TWO SPECIES OF PROFUSULINELLA (P. ALJUTOVICA AND P. OVATA), EARLY MOSCOVIAN (PENNSYLVANIAN) FUSULINES FROM SOUTHERN TURKEY AND SUBDIVISION OF PRIMITIVE GROUPS OF THE FAMILY FUSULINIDAE

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Abstract. Early Moscovian (Pennsylvanian) fusulines, Profusulinella aljutovica and Profusulinella ovata, from the Hadim area, southern Turkey, are described systematically. They are contained in the bedded limestone (algal fusuline grainstone) of the Yaricak Formation of the Aladag Unit in the Tauride Block. Morphologic analysis of these and similar species suggests: (1) Aljutovella should be synonymous with Profusulinella; (2) Ovatella, Depratina, Staffelaeformes, Aljutovella (Elongatella), Tikhonovichella, Sknevetatella, and Priscodella proposed in 1980’s and 1990’s are also synonymous with Profusulinella; and (3) the families Profusulinellidae and Aljutovelliidae are not necessary and Profusulinella is included in the subfamily Fusulinellinae placed under the family Fusulinidae.

Riassunto. Viene descritta la sistematica di due fusulinidi dal Moscoviano inferiore (Pennsylvaniano) Profusulinella aljutovica e Profusulinella ovata, provenienti dall’area di Hadim, nella Turchia meridionale. Le specie provengono da un calcare stratificato (grainstone alga e fusuline) della Formazione Yaricak nell’unità strutturale Aladag nei Tauridi. L’analisi morfologica di queste forme e di altre specie simili suggerisce che: 1) il genere Aljutovella dovrebbe essere sinonimo con Profusulinella; 2) Ovatella, Depratina, Staffelaeformes, Aljutovella (Elongatella), Tikhonovichella, Sknevetatella e Priscodella, genitori proposti negli anni 1980 e 1990 sono ugualmente sinonimi con Profusulinella; e 3) le famiglie Profusulinellidae e Aljutovelliidae non sono necessarie, con Profusulinella inclusa nella sottofamiglia Fusulinellinae, posta entro la famiglia Fusulinidae.

Introduction

Fusuline faunas of the Tauride Block in the Hadim area, southern Turkey (Fig. 1) have particular implications in relation to the paleogeographic loca-
Moscovian (Vereian) limestones of the Yaricak Formation in the Hadim area, southern Turkey. The taxonomy of Profusulinella and similar taxa are discussed in conjunction with systematic description of these two species. The limestone sample used in this paper was collected from the Hadim area on the occasion of the field excursion immediately after the conference on Paleozoic Benthic Foraminifera (PaleoForum 2001) held in Ankara 20–24 August 2001.

All the specimens herein described are registered with prefix D2- and stored in the Museum of Nature and Human Activities, Hyogo, Japan (Fumio Kobayashi Collection, MNHAM).

**Fig. 1** - Map showing the distribution of the Tauride Block and the Hadim area, southern Turkey.

### Material and foraminiferal fauna

In the Hadim area, the Serpukhovian is subdivided into three fusuline zones, the Bashkirian into four, and the Moscovian into two based on the first occurrences of zonal species (Altiner & Özgül 2001). Profusulinella first appears in the fourth zone of the Bashkirian (Profusulinella Zone) and ranges into the lower zone of the Moscovian (Eofusulina mutabilis - Profusulinella prisca - Eofusulina (Paraefusulina) Zone). Pseudostaffella antiqua, P. antiqua grandis, P. compressa, P. proozaeai, Profusulinella bonai, P. parva, P. staffellaformis, and P. rhomboides are reported from the Bashkirian Profusulinella Zone. In addition to three zonal indicators, Pseudostaffella praegeorski, two species of Neostaffella, eight species of Profusulinella including P. primitiva and P. subovata, four species of Aljutovella, and Eofusulina triangula are characteristic of the lower part of the Moscovian (Altiner & Özgül 2001). Profusulinella and Aljutovella were not reported from the upper part of the Moscovian (Profusulinella ex gr. bocki - Beedina Zone) according to Altiner & Özgül (2001).

