyamai* Sada, *P. rhomboides* (Lee et Chen) and *P. fusiformis* Sada, and the zone can be compared with the *Pseudostaffella minuta* Zone to the *Profusulinella beppensis* Zone of Akiyoshi (Matsusue, 1992).

The *Fusulinella* Zone consists of micrite and sparite limestones and its thickness attains 70 to 110 m. The characteristic species of this zone are *Fusulinella taishakuensis* Sada and *F.* sp. This zone is considered to be comparable with the *Fusulinella biconica* Zone to the *Fusulinella taishakuensis* Zone of Akiyoshi (Ueno, 1989).

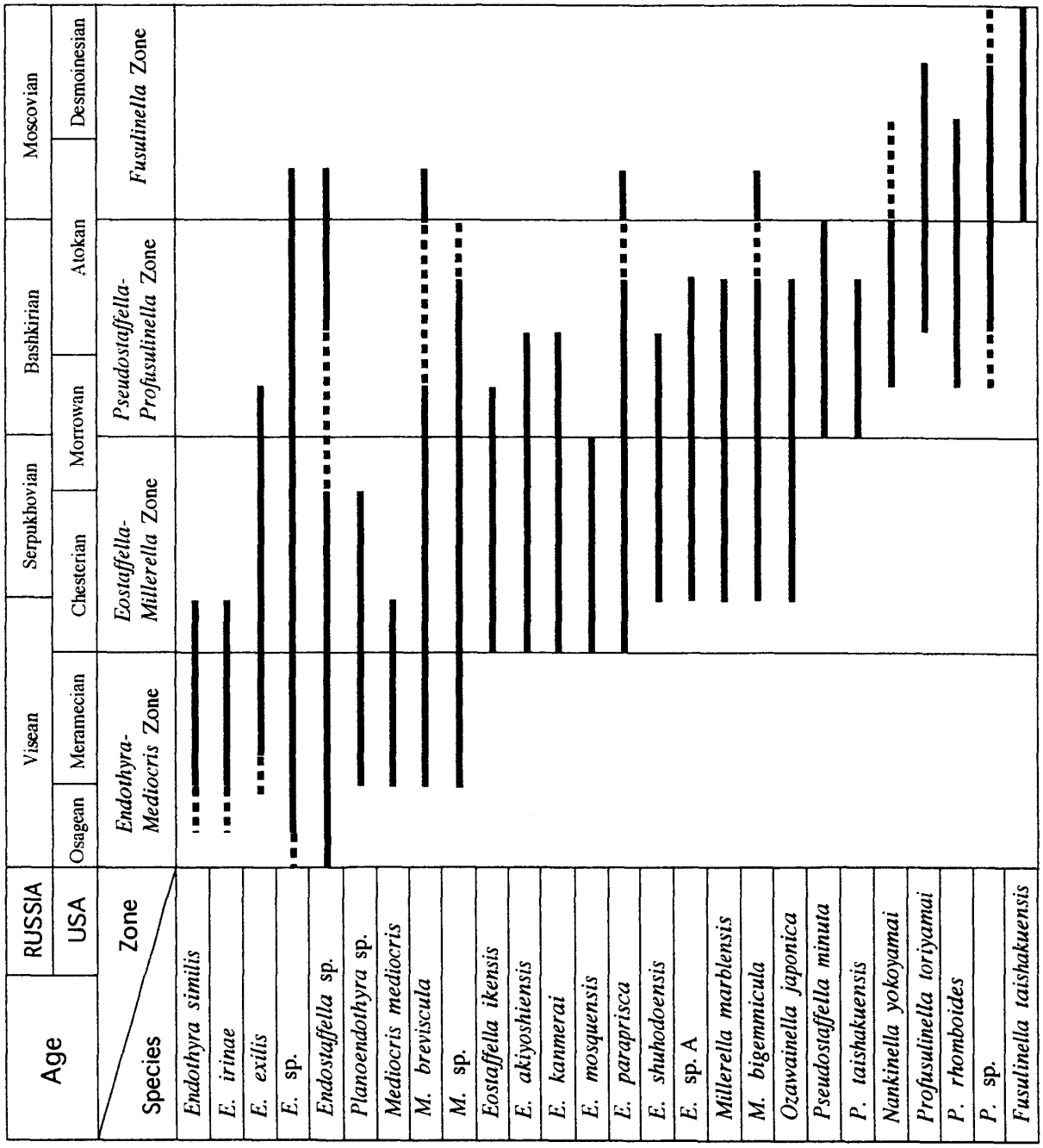


Figure 5. The microfossil faunas and their stratigraphic ranges in the Koyama Limestone.

Ⅲ. Systematic Description

Superfamily Fusulinacea von Moller, 1878

Family Ozawainellidae Thompson and Foster, 1937

Subfamily Ozawainellinae Thompson and Foster, 1937

Genus *Millerella* Thompson, 1942

Type species. — *Millerella marblensis* Thompson, 1942

Millerella marblensis Thompson
Figure 8-1—3

Millerella marblensis Thompson, 1942, p. 405-407, pl. 1, figs. 3-14.
Millerella marblensis, Thompson, 1944, p. 420-423, pl. 1, figs. 1-9, pl. 2, figs. 1-15.
Millerella marblensis, Tompson, 1948, p. 76, pl. 23, figs. 1-12, pl. 24, figs. 1-9.
Millerella marblensis, Thompson, 1951, p. 118, pl. 13, figs. 14, 17, pl. 14, figs. 3-5.
Millerella marblensis, Skinner and Wilde, 1954, p. 449, pl. 49, fig. 3.
Millerella cf. *marblensis*, Igo, 1957, p. 178-179, pl. 1, figs. 13-14, 18-19.
Millerella marblensis, Rich, 1961, pl. 142, figs. 1-9.
Millerella marblensis, Moore, 1964, p. 298-305, pl. 47, figs. 1-24, pl. 48, figs. 1-23.
Millerella marblensis, Ross and Sabins, 1965, p. 183-184, pl. 21, figs. 18-27.
Millerella marblensis, Ross and Tyrrell, 1965, p. 621-622, pl. 76, figs. 38-42.
Millerella marblensis, Pajic, 1965, p. 237, pl. 4, fig. 1.
Millerella marblensis, Sada, 1967, p. 140-142, pl. 12, figs. 13-14, pl. 13, figs. 1-3, 9.
Millerella aff. *marblensis*, Douglass, 1971, p. 5, pl. 2, figs. 2-3.
Millerella marblensis, Kobayashi, 1973, p. 207-208, pl. 30, figs. 23-24.
Millerella marblensis, Sada and Danner, 1974, p. 257-258, pl. 37, figs. 6-12, 14.
Millerella marblensis, Sada, 1975a, p. 6-7, pl. 1, figs. 1-7, pl. 6, figs. 6-8.
Millerella marblensis, Sada, 1975b, p. 33-35, pl. 8, figs. 6-9.
Millerella marblensis, Zeller, 1977, pl. 1, fig. 19, pl. 2, figs. 1-2, 6, 17-18, 25-26, pl. 3, fig. 1.
Millerella marblensis, Sada, 1980, p. 65-66, pl. 1, fig. 6.
Millerella marblensis, Groves, 1983, p. 17-18, pl. 4, figs. 13-17, pl. 5, fig. 10 ?.
Millerella marblensis, Rui Lin , 1983, pl. 1, figs. 18-19.
Millerella cf. *marblensis*, Ginkel, 1983, p. 211, pl. 2, figs. 1-2.
Millerella marblensis, Groves, 1984, pl. 6, figs. 15-17.
Millerella aff. *marblensis*, Matsusue, 1986, pl. 6, fig. 17.
Millerella marblensis, Rui Lin , 1987, p. 383, pl. 3, figs. 9-11.
Millerella marblensis, Sada et al., 1992, p.96-98, Figure 3-19—27.
Millerella marblensis, Fujimoto and Sada, 1994, p. 50-51, Figure 5-4—6.

Remarks. — Shell of *Millerella marblensis* Thompson illustrated in Figure 8-1 measures 168 μm in length and 470 μm in width, giving a form ratio of 0.36. Outer volutions are evolute. Spirotheca is composed of a tectum and inner and outer tectoria. Chomata are small and primitive.

In measured values, shell shape and internal biocharacters, the present species can be referred to *Millerella marblensis* originally described by Thompson (1942) from the Lower Pennsylvanian Marble Falls Limestone in Texas.

Localities. — The representative localities are as follows: K55024, K56052 (Hoya area);

K55042, K55051 (Iwayadani area); K55089, K55101 (Idekoyama area); HO56, HO82 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to *Pseudostaffella-Profusulinella* Zone.

Table 5. Measurements of *Millerella marblensis* Thompson (in mm).

