



New species and evolution of the foraminiferal family Janischewskinae in the middle–upper Mississippian of South China

Chao Liu, Daniel Vachard, Pedro C3zar, and Ismael Coronado

ABSTRACT

Rich foraminiferal assemblages from the Bama Platform in South China allow clarifying the systematics, composition, and biostratigraphy of the family Janischewskinae. The family is comprised of four genera, *Janischewskina*, *Cribrospira*, *Bibradya*, and *Parajanischewskina*. The genera *Rhodesinella* and *Groessensella* are considered to be synonyms of *Cribrospira* and *Bibradya*, respectively, and some specimens of the genus *Ugurus* have been included under the genus *Bibradya*. Seven new species are described in this study: *Cribrospira evoluta*, *C. paradenticulata*, *Bibradya primitiva*, *B. densicamerata*, *B. maxima*, *B. subita*, and *Parajanischewskina nautiliformis*. The biostratigraphy of the Janischewskinae in South China resembles that in the Russian Platform, i.e., primitive *Cribrospira* are first recorded from the Tulian, primitive *Bibradya* from the Aleksinian, evolved *Cribrospira* (e.g., *C. panderi*) and large *Janischewskina* species from the Mikhailovian, *Parajanischewskina* and *Bibradya maxima* from the Venevian, and some species from the base of the Serpukhovian (Tarusian), such as *Janischewskina delicata*, *J. gibshmanae*, *Bibradya subita*, and *Parajanischewskina nautiliformis*. On the other hand, *Janischewskina adtarusia* is only documented from the late Serpukhovian strata (Zapaltubian).

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Keywords: foraminifers; new species; late Vis3an; Serpukhovian; biostratigraphy

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INTRODUCTION

The Janischewskinidae is one of the most important families for the subdivision of the Viséan and Serpukhovian (Middle and Late Mississippian), and some genera and species can be used to construct precise biostratigraphy of some regional stages in the Palaeotethys. Since the pioneer studies in the Russian Platform (e.g., Rauser-Chernousova, 1948a; Reitlinger, 1950; Ganelina, 1956), the biostratigraphic and systematic knowledge of the group has been notably improved (Lipina and Reitlinger, 1971; Makhlina et al., 1993; Vdovenko, 2001; Gibshman, 2003; Cózar and Somerville, 2006; Gibshman and Baranova, 2007; Gibshman et al., 2020; Vachard and Le Coze, 2022). In the past, some of the genera discussed in the current study were not defined formally, and the others were included within the family Bradyinidae Reitlinger, 1950, with a much wider concept for the family that it is currently understood. In more recent classifications, the family Janischewskinidae has been considered as independent of the family Bradyinidae (e.g., Rauser-Chernousova et al., 1996; Vachard and Le Coze, 2022). The family Janischewskinidae is rather diversified in the Moscow Basin, where in the southern part, there are better biostratigraphic and lithostratigraphic controls, but it is possibly more abundant in the western part, and there, some species exhibit longer stratigraphic ranges, such as the large *Janischewskina* (compare Makhlina et al., 1993 and Kabanov et al., 2016 with Savitsky et al., 2015 and Gibshman et al., 2020). In Western Europe, although species diversity is lower than that in the Russian Platform (e.g., Cózar and Somerville, 2006, 2021; Vachard et al., 2016; Cózar et al., 2022), the family is common (e.g., Conil et al., 1980), with some well-known species being absent and/or their first occurrences being much later than those in the Moscow Basin in some cases (e.g., Cózar et al., 2019; Cózar and Somerville, 2021). Species diversity in the Urals and Ukraine seems to be also lower than that in the Moscow Basin (see Aizenverg et al., 1968; Vdovenko, 2001; Stepanova and Kucheva, 2009; Kulagina et al., 2019; Kulagina, 2022).