Sample treated herein was collected from Moscovian limestone of the Yaricak Formation exposed at the point (36° 54′ 44″ N and 32° 23′ 24″ E), about 10 km SW of the town of Hadim, southern Turkey (Fig. 1). It is highly fossiliferous and consists of algal limestone grainstone with dominant foraminifers, subordinate red algae (Ungarella and Konia) and problematic algae, and accessory brachiopods and crinoids. Fusulines are mostly assignable to Profusulinella aljutovica and Profusulinella ovata. Other genera are Staffella, Nasakinella, Eofusulina, and Eoschubertella. The Moscovian, consisting of the Vereian, Bashkirian, Podolskian, and Myachkovian substages in ascending order, is biostratigraphically subdivided into 11 fusuline zones in the stratotype sections of the Moscow Synclise (Isakova 2002). Eofusulina and evolved forms of Neostaffella that first appeared in the Kashirian in the type sections (Isakova 2002) are not contained in the present material. Non-fusuline foraminifers are assigned to Bradyina, Endothyra, Planendothyra, Globivalvulinia, Bisertella, Palaeotextularia, and Spiriferina. Based on the foraminiferal assemblage, the present sample is thought to be early Moscovian (Vereian) assignable to the lower part of the Eofusulina mutabilis - Profusulinella prisca - Eofusulina (Paraefusulina) Zone of Altiner & Özgül (2001).

### Subdivision of primitive groups of the Family Fusulinidae

Rauzer-Chernousova in Rauzer-Chernousova et al. (1951) proposed the genus Aljutovella and assigned to it seven species and varieties formerly assigned to Profusulinella, Fusulinella, or Fusulina, as well as 25 new species. Aljutovella was distinguished from Profusulinella by having characteristic “вьечки” referable to cells, meshes, alveoli, or other meanings in tangential sections that resemble the structure of the septa of the genus Fusulina and the partial “поры” referable to pores in the wall of the outermost whorl. The former probably corresponds not to alveolar wall but to small cells or chamberlets formed by septal folding. The latter is found in Kashirian forms (Rauzer-Chernousova et al., 1951, p. 21, Fig. 8B). A porous wall under the tectum is also recognized in some species of Profusulinella. Thus, Aljutovella in the original description is not clearly distinguished from Profusulinella based both on slight differences of their wall structure and of an intensity and mode of septal folding in axial and polar regions in generic rank, though it might be possible in species rank.

Aljutovella has been widely accepted by Russian workers (e.g., Rauzer-Chernousova et al. 1951; Bensh 1969; Rozovskaya 1975; Leven & Davydov in Leven et al. 2005) and by others outside Russia (e.g., Sheng 1958; van Ginkel 1965; Villa 1995). In contrast, it has been questioned by some workers (e.g., Thompson 1964; Loeblich & Tappan 1988). Ross (1999) showed that the porous wall of Aljutovella is diagenetic feature commonly found in other poorly preserved fusulines in weathered zones. Disagreement concerning the generic composition and classification of the family Fusulinidae increased pursuant to the creation of many new genera and subgenera under the new families Profusulinellidae and Aljutovellidae by Solovieva in Rauzer-Chernousova et al. (1996).

The family Profusulinellidae was erected to accommodate six genera, Profusulinella, Taitzeboellia, Sheng, 1951, Ovatella Solovieva in Rauzer-Chernousova et al., 1996, Depratina Solovieva in Rauzer-Chernousova et al., 1996, Staffellaformes Solovieva, 1986, and Moellerites Solovieva, 1986. As indicated by
Villa et al. (2001) and Groves et al. (2007), three species groups within Profusulinella were reorganized by Solovieva in Rauzer-Chernousova (1996) into Ovatella, Depratina, and Staffellaeformes. Groves et al. (2007) thought that Moellerites was erected for the transitional forms from Profusulinella to Fusulinella.