Specimen	H056b	K55089b	H082a1
Figure	8-1	8-2	8-3
Length	0.168	0.148	0.172
Width	0.470	0.420	0.755
Form ratio	0.36	0.35	0.23
Proloculus	0.044	0.021	0.033
Diameter of whorl			
Vol.			
1	0.157	0.101	0.116
2	0.233	0.187	0.200
3	0.470	0.353	0.358
3 1/2		0.420	
4			0.604
4 1/2			0.745
Thickness of spirotheca			
0	0.010	0.010	0.008
1	0.013	0.011	0.009
2	0.020	0.011	0.011
3	0.028	0.015	0.019
3 1/2		0.014	
4			0.020
4 1/2			0.028

Millerella bigemmicula Igo, 1957
Figure 7-12

Millerella bigemmicula Igo, 1957, p. 172-174, pl. 1, figs. 1-4, 9.
Eostaffella etoi Ota, 1971, p. 69-70, pl. 13, figs. 16-33 (part).
Millerella bigemmicula, Kobayashi, 1973, p. 208, pl. 30, figs. 21-22.
Millerella bigemmicula, Sada, 1975a, p. 7-9, pl. 1, figs. 9-11, 14 (part).
Millerella bigemmicula, Sada, 1980, p. 66, 68, pl. 1, figs. 7-10.
Eostaffella etoi, Sashida, 1981, p. 6-8, pl. 2, figs. 3-13.
Eostaffella etoi, Igo and Adachi, 1981, p. 113, pl. 4, figs. 2-12.
Millerella cf. *bigemmicula*, Ginkel, 1983, p. 209, pl. 1, figs. 35-36 (part).
Eostaffella bigemmicula, Matsusue, 1986, pl. 6, fig. 5.
Eostaffella bigemmicula, Ueno, 1989, pl. 1, fig. 8.

Remarks. — Shell of the illustrated specimen (Figure 7-12) is discoidal, having a broadly rounded periphery and umbilicated poles. Shell of four volutions is 139 μm in length and 459 μm in width, possessing a form ratio of 0. 30. Last volution is partially evolute to evolute. Outside diameter of proloculus measures 39 μm. Diameters of whorls of the 1st to the 4th volution are 87, 151, 260 and 459 μm, respectively.

The present specimen can be identified with *Millerella bigemmicula* described by Igo (1957), Ota (1971), Sada (1975a, 1980) and others, judging from discoidal and evolute form, size, and internal biocharacters of shells.

Localities. — The representative localities are as follows: K55026, K56061 (Hoya area); K55040, K55048 (Iwayadani area); K55100, K56270 (Idekoyama area); HO37, HO78 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to lower part of *Fusulinella* Zone.

Genus *Ozawainella* Thompson, 1935

Type species. — *Fusulinella angulata* Colani, 1924

Ozawainella japonica Sada

Figure 8-5

Ozawinella japonica Sada, 1975b, p. 13-15, pl. 2, figs. 5-7, 12, pl. 3, figs. 1-13, pl. 4, figs. 1-11, pl. 6, fig. 3.

Ozawainella japonica, Igo and Adachi, 1981, p. 115-116, pl. 4, figs. 13-15, 17.

Ozawainella japonica, Matsusue, 1986, pl. 7, fig. 7.

Ozawainella japonica, Ozawa and Kobayashi, 1990, pl. 2, figs. 5-6.

Ozawainella japonica, Fujimoto and Sada, 1994, p. 61-63, Figure 5-7—9.

Remarks. — Shell of *Ozawainella japonica* is discoidal and involute. Periphery is angular and lateral slopes are straight to convex. The present specimen is 170 μm in length and 465 μm in width, giving a form ratio of 0. 37. Proloculus is spherical and its outside diameter is 33 μm.

The present specimen illustrated in Figure 3-5 is not in good preservation. However, the specimen is referable to *Ozawainella japonica* described by Sada (1975b) from the Akiyoshi Limestone in its size and internal biocharacters.

Localities. — The representative localities are as follows : K56019, K56052 (Hoya area); K55048, K55052 (Iwayadani area); K55004, K55100 (Idekoyama area); H007, H072 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to *Pseudostaffella-Profusulinella* Zone.

Subfamily Pseudostaffellinae Putrya, 1959

Genus *Eostaffella* Rauzer-Chernousova, 1948

Type species. — *Staffella (Eostaffella) parastruvei* Rauzer-Cherunousova, 1948

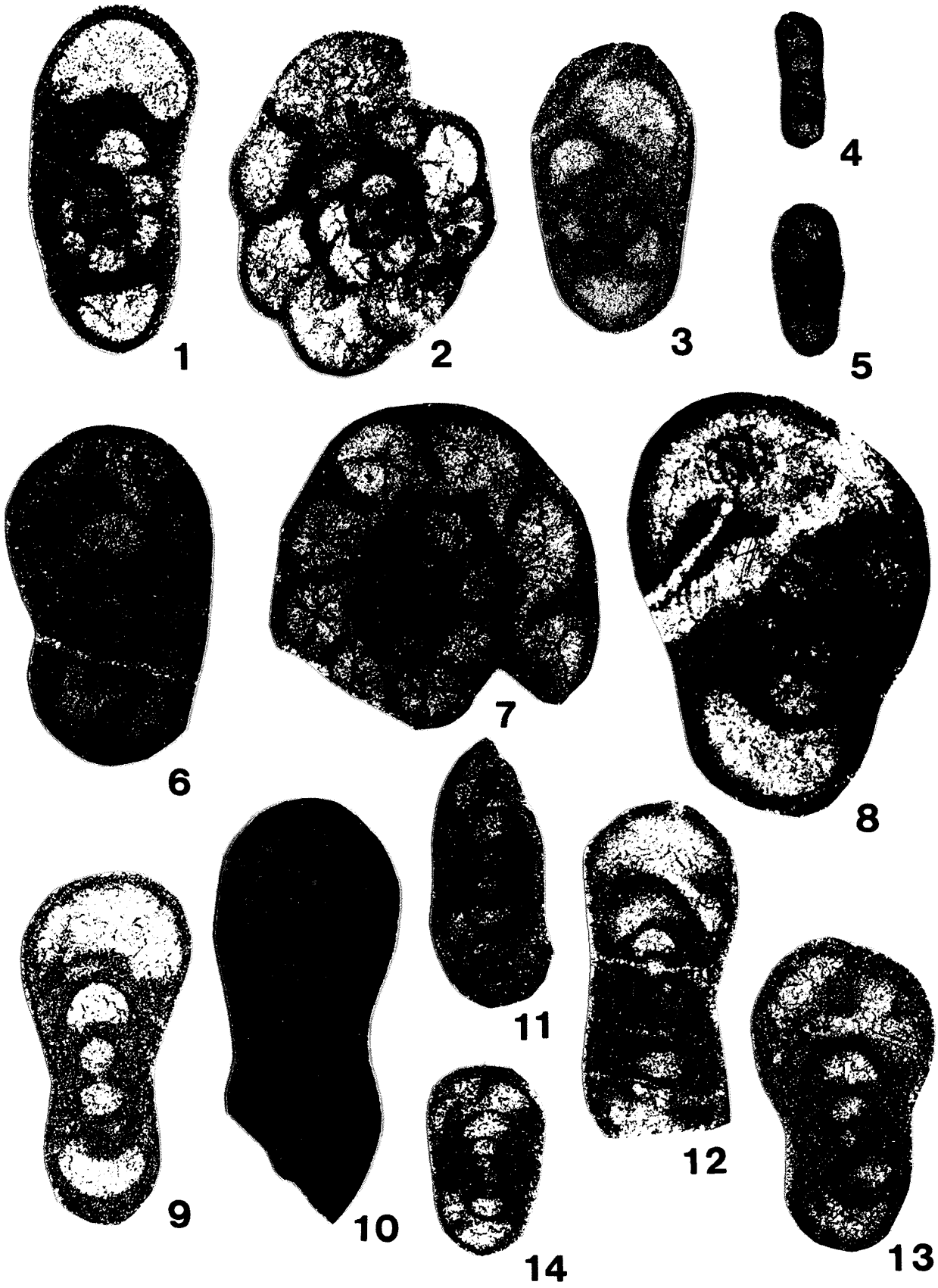
Eostaffella kanmerai (Igo)

Figure 7-1—2

Millerella kanmerai Igo, 1957, p. 175-177, pl. 1, figs. 20-26, pl. 2, fig. 14.
Eostaffella kanmerai, Sada, 1964, p. 230-231, pl. 21, figs. 8, 16-17.
Eostaffella kanmerai, Sada, 1967, p. 144-145, pl. 12, figs. 1-10.
Eostaffella kanmerai, Sada, 1969, p. 120-121, pl. 12, figs. 1-13, pl. 13. figs. 1-2.
Eostaffella kanmerai, Sada and Danner, 1974, p. 259-261, pl. 37, figs. 1-3, 5, 18-19.
Eostaffella kanmerai, Sada, 1975b, p. 35-36, pl. 8, figs. 1-5.
Eostaffella kanmerai, Niikawa, 1978, p. 538, pl. 1, figs. 11-12.
Eostaffella kanmerai, Sada, 1980, p. 68-69, pl. 1, figs. 1-5, 11-13.
Eostaffella kanmerai, Rich, 1980, p. 40-41, pl. 18, figs. 6, 8-12, 14 ?.
Eostaffella kanmerai, Sada et al., 1984, p. 390-391, pl. 75, figs. 1-8.
Eostaffella kanmerai, Niko, 1987, p. 123, Figure 4-H—J.
Eostaffella kanmerai, Sada et al., 1992, Figure 4-7—8.
Eostaffella kanmerai, Fujimoto and Sada, 1994, p. 52-53, Figure 4-6—9.