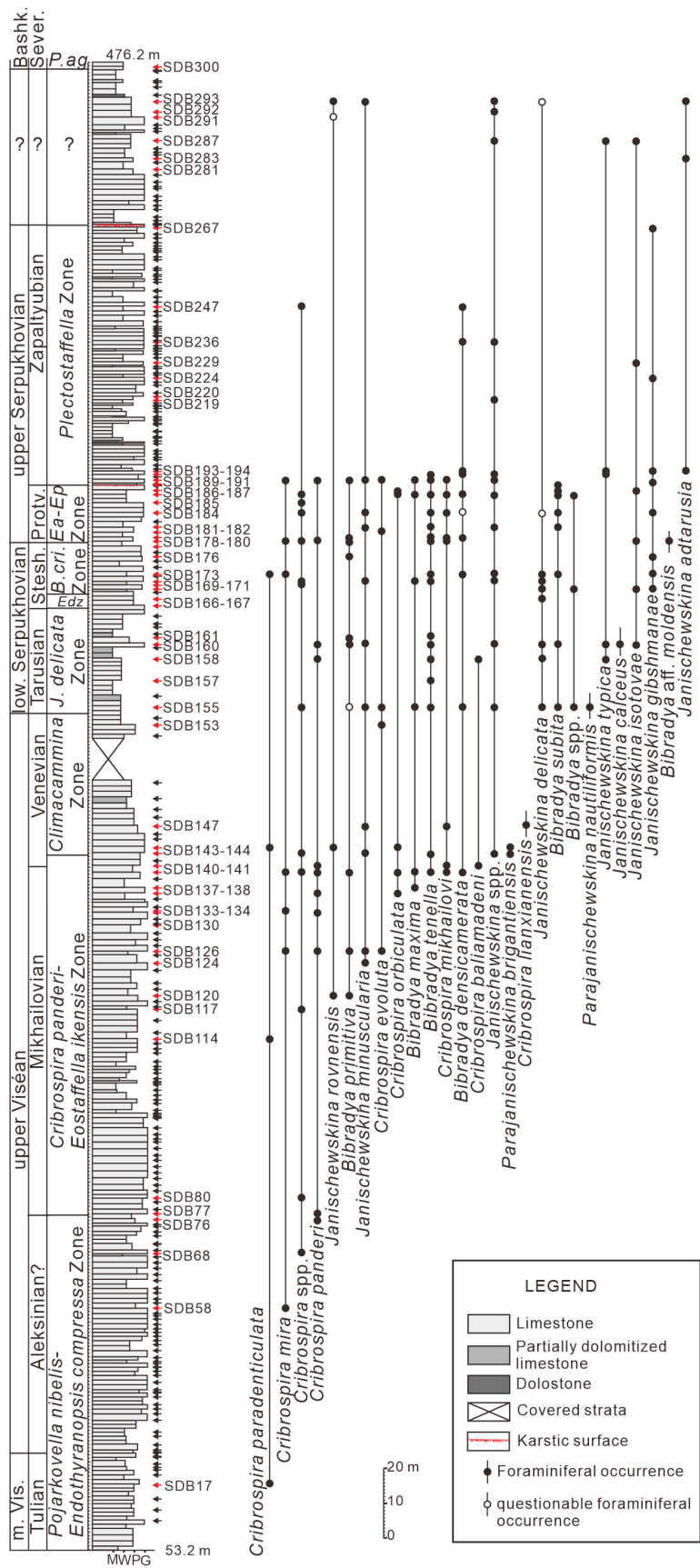
The Janischewskinidae has an important environmental dependence, and as an overall rule, they are more abundant in shallow-water facies (Gallagher, 1998; Somerville, 2008). Their abun-

dance decreases obviously in the outer platform to slope far below the storm wave base, where the foraminiferal assemblages are alternatively dominated by other families better adapted to quiet environments, such as Lasiodiscidae (e.g., Cózar et al., 2018, 2019). This effect is also observed in the Mississippian deep-water settings in the Pengchong area, South China (Shen and Wang, 2016). In the Youjiang Basin (Figure 1), the development of isolated platforms allowed the formation of shallow-water carbonates surrounded by deep-water siliciclastic facies (Liu et al., 2014, 2015). The Bama Platform in the northern basin provides a recognizable trend from shallow- to relatively deeper-water environments, and from agitated to quiet environments, represented by the Kacai section (the shallowest and more agitated) and Shuidong section to the Gongchuan section (the deepest and quietest), and thus, the abundance of the Janischewskinidae decreases with the same trend. As a result, the family weakens its biostratigraphic importance for the Gongchuan section. The bio- and lithostratigraphy of the Bama Platform is still a work in progress, and this study is exclusively focused on the family Janischewskinidae.