The family Aljutovellidae consists of Aljutovella (Aljutovella), Aljutovella (Elongatella), Tikhonovichiella, Skelnevatella, and Priscoidella according to Solovieva in Rauzer-Chernousova et al. (1996). These genera and subgenera were proposed by the reorganization of known species groups of Aljutovella. Profusulinella aljutovica elongata Rauzer-Chernousova, 1938 Aljutovella tikhonovichi Rauzer-Chernousova in Rauzer-Chernousova et al., 1951 Profusulinella skelnevatica Putrya in Putrya & Leontovich, 1948 and Profusulinella priscoidea Rauzer-Chernousova, 1938 were designated as the type species of Aljutovella (Elongatella), Tikhonovichiella, Skelnevatella, and Priscoidella, respectively. Three-layered wall structure (tectum and lower and upper tectoria) is clearly expressed in the original description of these type species. A diaphanotheca is partly developed in the terminal whorl of Profusulinella priscoidea according to Rauzer-Chernousova (1938). Although shape and massiveness of chomata were added to the diagnostic features of the family Aljutovellidae in Rauzer-Chernousova et al. (1996), Aljutovella and related forms are not easily distinguished from Profusulinella. In my opinion, differences in the development of chomata, shape of the test and intensity of septal folding are expressed within and among populations, and these differences are insufficient to warrant the recognition of multiple genera and subgenera. The recognized generic composition of Aljutovellidae by recent workers (e.g., Isakova 2002; Leven 2009) follows that by Solovieva in Rauzer-Chernousova et al. (1996).

Profusulinella aljutovica from the Hadim area, shown in Pl. 1, has a more elongate fusiform test and stronger septal folding than Profusulinella ovata. The wall consists of thin distinct tectum and lower thicker protheca comparable to the lower tectorium of previous authors. A thin layer comparable to the upper tectorium is not always present. Presence or absence, and thickness of the upper tectorium largely depend upon the state of preservation of specimens. Broad morphologic variations are recognized in every test character as well as in those of Profusulinella ovata illustrated in Pl. 2. For example, the specimens shown in Pl. 1, figs. 3 and 10 look like a form of “Skelnevatella” in their inflated fusiform tests with pointed poles and massive chomata. Furthermore, based on similar test characters, the specimens in Pl. 1, figs. 8 and 13 appear to be a form of “Tikhonovichiella”; and that in Pl. 1, fig. 7 appears to be a form of “Priscoidella”. Obviously, these characters are highly variable and change continuously from specimen to specimen. Differences among the 28 specimens illustrated are considered to only represent the intraspecific variation of Profusulinella aljutovica.

In conclusion, primitive fusulines in the present material are assigned to Profusulinella and recognized as two species, P. ovata and P. aljutovica. Aljutovella, Ovatella, Depratina, Staffellaeformes, Aljutovella (Elongatella), Tikhonovichiella, Skelnevatella, and Priscoidella are unnecessary names erected for what amount to species groups. All of them are thought to be junior synonyms of Profusulinella. Given this, the families Profusulinidae and Aljutovellidae are redundant, too.

**Systematic Paleontology**

**Suborder Fusulinina Wedekind, 1937**

**Superfamily Fusulinoidea von Möller, 1878**

**Family Fusulinidae von Möller, 1878**

**Subfamily Fusulinellinae Staff and Wedekind, 1910**


**Genus Profusulinella Rauzer-Chernousova and Belyaev, in Rauzer-Chernousova et al., 1936**

Type species: Profusulinella parahomboides Rauzer-Chernousova and Belyaev in Rauzer-Chernousova et al., 1936, p. 175.

Ovatella Solovieva in Rauzer-Chernousova et al., 1996, p. 93 (type, Profusulinella ovata Rauzer-Chernousova, 1938).

Depratina Solovieva in Rauzer-Chernousova et al., 1996, p. 93, 94 (type, Schwagerina prisca Deprat, 1912).


Aljutovella Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, p. 182 (type, Profusulinella aljutovica Rauzer-Chernousova, 1938).

Aljutovella (Aljutovella) Rauzer-Chernousova; Solovieva in Rauzer-Chernousova et al., 1996, p. 96.

Aljutovella (Elongatella) Solovieva in Rauzer-Chernousova et al., 1996, p. 96 (type, Profusulinella aljutovica elongata Rauzer-Chernousova, 1938).

Tikhonovichiella Solovieva in Rauzer-Chernousova, 1996, p. 96 (type, Aljutovella tikhonovichi Rauzer-Chernousova in Rauzer-Chernousova et al., 1951).

Skelnevatella Solovieva in Rauzer-Chernousova et al., 1996, p. 96 (type, Profusulinella skelnevatica Putrya in Putrya and Leontovich, 1948).