Table 6. Measurements of *Eostaffella kanmerai* (Igo) (in mm).

Specimen	K55004e	K55110b
Figure	7-1	7-2
Length	0.162	0.190
Width	0.462	0.499
Form ratio	0.35	0.38
Proloculus	0.044	0.034
Diameter of whorl		
Vol.		
1	0.128	0.134
2	0.257	0.235
3	0.462	0.376
3 1/2		0.499
Thickness of spirotheca		
0	0.010	0.008
2	0.022	0.015
3	0.016	0.011
3 1/2		0.014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Remarks. — Shell of the illustrated specimen (Figure 7-2) is 190 μm long and 499 μm wide, having a form ratio of 0.38. Shell is discoidal in shape with subangular to rounded periphery and umbilicated poles. The inner and outer volutions are involute and spirotheca is composed of a tectum and inner and outer tectoria. In measured values and biocharacters of shells, the present species is quite similar to *Eostaffella kanmerai* from the Ichinotani Formation (Igo, 1957) in Gifu Prefecture, the Atetsu (Sada, 1964 ; Sada et al., 1992), North America (Sada and Danner, 1974) and others.

Localities. — The representative localities are as follows: K55024, K56011 (Hoya area); K55051, K55065 (Iwayadani area); K55004, K55008 (Idekoyama area); H033, K55110 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to lower part of *Pseudostaffella-Profusulinella* Zone.

Eostaffella akiyoshiensis Sada
Figure 7-3—5

Eostaffella akiyoshiensis Sada, 1975a, p. 9-10, pl. 1, figs. 15-23.
Eostaffella akiyoshiensis, Matsusue, 1986, pl. 6, fig. 9.
Eostaffella akiyoshiensis, Ueno, 1989, pl. 1, fig. 5.
Eostaffella akiyoshiensis, Sada et al., 1992, Figure 4-1—6, 9—10.
Eostaffella akiyoshiensis, Fujimoto and Sada, 1994, p. 53-54, Figure 3-10—13.

Remarks. — Shell of *Eostaffella akiyoshiensis* is discoidal in shape with rounded periphery, convex lateral slopes and umbilicated poles. Shell of the specimen (Figure 7-3) is 191 μm in length and 380 μm in width. Form ratio is 0.50. Spirotheca consists of a tectum and inner and outer tectoria. In size and internal biocharacters, the present species can be referred to *Eostaffella akiyoshiensis* from Akiyoshi (Sada, 1975a).

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Figure 6. 1-2. *Endothyra exilis* Rauzer-Chernousova, 1, Axial section, Rg. No. K56020b. 2, Sagittal section, Rg. No. K56013b. 3. *Endothyra similis* Rauzer-Chernousova and Reitlinger, Axial section, Rg. No. K56032a. 4-5. *Mediocris breviscula* (Ganelina), 4-5, Axial sections, Rg. No. K55038b and K55071b, respectively. 6-7. *Endothyra* sp., 6, Axial section, Rg. No. K55083a. 7, Sagittal section, Rg. No. K55096b. 8. *Endothyra irinae* Reitlinger, Axial section, Rg. No. H026b. 9. *Endostaffella* sp., Axial section, Rg. No. K56211f. 10. *Planoendothyra* sp., Axial section, Rg. No. K55025a. 11-12. *Mediocris mediocris* (Vissarionova), 11-12, Axial sectons, Rg. No. K55082a and K56046b, respectively. 13-14. *Mediocris* sp., 13-14, Axial sections, Rg. No. K55092a and K56216a, respectively.
All figures x100.

Localities. — The representative localities are as follows: K56012, K56051 (Hoya area), K55051, K56008 (Iwayadani area); K55010, K55100 (Idekoyama area); H065, H066, H083 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to lower part of *Pseudostaffella-Profusulinella* Zone.

Table 7. Measurements of *Eostaffella akiyoshiensis* Sada (in mm).

Specimen	H065a	H083b1
Figure	7-3	7-4
Length	0.191	0.151
Width	0.380	0.382
Form ratio	0.50	0.40
Proloculus	0.041	0.035
Diameter of whorl		
Vol.		
1	0.162	0.085
2	0.249	0.150
3	0.380	0.233
4		0.382
Thickness of spirotheca		
0	0.009	0.006
1	0.007	0.011
2	0.016	0.014
3	0.015	0.015
4		0.023

Eostaffella shuhodoensis Sada
Figure 7-11

Eostaffella shuhodoensis Sada, 1975a, pl. 2, figs. 2-4.

Remarks. — Shell of *Eostaffella shuhodoensis* Sada (Figure 7-11) is 289 μm long and 589 μm wide, having a form ratio of 0.49, and discoidal form with rounded periphery and umbilicated poles. Proloculus is large and measures 31 μm. Diameters of the whorls of the 1st to the 4th volution are 134, 212, 396 and 589 μm, respectively.

The present specimen closely resembles the Akiyoshi one (Sada, 1975a, pl. 2, fig. 2) in size, modes and internal biocharacters of shell. The present species may be ascribed to *Eostaffella shuhodoensis* Sada.

Localities. — The representative localities are as follows: K56052, K56018 (Hoya area); K55042, K55065 (Iwayadani area); K55008, K56270 (Idekoyama area); KH004, K55106 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to lower part of *Pseudostaffella-Profusulinella* Zone.

Eostaffella mosquensis Vissarionova
Figure 7-10

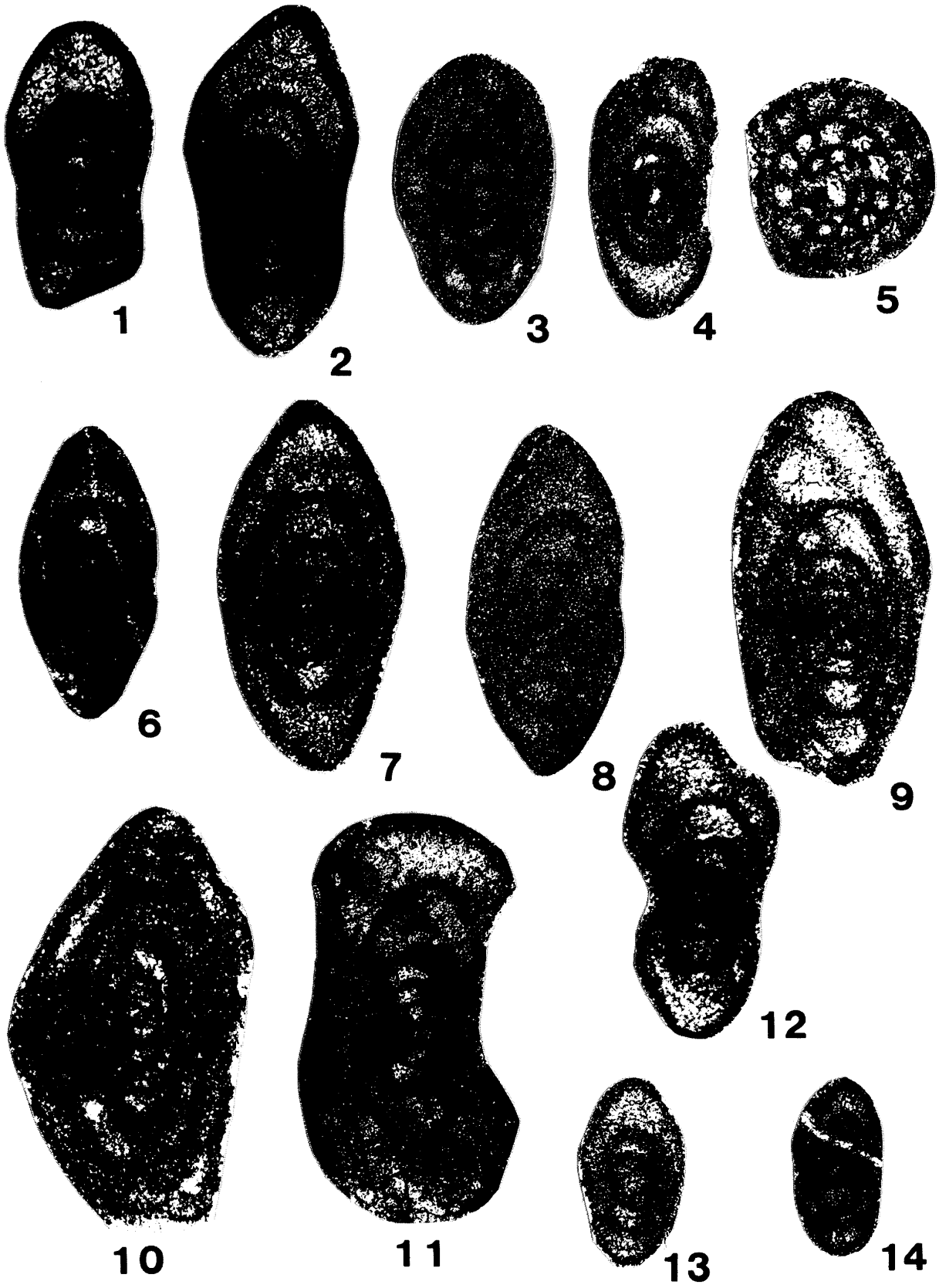
Eostaffella mosquensis Vissarionova, 1948, p. 222, pl. 14, figs. 4-6.
Eostaffella mosquensis, Ganelina, 1951, p. 188-189, pl. 2, figs. 1-2.
Eostaffella mosquensis, Durkina, 1959, p. 196-197, pl. 20, fig. 10.
Eostaffella mosquensis, Rozovskaya, 1963, p. 93-94, pl. 16, figs. 16-17, pl. 17, figs. 1-5.
? *Eostaffella mosquensis*, Ozawa, 1976, p. 121-123, pl. 22, figs. 1-15, 17-19.
Eostaffella mosquensis, Niikawa, 1978, p. 538, pl. 1, figs. 5-7,15.
? *Eostaffella mosquensis*, Rich, 1980, p. 41, pl. 18, figs. 13, 15-16, 20, 25.
Eostaffella mosquensis, Wang Yujing et al., 1981, p. 17, pl. 1, figs. 4-5.
Eostaffella mosquensis, Da Y. and Sun Q., 1983, p. 7, pl. 1, figs. 3-4.
Eostaffella mosquensis, Zhao Zhixin et al., 1984, p. 55, pl. 1, figs. 1-4.
Eostaffella mosquensis, Matsusue, 1986, pl. 6, figs. 1-2.
Eostaffella mosquensis, Niko, 1987, p. 123, figs. 5-D, F, G, H.
Eostaffella mosquensis, Rui Lin, 1987, p. 377-378, pl. 2, figs. 19-23.
? *Eostaffella mosquensis*, Zhang Zuqi et al., 1987, p. 111, pl. 4, fig. 11.
Eostaffella mosquensis, Ueno, 1989, pl. 1, fig. 6.
Eostaffella mosquensis, Ozawa and Kobayashi, 1990, pl. 1, figs. 16-18.
Eostaffella mosquensis, Fujimoto and Sada, 1994, p. 54-55, Figure 4-2.