Our investigation on foraminifers from the Bama Platform suggests that the foraminiferal assemblages from the middle Viséan to the lowermost upper Viséan are more similar to the Western European foraminifers than to those from the Russian Platform (Liu et al., in press). In contrast, for most of the upper Viséan and Serpukhovian, assemblages are comparable to those of the Russian Platform, a fact which justifies the use of the Russian lithostratigraphic and foraminiferal zonal schemes for comparison with the younger part of the succession (Liu et al., in press; Figures 2–3). In the Bama Platform, representatives of the genera *Cribrospira*, *Janischewskina*, *Bibradya*, and *Para-janischewskina* have been recorded. These genera promise a biostratigraphic subdivision of the upper Viséan–Serpukhovian in the platform, and the recognition of some regional substages described in Europe. Furthermore, these foraminifers allow a better understanding of the migration routes from basins in Europe to this sector in the eastern Palaeotethys, and the connections between basins.

The high diversity of the family in South China allows the description of seven new species, and to

3



Caption next page.

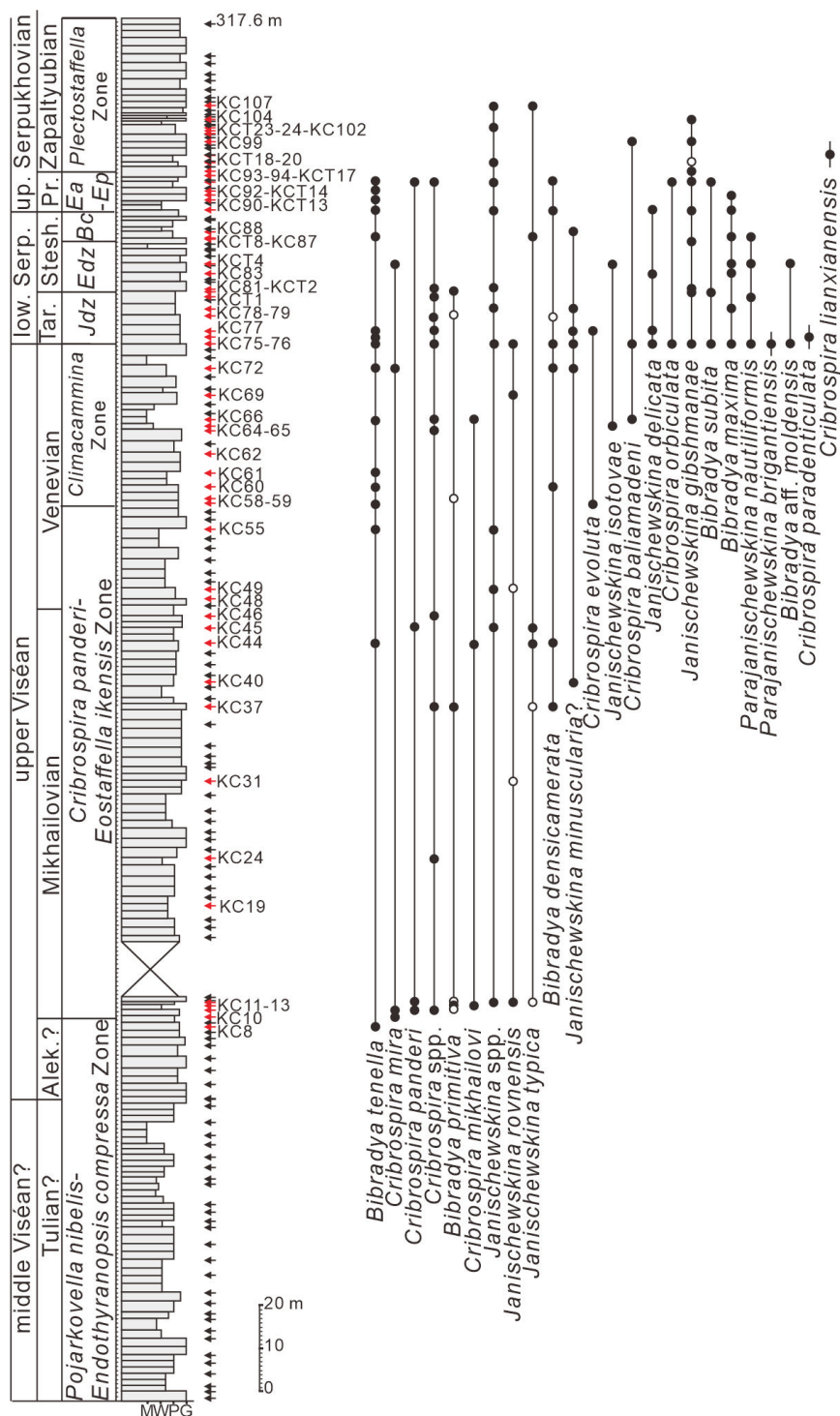


FIGURE 3. Distribution of the Janischewskinae in the Kacai section. Legend and abbreviations as in Figure 2, and additionally, Alek. — Aleksinian, Tar. — Tarusian, Pr. — Protvian, up. — upper, Jdz — *Janischewskina delicata* Zone, Bc — *Bradyina cribrostomata* Zone.

FIGURE 2 (previous page). Distribution of the Janischewskinae in the Shuidong section. Red arrows correspond to the productive samples in Janischewskinae, and black arrows to unproductive samples. Abbreviations: M — mudstone, W — wackestone, P — packstone, G — grainstone; m. — middle, low. — lower, Vis. — Viséan, Bashk. — Bashkirian, Stesh. — Steshevian, Protv. — Protvian, Sever. — Severokeltmian, J. — *Janischewskina*, B. cri. — *Bradyina cribrostomata* Zone, Edz — *Eostaffellina decurta* Zone, Ea-Ep — *Eostaffellina actiosa-Eostaffellina protvaensis* Zone, P. ag — *Pseudostaffella antiqua grandis* Subzone.

clarify the systematics of the genera *Cribrospira* and *Bibradya*, as well as to confirm the validity of the genus *Parajanischewskina*.

GEOLOGICAL AND STRATIGRAPHICAL SETTING

During the Mississippian, South China was located in the equatorial eastern Palaeotethys. The southwestern portion of the block consisted of the Upper Yangtze Land, the attached platforms along the oldland, and the Youjiang Basin (also known as the Nanpanjiang Basin) (Liu and Xu, 1994). These palaeogeographical elements brought about a striking sedimentary differentiation (Figure 1A).