Priscoidella Solovieva in Rauzer-Chernousova et al., 1996, p. 97 (type, Profusulinella priscoidea Rauzer-Chernousova, 1938).
Discussion. All genera and subgenera listed above except for *Staffellaformes* were proposed for the typical forms of species groups of *Profusulinella* or *Aljutovella* in the systematic classification in Rauzer-Chernousova et al. (1951). *Profusulinella staffellaformis*, type species of *Staffellaformes* was proposed, was included in the *Profusulinella parva* group in Rauzer-Chernousova et al. (1951). In my opinion none of these listed nominal taxa differs significantly from *Profusulinella* so that all can be regarded as junior synonyms of *Profusulinella*, as discussed above. The family Aljutovelliidae is accordingly unnecessary. *Moellerites* proposed by Solovieva (1986) with *M. lopasniensis* Solovieva, 1986 as the type species might be synonymous with either *Profusulinella* or *Fusulinella*. The genus *Taitzeboella* Sheng, 1951 is distinct from *Profusulinella* and is placed with *Profusulinella* in the subfamily Fusulinellinae of the family Fusulinidae. Therefore, the family Profusulinellidae erected by Solovieva in Rauzer-Chernousova et al. (1996) is also unnecessary.

**Profusulinella aljutovica** Rauzer-Chernousova, 1938

1938 *Profusulinella aljutovica* Rauzer-Chernousova, p. 97, 98, pl. 1, figs 10-12.

1951 *Aljutovella aljutovica* (Rauzer-Chernousova); Safonova and Rauzer-Chernousova in Rauzer-Chernousova et al., p. 193, 194, pl. 22, figs 1, 2.

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**PLATE I**

Figs 1-28 - *Profusulinella aljutovica* Rauzer-Chernousova, 1, 3, 5, 7, 9, 17-50, others: x 25


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**Tab. 1** - Measurement of *Profusulinella aljutovica* Rauzer-Chernousova.
to 5.5 whorls, about 1.5 to 2.2 mm in length, about 0.9 to 1.2 mm in width, with approximate length/width ratio from 1.5 to 2.1 (Tab. 1).

Proloculus spherical to subspherical and 0.04 to 0.14 mm in its outside diameter. Inner one or two whorls fusiform to costelloid, and their length and width vary depending on the size of proloculus and an orientation of thin sections. Beyond the second, whorls become fusiform with variable rate of expansion and form ratio, and shape of poles. Length and width in corresponding whorls largely variable depended upon the size of a proloculus. Length from the first to fifth whorls 0.05 to 0.35, 0.25 to 0.72, 0.56 to 1.32, 1.06 to 1.66, and 1.58 to 2.08 mm in 17 specimens. Width from the first to fifth whorls 0.10 to 0.26, 0.15 to 0.45, 0.28 to 0.68, 0.48 to 0.97, and 0.90 to 1.16 mm in 28 specimens (Tab. 1).

Wall thin, less than 0.05 mm in the thickest part of outer whorls, consisting of almost single layer in the costelloid whorl, and distinct tectum, and lower thicker and upper thinner layers. Upper thin layer corresponding to upper tectornium not continuous in most specimens.

Septa closely spaced and weakly fluted in polar regions of outer whorls. Septal counts from the first to fifth whorls 5 to 8, 6 to 12, 8 to 16, 10 to 23, and 21 in 13 specimens (Tab. 1). They attain 26 to 28 in their maximum in the fifth whorl.

Chomata present in almost all whorls and also on the proloculus in specimens with a large proloculus. Their shape, size, and degree of symmetry through tunnel is variable. Axial fillings absent.

Tunnel high and in general one-thirds to one-half as high as chambers. Its path wider in outer test than in inner test in general.

**Discussion.** Differences in size, shape, and expansion of the test, proloculus size, the number of septa, and development of chomata vary from specimen to specimen. Therefore, they are thought to represent the intraspecific variation of this species originally described from the wells in Samara Bend by Rauzer-Chernousova (1938).

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**PLATE 2**

Figs 1-35 - *Profusulinella ovata* Rauzer-Chernousova, 1, 3, 5, 7, 10, 11: x50, others: x25.


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Tab. 2 - Measurement of *Profusulinella ovata* Rauzer-Chernousova.
Considering wide morphologic variation of the present material, at least the following two species are probably conspecific with this species: Aljutovella conspecta Leontovich in Rauzer-Chernousova et al., 1951 and A. arrisionis Leontovich in Rauzer-Chernousova et al., 1951 both of which were included in the Aljutovella aljutovcica group by Leontovich in Rauzer-Chernousova et al. (1951). Aljutovella skelnevtatica (Putrya in Putrya and Leontovich, 1948), A. cybacea Leontovich in Rauzer-Chernousova et al., 1951, and A. artificialis Leontovich in Rauzer-Chernousova et al., 1951 were included in the Aljutovella skelnevtatica group by Leontovich in Rauzer-Chernousova et al. (1951). They might or might not be conspecific with A. aljutovica.