Remarks. — Shell of *Eostaffella mosquensis* Vissrionova (Figure 7-10) is 314 μm in length and 594 μm in width, giving a form ratio of 0.53. Inner and outer volutions are involute. Outside diameter of proloculus measures 49 μm. Diameters of whorls of the 1st to the 4th volution are 145, 305, 465 and 594 μm, respectively. Spirothecal thickness of the 1st to 4th volution are 11, 20, 35 and 23 μm, respectively.

Eostaffella mosquensis has been described from many places in the Late Chesterian to the Early Morrowan. The present species (Figure 7-10) is poor in preservation. However, it resembles *Eostaffella mosquensis* originally described by Vissarionova in the measured values, internal modes and biocharacters, and can be identified with *Eostaffella mosquensis* Vissarionova (1948).

Localities. — The representative localities are as follows: K56012, K56201 (Hoya area); K55051, K56239 (Iwayadani area); K55011, K55100 (Idekoyama area); H068, K55107 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone.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Eostaffella ikensis Vissarionova
Figure 7-7—9

Eostaffella ikensis Vissarionova, 1948, p. 219-220, pl. 13, figs. 8-10, pl. 14, fig. 1.
Eostaffella ikensis, Grozdilova and Lebedeva, 1954, p. 123-124, pl. 13, figs. 17-18.
Eostaffella ikensis, Durkina, 1959, p. 199, pl. 20, figs. 19-20.
Eostaffella ikensis, Bogush and Yuferev, 1962, p. 173, pl. 6, fig. 28.
Eostaffella ikensis, Rozovskaya, 1963, p. 95-97, pl. 17, figs. 10-19.
Eostaffella ikensis, Han Jianxiu, 1980, p. 20, pl. 1, fig. 19.
Eostaffella aff. *ikensis*, Sashida, 1981, p. 6, pl. 2, figs. 1-2.
Eostaffella ikensis, Da Y. and Sun Q., 1983, p. 7, pl. 1, fig. 1.
Eostaffella ikensis, Matsusue, 1986, pl. 6, fig. 7.
Eostaffella ikensis, Zhang Zuqi et al., 1987, p. 117, pl. 3, fig. 6 .
Eostaffella ikensis, Fujimoto and Sada, 1994, p. 55-56, Figure 4-3.

Remarks. — Shell of *Eostaffella ikensis* Vissarionova illustrated in Figure 7-9 is 246 μm in length and 580 μm in width and has a form ratio of 0. 42. Shell is discoidal in form, with rounded periphery and convex lateral slopes. Inner and outer volutions are involute. Diameters of whorls of the 1st to the 4th volution in a specimen (Figure 7-9) are 118, 192, 316 and 580 μm, respectively. The last whorl expands rapidly.

The present species is closely allied to *Eostaffella ikensis* Vissarionova (1948) in the shell shape, measured values and internal characteristics. They may be conspecific.

Localities. — The representative localities are as follows: K56012, K56201 (Hoya area); K55042, K56241 (Iwayadani area); K55012, K56270 (Idekoyama area); H055, K55119 (Yokomatsu area)

Fusulinacean zone. — *Eostaffella-Millerella* Zone to lower part of *Pseudostaffella-Profusulinella* Zone.

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Figure 7. 1-2. *Eostaffella kanmerai* (Igo), 1-2, Axial sections, Rg. No. K55004e and K55110b, respectively. 3-5. *Eostaffella akiyoshiensis* Sada, 3-4, Axial sections, Rg. No. H065a and H083b1, respectively. 5, Sagittal section, H066a. 6. *Eostaffella paraprisca* Durkina, Axial section, Rg. No. K55053d. 7-9. *Eostaffella ikensis* Vissarionova, 7-9, Axial sections, Rg. No. H055b, K55119b1 and K56270b, respectively. 10. *Eostaffella mosquensis* Vissarionova, Axial section, Rg. No. K56239b. 11. *Eostaffella shuhodoensis* Sada, Axial section, Rg. No. K55106a. 12. *Millerella bigemmicula* Igo, Axial section, Rg. No. H078b. 13-14. *Eostaffella* sp. A, 13-14, Axial sections, Rg. No. H078a and K55116b, respectively.
All figures x100.

Table 8. Measurements of *Eostaffella ikensis* Vissarionova (in mm).

Specimen	H055b	K55119b1	K56270b
Figure	7-7	7-8	7-9
Length	0.249	0.208	0.246
Width	0.527	0.507	0.580
Form ratio	0.47	0.41	0.42
Proloculus	0.038	0.053	0.032
Diameter of whorl			
Vol.			
1	0.106	0.100	0.118
2	0.181	0.184	0.192
3	0.311	0.306	0.316
4	0.527	0.507	0.580
Thickness of spirotheca			
0	0.010	0.010	0.008
1	0.006	0.011	0.012
2	0.011	0.012	0.019
3	0.016	0.014	0.014
4	0.018	0.019	0.025

Eostaffella paraprisca Durkina
Figure 7-6

Eostaffella paraprisca Durkina, 1959, p. 189, pl. 19, fig. 10.
Eostaffella paraprisca, Matsusue, 1986, pl. 6, fig. 3.
Eostaffella paraprisca, Ueno, 1989, pl. 1, fig. 9.
Eostaffella paraprisca, Fujimoto and Sada, 1994, p. 56-57, Figure 3-16—17.

Remarks. — Shell of *Eostaffella paraprisca* Durkina is small for the genus and discoidal in shape. Inner and outer volutions are involute. Shell of the present specimen (Figure 7-6) is 181 μm long and 419 μm wide, giving a form ratio of 0.43. Diameters of whorls of the 1st to the 3rd volution are 111, 239 and 396 μm, respectively.

The present species resembles *Eostaffella paraprisca* described by Durkina (1959) in size, internal modes and biocharacteristics. They may be regarded as the same species.

Localities. — The representative localities are as follows: K55024, K56080 (Hoya area); K55042, K55053 (Iwayadani area); K55010, K55086 (Idekoyama area); H010, H066 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to lower part of *Fusulinella* Zone.

Eostaffella sp. A
Figure 7-13—14

Eostaffella sp. A, Fujimoto and Sada, 1994, p. 59, Figure 4-10—11.

Remarks. — Shell of *Eostaffella* sp. A is discoidal in shape and inner and outer volutions are involute. Shell of the illustrated specimen (Figure 7-13) is 130 μm long and 271 μm wide and its form ratio is 0.48.

The present species is small for the genus and it somewhat resembles *Eostaffella paraprisca* described by Fujimoto and Sada (1994) from the Hina Limestone in Okayama Prefecture. The final identification, however, will be put off until more information is obtained.

Localities. — The representative localities are as follows: K56201, K56202 (Hoya area); K55040, K56035 (Iwayadani area); K55087, K55101 (Idekoyama area); H078, K55116 (Yokomatsu area).

Fusulinacean zone. — *Eostaffella-Millerella* Zone to *Pseudostaffella-Profusulinella* Zone.