Volcanic rocks and cherts suggest that during the Devonian, the Youjiang Basin was a rift basin, with eastward expansion generating two directional groups of faults (NW–SE and NE–SW), passing into a passive continental margin for the Carboniferous (Liu et al., 2015). The open platform facies were ascribed to the Du'an Formation (about 434 m-thick), ranging from the late Tournaisian up to the Serpukhovian (Yao and Aretz, 2020) or Viséan to Serpukhovian (Liu et al., 2015). This formation mostly contains thickly-bedded bioclastic pack- to grainstones, coral-microbial-bryozoan reefs, and intraclastic pack- to grainstones (Fang and Hou, 1989; Yao and Aretz, 2020). Persistent rifting and subsidence of the basin caused a number of tectonic blocks to tear away from the southern margin of the Yangtze Land, giving rise to a submarine landscape composed of numerous isolated shallow-water carbonate platforms surrounded by basinal facies during the Carboniferous (Liu et al., 2014) (Figure 1A).

The Bama Platform represented a typical isolated platform in the north, and its margins were associated with synsedimentary normal faults. Two shallow-water sections, the Shuidong (24°29'2"N/107°22'58"E; Figure 2) and Kacai (24°13'54"N/107°9'34"E; Figure 3) sections on the marginal position of the northern Bama Platform (Figure 1B), have been measured and sampled. These sections contain limestones of the middle Viséan to late Serpukhovian (work in progress), being laterally equivalent to the upper part of the Du'an Formation. The Kacai section (317.6 m thick) is mainly formed by shoal carbonates (i.e., gray thick-bedded to massive skeletal pack- to grainstones), and shoal and back-shoal subtidal to intertidal carbonates (i.e., gray or dark gray thick- to medium-bedded to massive skeletal wacke- to grainstones) for the Shuidong section (423 m thick) (Liu, 2017). No evident depositional hiatus was detected from the

Kacai section, whereas in the Shuidong section, the lower and upper boundaries of the *Plectostaffella* Zone or the Zapaltyubian Substage are marked by karstic surfaces (Figure 2). Syn-rift normal-fault movements resulted in greater depositional thickness for these two sections at the platform margins than that in the platform interior Gongchuan section, which was deposited in lagoonal environments (Liu et al., 2015).