**Profusulinella ovata** Rauzer-Chernousova, 1938

1938 *Profusulinella ovata* Rauzer-Chernousova, p. 101, pl. 1, figs. 14-16.

1951 *Profusulinella subovata* Salonoiva in Rauzer-Chernousova et al., p. 164, pl. 14, figs 5, 6.

1996 *Ovatella ovata* (Rauzer-Chernousova); Solovieva in Rauzer-Chernousova et al., p. 93, pl. 23, fig. 3.

**Material:** Twenty-three axial, eleven sagittal, and one tangential sections illustrated, and others.

**Description.** Test inflated fusiform to oval with arched to broadly arched periphery, rounded poles. Axis of coiling straight in general, but crossing at a large angle between inner lenticular and outer fusiform whorls in specimens. Mature specimens with 4 to 5.5 whorls, rarely 6. Length about 1.1 to 1.6 mm and width about 0.8 to 1.2 mm in width giving approximate length/width ratio from 1.3 to 1.6 (Tab. 2).

Proloculus spherical and 0.05 to 0.17 mm in its outside diameter. Inner one to two whorls vary from eostaffelloid to inflated fusiform, and their length and width vary depending on the size of proloculus. Outer whorls inflated fusiform to oval with variable rate of expansion and form ratio. Length and width in corresponding whorls largely variable depending upon the size of proloculus. Length from the first to sixth whorls 0.06 to 0.42, 0.25 to 0.77, 0.36 to 1.24, 0.69 to 1.57, 1.01 to 1.55, and 1.43 to 1.53 mm in 24 specimens. Width from the first to sixth whorls 0.10 to 0.26, 0.14 to 0.48, 0.26 to 0.74, 0.42 to 1.07, 0.64 to 1.19, and 0.88 to 1.18 mm in 35 specimens (Tab. 2).

Wall thin, less than 0.04 mm in the thickest part of outer whorls, appears to be thicker due to secondary coating of dark layer. It is almost structureless in the eostaffellloid one or two whors. In later whors it exhibits a distinct tectum, and lower thicker and upper thinner layers. Upper thinner layer is discontinuous and indistinct in most specimens.

Septa closely spaced and almost plane to very weakly fluted in polar regions of outer whors. Septal counts from the first to fifth whors 4 to 7, 7 to 12, 10 to 16, 14 to 21, and 17 to 23 in 17 specimens (Tab. 2).

Chomata massive, roughly symmetrical through tunnel, and well developed in inner fusiform whors. They are present on the proloculus and eostaffelloid whors, but tend to be indistinct or absent in outer fusiform whors. Their shape and size are variable. Axial fillings absent.

Tunnel high and probably one-thirds to one-half as high as chambers. Its path becomes wider outwards in general.

**Discussion.** This species is discriminated from *Profusulinella aljutovica* by their smaller and more inflated fusiform test in general. Proloculus size, the number of whorl, height and width of inner whors, and development of chomata vary from specimen to specimen, showing wide morphologic variation in the Hadim specimens.

Specimens having relatively small proloculus resemble Rauzer-Chernousova’s (1938) original material from the upper part of the Vereian (lower Moscovian) of Samara Bend. Those with larger proloculi (e.g., Pl. 2, figs 1, 14, 15) are more similar to *Profusulinella subovata* Salonoiva in Rauzer-Chernousova et al., 1951. They are probably conspecific each other.

Those having subspherical test and tightly coiled inner whors (e.g., Pl. 2, figs 5, 10) appear to be more like *Profusulinella prisca sphaeroidea* Rauzer-Chernousova in Rauzer-Chernousova et al. (1951) and *Profusulinella prisca timanica* Kireeva in Rauzer-Chernousova et al. (1951) than to *Profusulinella ovata*. Although the range of morphologic variation in these two subspecies is unclear, they should be included into the *Profusulinella prisca* group, as done by Rauzer-Chernousova et al. (1951).

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