Genus *Mediocris* Rozovskaya, 1961

Type species. — *Eostaffella mediocris* Vissarionova, 1948

Mediocris mediocris (Vissarionova)
Figure 6-11—12

Eostaffella mediocris Vissarionova, 1948, p. 222-223, pl. 14, figs. 7-9.
Eostaffella mediocris, Durkina, 1959, p. 193, pl. 20, figs. 1-3 (non pl. 19, fig. 17).
Mediocris mediocris, Rozovskaya, 1963, p. 103-104, pl. 18, figs. 26-33.
Mediocris mediocris, Bogush and Yuferev, 1962, p. 158, pl. 6, fig. 5.
? *Pseudoendothyra* ex. gr. *spiroides*, Okimura, 1963, pl. 39, fig. 16.
Mediocris mediocris, Poyarkov, 1965, p. 96-98, pl. 1, figs. 8-10.
Mediocris mediocris, Mamet, 1973, p. 118, pl. 7, figs. 17-18.
Eostaffella kanmerai, Sada and Danner, 1974, p. 259-261, pl. 37, fig. 1.
Mediocris mediocris, Ozawa, 1976, p. 124-126, pl. 24, figs. 1-14.
Mediocris mediocris, Sashida, 1981, p. 12, pl. 1, figs. 8-10, 13-18.
Mediocris mediocris, Bird and Mamet, 1983, p. 139-140, pl. 1, fig. 10.
Mediocris mediocris, Niko, 1985, p. 170, pl. 2, figs. 1-10, 14-17.
Mediocris mediocris, Adachi, 1985, p. 127, pl. 22, figs. 10-12, 16-17 (non 13-15).
Mediocris evolutis grandiosa, Adachi, 1985, p. 107-108, pl. 19, figs. 11-13.
Mediocris mediocris, Matsusue, 1986, pl. 5, fig. 3.
Mediocris mediocris, Rui Lin, 1987, p. 382, pl. 3, figs. 21-22.
Mediocris mediocris, Ueno, 1989, pl. 1, fig. 1.
Mediocris mediocris, Ozawa and Kobayashi, 1990, pl. 1, fig. 9-10.
Mediocris mediocris, Fujimoto and Sada, 1994, p. 59-60, Figure 3-1—5.

Remarks. — Shell of *Mediocris mediocris* is small and discoidal, with rounded periphery

and umbilicated poles. Inner and outer volutions are involute except for the last one that is partially evolute. Shell of the present species (Figure 6-12) is 168 μm in length and 536 μm in width. Form ratio is 0.31. Spirotheca is composed of a tectum and inner and outer tectoria. Chomata are very primitive and asymmetrical.

The present species may be referable to *Mediocris mediocris* Vissarionova (1948) in general outline of shell, measured values and internal biocharacteristics.

Localities. — The representative localities are as follows: K56024, K56046 (Hoya area); K55035, K56008 (Iwayadani area); K55082, K56291 (Idekoyama area); H019, H022 (Yokomatsu area).

Fusulinacean zone. — *Endothyra-Mediocris* Zone to the lower part of *Eostaffella-Millerella* Zone.

Table 9. Measurements of *Mediocris mediocris* (Vissarionova) (in mm).

Specimen	K55082a	K56046b
Figure	6-11	6-12
Length	0.168	0.168
Width	0.407	0.536
Form ratio	0.41	0.31
Proloculus	0.061	0.041
Diameter of whorl		
Vol.		
1	0.152	0.111
2	0.290	0.204
2 1/2	0.407	
3		0.322
4		0.536
Thickness of spirotheca		
0	0.007	0.013
1	0.006	0.006
2	0.009	0.008
2 1/2	0.010	
3		0.020
4		0.011

Mediocris breviscula (Ganelina)
Figure 6-4—5

Eostaffella mediocris var. *breviscula* Ganelina, 1951, p. 197-198, pl. 3, figs. 1-3.
Mediocris breviscula, Rozovskaya, 1963, p. 108-109, pl. 19, figs. 14-17.
Mediocris breviscula, Poyarkov, 1965, p. 90-95, figs. 1-4.
Mediocris breviscula, Bird and Mamet, 1983, p. 137-139, pl. 1, figs. 1-9.

Mediocris cf. *breviscula*, Ginkel, 1983, p. 208, pl. 1, figs. 5-7.
Mediocris breviscula, Rui, 1987, p. 382, pl. 1, figs. 1-6.
Mediocris aff. *breviscula*, Ginkel, 1987, p. 201-202, Figs. 3.3-3.4.
Mediocris breviscula, Sada et al., 1992, p. 99-102, Figure 3-1—18.

Remarks. — Shell of *Mediocris breviscula* is small and discoidal, possessing rounded periphery and umbilicated poles. Shell of the present species (Figure 6-5) measures 81 μm in length and 219 μm in width. Its form ratio is 0.37. Inner volutions are involute and the last one is partially evolute.

In shell shape, measured values and internal biocharacters, the present species is quite similar to *Mediocris breviscula* described by Ganelina (1951), Ginkel (1983), Rui (1987), Sada et al. (1992) and others.

Localities. — The representative species are as follows: K56015, K56054 (Hoya area); K55038, K55071 (Iwayadani area); K55006, K55095 (Idekoyama area); H020, H033 (Yokomatsu area).

Fusulinacean zone. — *Endothyra-Mediocris* Zone to lower part of *Fusulinella* Zone.

Table 10. Measurements of *Mediocris breviscula* (Ganelina) (in mm).

Specimen	K55038b	K55071b
Figure	6-4	6-5
Length	0.053	0.081
Width	0.200	0.219
Form ratio	0.27	0.37
Proloculus	0.036	0.031
Diameter of whorl		
Vol.		
1	0.107	0.095
2	0.200	0.118
2 1/2		0.219
Thickness of spirotheca		
0	0.009	0.008
1	0.008	0.006
2	0.007	0.006
2 1/2		0.010

Genus *Pseudostaffella* Thompson, 1942

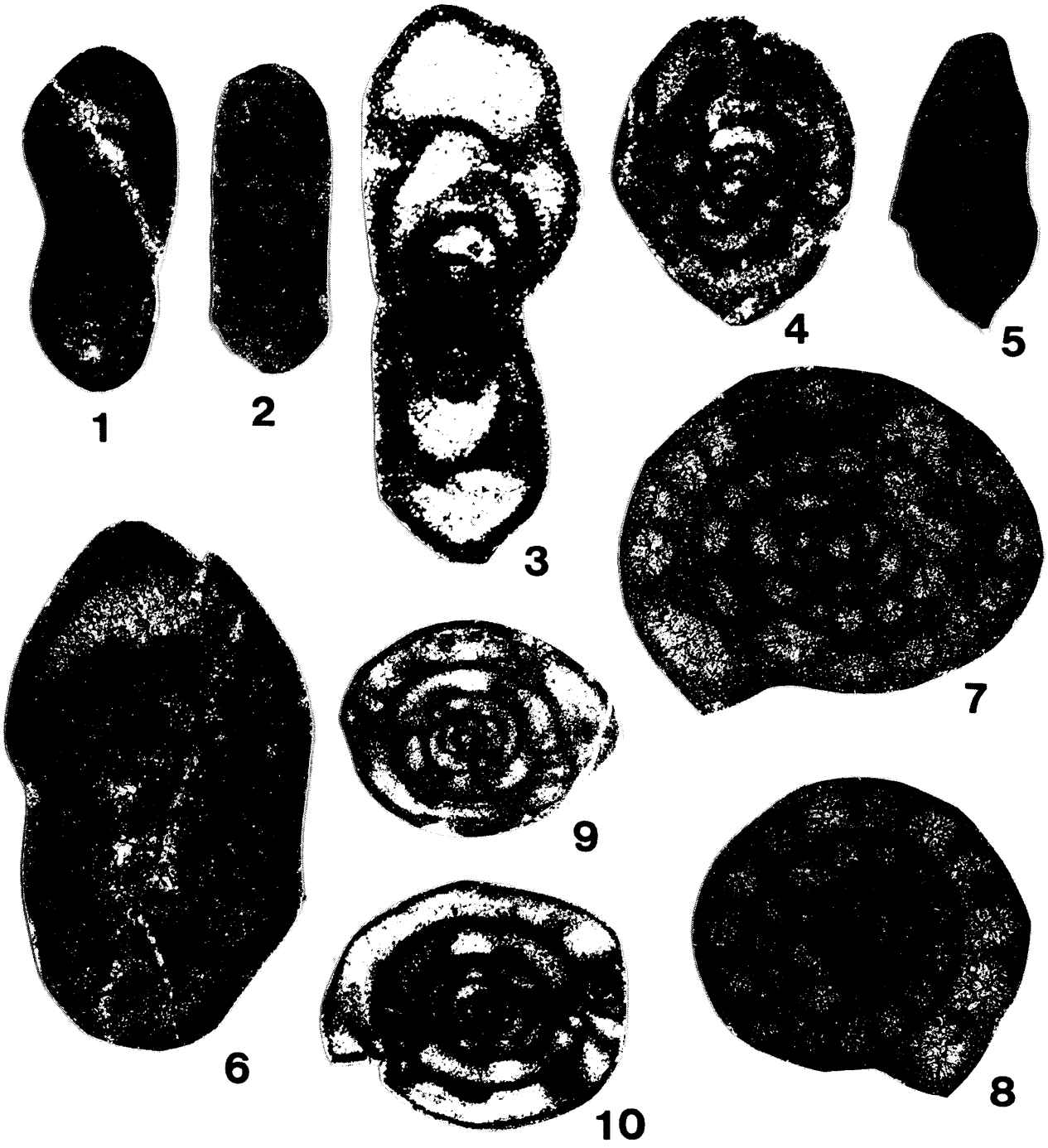
Type species. — *Pseudostaffella needhami* Thompson, 1942

Pseudostaffella minuta Sada

Figure 8-4

Pseudostaffella minuta Sada, 1975a, p. 21-22, pl. 7, figs. 6-9.
Pseudostaffella minuta, Matsusue, 1986, pl. 7, fig. 1.
? *Pseudostaffella (Semistaffella) variabilis*, Ozawa and Kobayashi, 1990, pl. 2, figs. 7-8.
Pseudostaffella minuta, Fujimoto and Sada, 1994, p. 63-64, Figure 5-11—14.