SYSTEMATIC PALAEONTOLOGY

(P. Cózar and D. Vachard)

Class FUSULINATA Maslakova, 1990 emend.

Vachard et al., 2013

Subclass FUSULINANA Maslakova, 1990 emend.

Vachard, 2016

Order ENDOTHYRIDA Brady, 1884 nom. transl.

Fursenko, 1958

Suborder ENDOTHYRINA Bogush, 1985

Superfamily BRADYINOIDEA Reitlinger, 1950

nom. transl. Rauser-Chernousova et al., 1996

Family JANISCHEWSKINIDAE Reitlinger in

Rauser-Chernousova et al., 1996

Description. Test free, nautiloid to compressed laterally, with a juvenarium endothyroid passing to a planispiral final coiling. Coiling follows a progressive increase of the spire with a common rapid increase of the final whorl, in species trending to the uncoiling.

Secondary deposits absent. The most common septa are simple, curved backward, but also furrowed, blunt, swollen, and bifurcated. Cribrate aperture in the final whorl, rarely present in the penultimate chambers. Wall microgranular to granular with some agglutinated grains in the more ancestral forms, or with a porous tectum.

Composition. *Bibradya* Strank, 1983 (= *Mirifica* Shlykova, 1969, part; = *Groessensella* Strank in Somerville and Strank, 1984); *Cribrospira* Möller, 1878 (= *Rhodesinella* Conil and Longerstaey in Conil, 1980, part); *Janischewskina* Mikhailov, 1939; and *Parajanischewskina* Cózar and Somerville, 2006.

Remarks. The family was described in Rauser-Chernousova et al. (1996) as including *Janischewskina*, *Bibradya* (= *Mirifica* Shlykova, 1969, preoccupied, replaced name *Ugurus* Özdiçmen, 2009), *Cribrospira*, and *Groessensella*. In contrast, Hance et al. (2011) and Vachard and Le Coze (2022) considered that the family only consists of *Cribrospira*, *Janischewskina* (= ?*Parajanischewskina*), and *Rhodesinella*.

The genus *Ugurus* (= *Mirifica*) shows a similar wall structure with *Omphalotis* Shlykova, 1969, i.e.,

thin dark outer tectum and thick grey inner layer, as well as a simple and basal aperture, although certainly, some furrowed and blunt septa are observed in the specimens included in the genus (e.g., Aizenverg et al., 1968, plate 8, fig. 3). The holotype of the type species *Endothyra mirifica* Rauser-Chernousova, 1948b is an axial section, which does not allow the recognition of the septa, nor the aperture, but it shows continuous low basal secondary deposits and a thin microgranular wall. However, the illustrated paratype is a nearly equatorial section, which shows strongly furrowed septa, incipient bifurcation of swollen septa of the sixth final chambers, and some small agglutinated grains in the wall. Although the inner whorls are a little obscure, the final whorl is free of secondary basal deposits. In addition, in the paratype, the aperture is not clearly visible, and the swollen last septum is joined to the apertural face, with a basal

aperture and possibly another hole at the junction with the septum, which suggests that the last chamber is missing or has a rudimentary cribrate aperture. We interpret that in the type material of Rauser-Chernousova (1948b), there is a mixture of true *Ugurus* (holotype, fig. 17), and the paratype (fig. 18) belongs to *Bibradya*. Taking into consideration that the holotype of the type species of the genus is correct, there is no nomenclatural conflict, and this genus (skipping the features described from the paratype) should be included within the subfamily Omphalotininae Vdovenko in Rauser-Chernousova et al., 1996.