Remarks. — Shell of the illustrated specimen (Figure 8-4) is very small and subspherical and is 310 μm long and 408 μm wide, giving a form ratio of 0.76. Proloculus measures 30 μm. Diameters of whorls of the 1st to the 4th-and-a-half volution are 83, 145, 229, 345 and 408 μm, respectively. Spirotheca consists of a tectum and inner and outer tectoria. Spirothecal thickness of the first to the 4th-and-a-half volution is 6 to 24 μm.



The present species are identified with *Pseudostaffella minuta* Sada (1975a) from the Akiyoshi Limestone of Yamaguchi Prefecture in shell shape, internal biocharacters and measured values.

Localities. — The representative localities are as follows: K56013, K56018 (Hoya area); K55045, K56010 (Iwayadani area); K55004, K55089 (Idekoyama area); H062, H083 (Yokomatsu area).

Fusulinacean zone. — *Pseudostaffella-Profusulinella* Zone.

Pseudostaffella taishakuensis Sada
Figure 8-9—10

Pseudostaffella taishakuensis Sada, 1972, p. 440-441, pl. 52, figs. 13-21, pl. 53, fig. 12.

Remarks. — Shell of the present species (Figure 8-10) is small and subspherical in shape. Shell of 5th-and-a-half volutions measures 802 μm in length and 657 μm in width. Its form ratio is 1.2. Spirotheca is composed of a tectum and inner and outer tectoria. Chomata are well developed in the outer volutions.

Judging from general outline of shell, internal modes and measured values of shell, the present species can be referred to *Pseudostaffella taishakuensis* originally described by Sada (1972) from the Taishaku Limestone.

Localities. — The representative localities are as follows: K56018, K56202 (Hoya area); K55043, K56252 (Iwayadani area); K55086, K55098 (Idekoyama area); H082, H083 (Yokomatsu area).

Fusulinacean zone. — *Pseudostaffella-Profusulinella* Zone.

←

Figure 8. 1-3. *Millerella marblensis* Thompson, 1-3, Axial sections, Rg. No. H056b, K55089b and H082a1, respectively. 4. *Pseudostaffella minuta* Sada, Axial section, Rg. No. H083a. 5. *Ozawainella japonica* Sada, Axial section, Rg. No. K55048d. 6. *Nankinella yokoyamai* Sada, Axial section, Rg. No. K55047c. 7-8. *Profusulinella* sp., 7-8, Sagittal sections, Rg. No. K55119b2 and K55119b3, respectively. 9-10. *Pseudostaffella taishakuensis* Sada, 9-10, Axial sections, Rg. No. H083b2 (x50) and H082a2 (x50), respectively.
All figures x100 unless otherwise stated.

Table 11. Measurements of *Pseudostaffella taishakuensis* Sada (in mm).

Specimen	H083b2	H082a2
Figure	8-9	8-10
Length	0.737	0.802
Width	0.576	0.657
Form ratio	1.28	1.22
Proloculus	0.027	0.030
Diameter of whorl		
Vol.		
1	0.068	0.111
2	0.114	0.186
3	0.209	0.220
4	0.309	0.369
5	0.472	0.560
5 1/2	0.576	0.657
Thickness of spirotheca		
0	0.005	0.008
1	0.005	0.011
2	0.010	0.013
3	0.013	0.015
4	0.029	0.018
5	0.031	0.017
5 1/2	0.026	0.020

Family Fusulinidae von Moller, 1878
Subfamily Fusulinellinae Staff and Wedekind, 1910

Genus *Profusulinella* Rauzer-Chernousova and Beljaev, 1936

Type species. — *Profusulinella pararhomboides* Rauzer-Cherunousova and Beljaev, in Rauzer-Chernousova et al., 1936

Profusulinella toriyamai Sada
Figure 9-1—2

Profusulinella sp. A Toriyama, 1958, p. 35-36, pl. 1, figs. 20-21.
Profusulinella toriyamai Sada, 1961, p. 97-99, pl. 9, figs. 1-13.
Profusulinella toriyamai, Sada, 1972, p. 438-439, pl. 52, figs. 1-4.

Remarks. — Shell of *Profusulinella toriyamai* Sada is small and ellipsoidal in shape. The present specimen illustrated in Figure 9-2 is 546 μm long and 393 μm wide, giving a form ratio of 1.3. Proloculus is spherical and its outside diameters is 61 μm. Diameters of

whorls of the 1st to the 4th volution are 103, 168, 278 and 393 μm, respectively. Spirotheca consists of a tectum and inner and outer tectoria and its thickness of the 1st to the 4th volution is 8 to 23 μm.

In shell shape, internal modes and measured values, the present species is ascribed to *Profusulinella toriyamai* Sada.

Localities. — The represetative localities are as follows: K56019, K56066 (Hoya area); K56010, K56250 (Iwayadani area); H071, H083 (Yokomatsu area).

Fusulinacean zone. — Upper part of *Pseudostaffella-Profusulinella* Zone to *Fusulinella* Zone.

Superfamily Endothyracea Brady, 1884
Family Endothyridae Brady, 1884
Subfamily Endothyrinae Brady, 1884

Genus *Endothyra* Phillips, 1846
emend. Brady, 1846

Type species. — *Endothyra bowmani* Phillips, 1846

Endothyra exilis Rauzer-Cherunousova
Figure 6-1—2

Endothyra exilis Rauzer-Chernousova, 1948, p. 178-179, pl. 5, figs. 11-13.
Endothyra exilis, Golubtsov, 1957, p. 110-111, pl. 2, figs. 15-16.
Plectogyra exilis, Ivanova, 1973, pl. 5, fig. 8 ; pl. 14, fig. 11.
Omphalotis ? exilis, Armstrong and Mamet, 1977, p. 65.
Endothyra exilis, Rich, 1980, p. 21, pl. 6, fig. 6 ; pl. 7, figs. 1, 2, 16.

Remarks. — Shell of *Endothyra exilis* Rauzer-Chernousova illustrated in Figure 6-1 is discoidal and skew-coiled throughout growth. Shell is umbilicate on one side and involute to partially evolute. It is 204 μm in length 508 μm in width, giving a form ratio of 0. 40. Septa are straight to moderately curved and bent anteriorly. Spirotheca is composed of a thin tectum, and microgranular and thick fibrous inner layer.

The present specimens are similar to the specimens reported as *Endothyra exilis* by Rauzer-Chernousova (1948), Armstrong and Mamet (1977) and Rich (1980) in size, mode of coiling and internal biocharacters of shell.

Localities. — The represetative localities are as follows: K56013, K56025 (Hoya area); K55037, K55071 (Iwayadani area); K55092, K56020 (Idekoyama area); KH006, H006 (Yokomatsu area).

Fusulinacean zone. — *Endothyra-Mediocris* Zone to lower part of *Psudostaffella-Profusulinella* Zone.

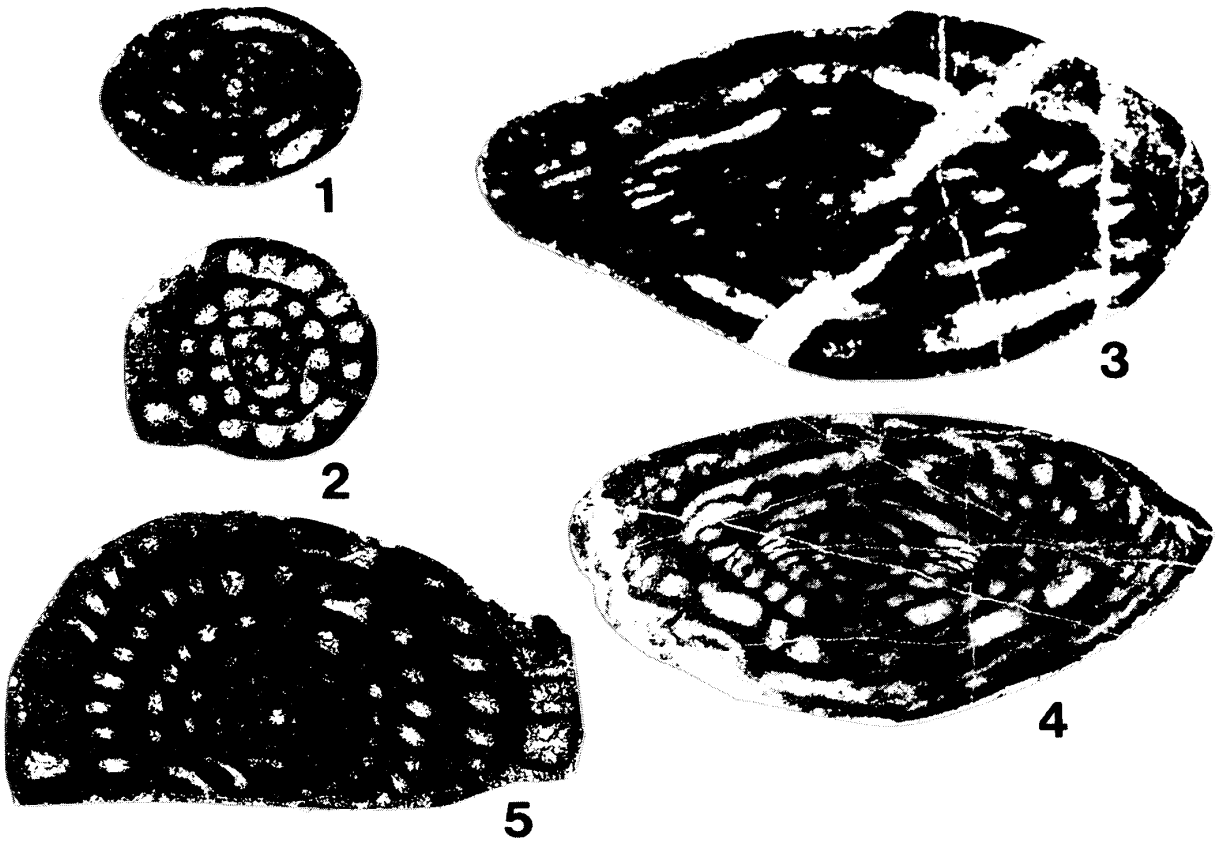


Figure 9. 1-2. *Profusulinella toriyamai* Sada, 1, Axial section, Rg. No. K56066b (x 50). 2, Sagittal section, Rg. No. H083b3 (x 50). 3-5. *Fusulinella taishakuensis* Sada, 3, Axial section, Rg. No. KH016b. 4, Tangential section, Rg. No. K56251b. 5, Sagittal section, Rg. No. K55027a.
All figures x40 unless otherwise stated.

References

Adachi, S. (1985): Smaller foraminifers of the Ichinotani Formation (Carboniferous-Permian), Hida Massif, central Japan. *Sci. Rep. Inst. Geosci., Univ. Tsukuba, Ser. B*, **6**, 59-139, pls. 8-23.

Armstrong, A. K. and Mamet, B. L. (1977): Carboniferous microfacies, microfossils and corals, Lisburne Group, Arctic Alaska. *U. S. Geol. Survey, Prof. Paper*, 849, 1-144, pl. 1-39.

Bird, K. J. and Mamet, B. L. (1983): Carboniferous foraminifer *Mediocris*, first occurrence in northern Alaska. *Jour. Foram. Res.*, **13**, 2, 134-143, pl. 1.

Bogush, O. I. and Yuferev, O. V. (1962): Foraminifery i stratigrafiya kamennougol'nykh otlozhenii Karatau i Talasskogo Alatau. *Akad. Nauk. SSSR, Sibirskoe Otdel., Inst. Geol. i Geofiz.*, 1-234, pls.1-9 (in Russian).

Da Yingtai and Sun Qiaoli (1983): Order Fusulinida. *In Paleontological Atlas of Northwestern China, Xinjian (2), (Late Paleozoic)*, 7-113, pls. 1-30 (in Chinese).

Douglass, R. C. (1971): Pennsylvanian fusulinids from southeastern Alaska. *U. S. Geol. Survey, Prof. Paper*, 706, 1-21, pls. 1-7.

Durkina, A. V. (1959): Foraminifery nizhnekamennougol'nykh otlozhenii Timano-Pechorskoi provinsii. *Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. (VNIGRI) Trudy, Nov. Ser.*, **136**, *Mikrofauna SSSR*, 10, 132-335, pls. 1-27 (in Russian).

Fujimoto, M. and Sada, K. (1994): Carboniferous primitive fusulinacea from the Hina Limestone in Okayama Prefecture, western Japan. *Mem. Fac. Integrated Arts and Sci., Hiroshima Univ., Ser. IV*, **20**, 47-70.

Ganelina, R. A. (1951): Eoshtaffelly i millerelly vizeiskogo i Namyurskogo yarusov nizhnego Karbona zapadnogokryla podmoskovnoi kotloviny. *Inst. (VNIGRI) Trudy, Nov. Ser.*, **56**, *Mikrofauna SSSR*, 6, 179-210, pls. 1-3 (in Russian).

Ginkel, A. C. van (1983): Carboniferous fusulinids in a coastal section near Pendueles (Asturias, Spain). *Leidse Geol. Med.*, **52**, 2, 193-263, pls. 1-11.

Ginkel, A. C. van (1987): Systematics and biostratigraphy of fusulinids of the Lena Formation (Carboniferous) near Puebla de Lillo (Leon, NW Spain). *Palaeontology, Proceed. B*, **90**, 3, 188-276.

Groves, J. R. (1983): Calcareous foraminifers and algae from the type Morrowan (Lower Pennsylvanian) region of northeastern Oklahoma and northwestern Arkansas. *Bull. Oklahoma Geol. Survey*, 133, 1-65.

Groves, J. R. (1984): Foraminifers and biostratigraphy of the Arco Hills, Bluebird Mountain, and lower Snaky Canyon Formations (Mid-Carboniferous) of east-central Idaho. *Jour. Foram. Research*, **14**, 4, 282-302, pls. 1-8.

Grozdilova, L. P. and Lebedeva, N. S. (1954): Foraminifery nizhnego karbona Kolvo-Visherskogo kraya. *Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. (VNIGRI) Trudy*, **81**, *Mikrofauna SSSR*, 7, 4-203, pls. 1-15 (in Russian).

Han Jianxiu (1980): Phylum Protozoa, Fusulinida. *In Paleontological Atlas of Northeast China (1), Paleozoic volume*, 18-95, pls. 1-35 (in Chinese).

Igo, H. (1957): Fusulinids of Fukuji, southeastern part of the Hida Massif, central Japan. *Sci. Rep. Tokyo Kyoiku Daigaku, Ser. C*, **5**, 47, 153-246, pls. 1-15.

Igo, H. and Adachi, S. (1981): Foraminiferal biostratigraphy of the Ichinotani Formation (Carboniferous-Permian), Hida Massif, central Japan. Part 1-Some foraminifers from the upper part of the Lower Member of the Ichinotani Formation. *Sci. Rep., Inst. Geosci., Univ. Tsukuba, Ser. B*, **2**, 101-118, pls. 4-6.

Kobayashi, F. (1973): Fusulinids of Nagaiwa Formation. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 92, 200-219, pls. 30-31.

Kobayashi, T. (1950): Regional geology of Japan, Chugoku region. *Asakura Shoten, Tokyo* (in Japanese).

Mamet, B. L. (1973): Microfacies Viseens du Boulonnais (Nord, France). *Revue du Micropaleont.*, **16**, 2, 101-124.

Matsusue, K. (1986): Foraminiferal biostratigraphy of the lower part of the Akiyoshi Limestone Group. *Sci. Repts., Dept. Geol., Kyushu Univ.*, **14**, 4, 163-185, pls. 2-7 (in Japanese with English abstract).

Matsusue, K. (1992): The Mid-Carboniferous boundary in the Akiyoshi Limestone Group, Southwest Japan, based on foraminifers. *In* Takayanagi, Y. and Saito, T. eds., *Studies in Benthic Foraminifera, Benthos '90, Sendai, 1990*, 381-388.

Moore, W. L. (1964): Note on the morphology and taxonomic position of the fusulinid *Millerella marblensis* Thompson. *Jour. Paleont.*, **38**, 2, 294-305, pls. 47-48.

Niikawa, I. (1978): Carboniferous and Permian fusulinids from Fukuji, central Japan. *Jour. Fac. Sci., Hokkaido Univ., Ser. 4*, **18**, 4, 536-610, pls. 1-14.

Niko, S. (1985): *Mediocris* (primitive fusulinacea) from the Ichinotani Formation, Fukuji District, central Japan. *Sci. Papers, Coll. Arts Sci., Univ. Tokyo*, **35**, 2, 165-180. pls. 1-3.

Niko, S. (1987): Early Carboniferous *Eostaffella* (primitive fusulinacea) from the Ichinotani Formation, Fukuji district, central Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 147, 117-130.

Okimura, Y. (1963): Foraminiferal zones underlying the *Profusulinella beppensis* Zone of the Akiyoshi Limestone Group. *Geol. Repts. Hiroshima Univ.*, 12, 305-318, pl. 39 (in Japanese with English abstract).

Ota, M. (1971): Faunas and correlation of the "Uzura" quarry limestone of Akiyoshi, Southwest Japan, Part 2, Fusulininan fauna. *Bull. Akiyoshi-dai Sci. Museum*, 7, 65-74, pls. 12-13.

Otoh, S. (1985): Unconformity between the non-metamorphic Paleozoic strata and the Upper Triassic Nariwa Group in the Oga area, Okayama Prefecture. *Jour. Geol. Soc. Japan*, **91**, 779-786 (in Japanese with English abstract).

Ozawa, T. (1976): Late Visean *Eostaffella* (Fusulininan foraminifera) from West Malaysia. *GPSEA*, 17, 117-128, pls. 22-24.

Ozawa, T. and Kobayashi, F. (1990): Carboniferous to Permian Akiyoshi Limestone Group. *In Organizing Committee Benthos '90 ed., Fossil and recent benthic foraminifera in some selected regions of Japan. Guidebook for field trips, 4th Intern. Symp. on Benthic Foraminifera, Sendai, 1990*, E1-E31, pls. 1-13.

Ozawa, Y. (1925): The post-Paleozoic and late-Mesozoic earth movements in the Inner Zone of Japan. *Jour. Fac. Sci. Imp. Univ. Tokyo, II* , 1, 91-104.

Pajic, V. (1965): The middle Carboniferous microfauna of western Serbia. *Bull. Inst. Geol. Geophys. Research (PROSVETA, Belgrade), Ser. A*, 21, 235-253.

Poyarkov, B. V. (1965): Sistjematika i filogenija roda *Mediocris* Rozovskaya, 1961. *Trudy Inst. Geol. Nauk Akad., SSSR, Voprosy Mikropaleontologii*, 9, 89-110, pl. 1 (in Russian).

Rauzer-Chernousova, D. M. (1948): O nekotorykh endotirakh gruppy *Endothyra bradyi* Mikailov. *Akad. Nauk SSSR, Inst. Geol. Nauk Trudy*, 62, *Geol. Ser.*, 19, 176-181, pl. 5 (in Russian).

Rich, M. (1961): Stratigraphic section and fusulinids of the Bird Spring Formation near Lee Canyon, Clark County, Nevada. *Jour. Paleont.*, 35, 6, 1159-1180, pls. 142-146.

Rich, M. (1980): Carboniferous calcareous foraminifera from northeastern Alabama, south-central Tennessee, and northwestern Georgia. *Contrib. Cushman Found. Foram. Research, Spec. Pub.*, 18, 1-62, pls. 1-22.

Ross, C. A. and Sabins, F. F. (1965): Early and Middle Pennsylvanian fusulinids from southeastern Arizona. *Jour. Paleont.*, 39, 2, 173-209, pls. 21-28.

Ross, C. A. and Tyrrell, W. W. (1965): Pennsylvanian and Permian fusulinids from the Whetstone Mountains, Southeast Arizona. *Ibid.*, 39, 4, 615-635, pls. 75-78.

Rozovskaya, S. E. (1963): Drevneiie predstaviteli fuzulinid i ikh predki. *Trudy Paleont. Inst. Nauk Akad., SSSR*, 97, 1-128, pls. 1-22 (in Russian).

Rui Lin (1983): Fusulinacean fauna from the Quanwangtou Limestone (early Upper Carboniferous) in Jiawang coal-field, northern Jiangsu. *Acta Palaeont. Sinica*, 22, 2, 170-182, pls. 1-2 (in Chinese with English abstract).

Rui Lin (1987): Fusulinaceans across Mid-Carboniferous boundary at Luosu of Luodian County, southern Guizhow. *Ibid.*, 26, 4, 367-391, pls. 1-3 (in Chinese with English abstract).

Sada, K. (1961): *Profusulinella* of Atetsu Limestone. *Jour. Sci. Hiroshima Univ., Ser. C*, 4, 1, 95-116, pls. 9-10.

Sada, K. (1964): Carboniferous and Lower Permian fusulinids of the Atetsu Limestone in West Japan. *Ibid.*, 4, 3, 225-269, pls. 21-28.

Sada, K. (1967): Fusulinids of the *Millerella* Zone of the Taishaku Limestone (Studies of the stratigraphy and the microfossil faunas of the Carboniferous and Permian Taishaku Limestone in West Japan, No. 1). *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 67, 139-147, pls. 12-13.

Sada, K. (1969): Microfossils of the lowest part of the Taishaku Limestone (Ditto, No. 4). *Ibid.*, 75, 119-129, pls. 12-13.

Sada, K. (1972): Fusulinids of the *Profusulinella* Zone of the Taishaku Limestone (Ditto, No. 2). *Ibid.* 87, 436-445, pls. 52-53.

Sada, K. (1975a): Early and Middle Pennsylvanian fusulinacea from Akiyoshi. *Mem. Fac. Integrated Arts and Sci., Hiroshima Univ., Ser. IV*, 1, 1-29. pls. 1-7.

Sada, K. (1975b): Early and Middle Pennsylvanian fusulinacea from the Omi Limestone in Japan. *Ibid.*, 1, 31-39, pl. 1.

Sada, K. (1980): Primitive fusulinacea from the Nakamura Limestone in western Japan. *Jour. Paleont.*, 54, 1, 65-70, pl. 1.

Sada, K. and Danner, W. R. (1974): Early and Middle Pennsylvanian fusulinids from southern British Columbia, Canada and northwestern Washington, U. S. A. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 93, 249-265, pls. 35-37.

Sada, K., Nomura, K. and Oho, Y. (1984): Primitive fusulinacea from Dangyokei of Taishaku (Studies of the stratigraphy and the microfossil faunas of the Carboniferous and Permian Taishaku Limestone in West Japan, No. 5). *Trans. Proc. Palaeont. Soc. Japan, N. S.*, 134, 388-392, pl. 75.

Sada, K., Tanaka, K., Fujimoto, M. and Oho, Y. (1992): Carboniferous primitive fusulinacean and endothyracean faunas in the lower part of the Atetsu Limestone. *Mem. Fac. Integrated Arts and Sci., Hiroshima Univ., Ser. IV*, 17, 91-109.

Sashida, K. (1981): Primitive fusulinids from the Shishidedai area, northeastern Akiyoshi Plateau, Southwest Japan. *Sci. Rep., Inst. Geosci., Univ. Tsukuba, Ser. B*, 2, 1-16, pls. 1-3.

Skinner, J. W. and Wilde, G. L. (1954): Fusulinid wall structure. *Jour. Paleont.*, 28, 4, 445-451, pls. 46-52.

Thompson, M. L. (1942): New genera of Pennsylvanian fusulinids. *Am. Jour. Sci.*, 240, 403-420, pls. 1-3.

Thompson, M. L. (1944): Pennsylvanian Morrowan rocks and fusulinids of Kansas. *Bull. Kansas Geol. Survey*, 52, 409-431, pls.1-2.

Thompson, M. L. (1948): Studies of American fusulinids. *Univ. Kansas, Paleont. Contrib. Protozoa*, 1, 1-184, pls.1-38.

Thompson, M. L. (1951): New genera of fusulinid foraminifera. *Contrib. Cushman Found. Foram. Research*, 2, 4, 115-119, pls. 12-13.

Toriyama, R. (1958): Geology of Akiyoshi, Part III, Fusulinids of Akiyoshi. *Mem. Fac. Sci., Kyusyu Univ., Ser. D, Geol.*, 7, 1-264.

Ueno, K. (1989): Carboniferous and Lower Permian foraminiferal biostratigraphy in the Akiyoshi Limestone Group. Studies of the Upper Paleozoic foraminifers in the Akiyoshi Limestone Group, Southwest Japan. Part 1. *Bull. Akiyoshi-dai Mus. Nat. Hist.*, 24, 1-39, pls. 1-8 (in Japanese with English abstract).

Vissarionova, A. Ya. (1948): Primitivnye fusulinidy iz nizhnego karbona Evropeiskoi chasti SSSR. *Akad. Nauk SSSR, Inst. Geol. Nauk Trudy*, 62, *Geol. Ser.*, 19, 216-226, pls. 13-14 (in Russian).

Wang Yujing, Sheng Jinzhang and Zhang Linxin (1981): Fusulinids from Xizang of China.

Ser. Sci. Exped. Qinghai-Xizang Plateau, Palaeont. of Xizang, Book 3, 1-80 (in Chinese).

Yokoyama, T., Hase, A. and Okimura, Y. (1979): Sedimentary facies of Koyama Limestone. *Jour. Geol. Soc. Japan*, **85**, 1, 11-25 (in Japanese with English abstract).

Yoshimura, N. (1961): Geological Studies of the Paleozoic Group in the Oga Plateau, Central Chugoku, Japan. *Geol. Rep. Hiroshima Univ.*, 10, 1-36 (in Japanese with English abstract).

Zeller, D. E. N. (1977): Microfauna from Chesterian (Mississippian) and Morrowan (Pennsylvanian) rocks in Washington County, Arkansas, and Adair and Muskogee Counties, Oklahoma. *Oklahoma Geological Survey Guidebook*, 18, 89-99, pls. 1-3.

Zhang Zuqi, Wang Hongbo and Xie Helin (1987): The Early Datangian Stage fusulinid fauna of Early Carboniferous from Liannan, Guangdong. *Spec. Paper Nation. Carb. Symp. China*, 93-149, pls. 1-4 (in Chinese with English abstract).

Zhao Zhixin, Han Jianxiu and Wang Zengji (1984): The Carboniferous strata and its fauna from southwestern margin of Tarim Basin in Xinjiang. *Geol. Publ. House*, 1-187, pls. 1-35 (in Chinese).