The genus *Groessensella* is not considered as a junior synonym of *Bibradya* (Figure 4A–B, 4F), because the four specimens of the type material described by Strank (in Somerville and Strank, 1984, fig. 6H–K) are composed of rather oblique sections, which could be misinterpreted as finally

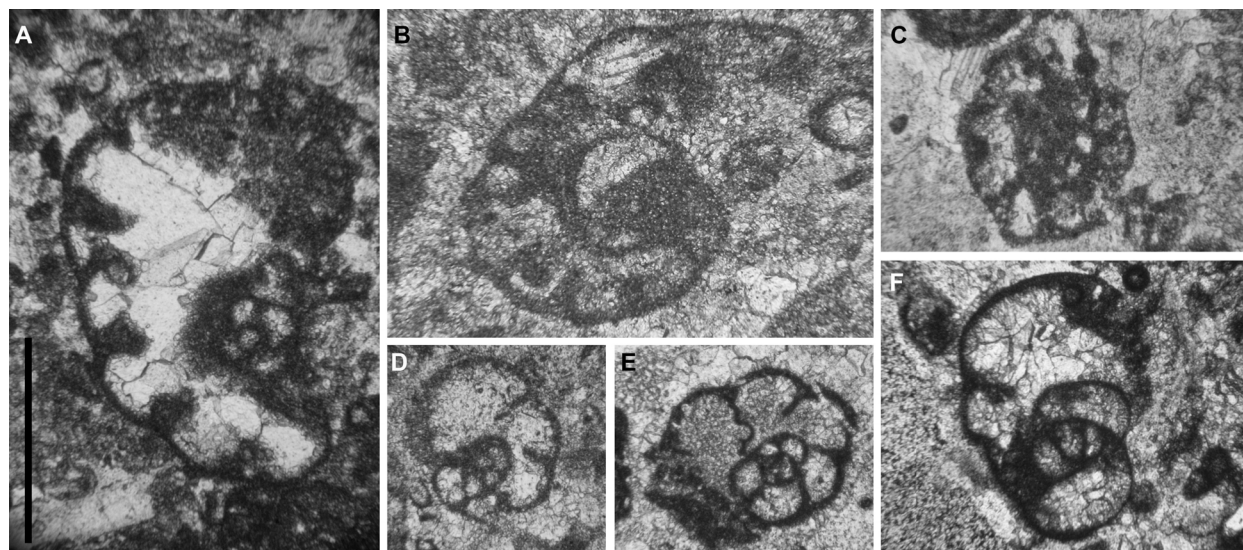


FIGURE 4. Selected primitive Janischewskiniidae with granular wall or with some agglutinated grains compared with a Mstiniidae. **A.** *Bibradya grandis* Strank, 1983, DPM-PC-TQ56-1250, Urswick Limestone Formation, Trowbarrow Quarry (N. England), late Asbian (late Viséan). Microgranular wall with rare agglutinated large grains in the third and sixth septa from the aperture. **B.** *Bibradya moldensis* (Strank in Somerville and Strank, 1984), HPU-SBD179-208, Shuidong section, Protvian (late Serpukhovian). Note the granular wall, rarely with small agglutinated grains. **C.** *Holkeria avonensis* (Conil and Longerstaey in Conil et al., 1980), DPM-PC-BS68-955, Park Limestone Formation, Barker Scar section (N. England), Holkerian (middle Viséan). Granular wall throughout the test with some large agglutinated grains in septa and outer wall. **D.** *Cribrospira pansa* Conil and Lys, 1965, DPM-PC-LF26-2162, Dalton Formation, Low Frith section (N. England), 'upper' Arundian (lower Viséan). Microgranular wall in the inner whorls with more granular aspect in the final whorls and with common small agglutinated grains. **E.** *Cribrospira pansa*, DPM-PC-WS36-1587, Dalton Formation, White Scar Quarry (N. England), 'top' Arundian (middle Viséan). Microgranular wall throughout the test, with large agglutinated grains in the wall of the final chambers. **F.** *Bibradya inflata* Strank, 1983, DPM-PC-TQ84-1954, Urswick Limestone Formation, Trowbarrow Quarry (N. England), late Asbian (upper Viséan). Microgranular wall throughout the test with some small agglutinated grains. (Scale bar equals 0.5 mm). [DPM- corresponds to the Palaeontological Collection in the Palaeontology Department of the Universidad Complutense de Madrid, PC- to the P. Cózar's collection, the following number corresponds to the number of thin-section (e.g., TQ56, WS36, ...), and the final number corresponds to the number of specimens].

uncoiled. However, a recent axial section recorded by Cózar et al. (2022, fig. 11G) shows this marked trend to the uncoiling in the final chambers (Figure 4B), but not a true uncoiling, and the genus *Groes-sensella* is thus thought to be redundant.

Vachard and Le Coze (2022) included *Groes-sensella* and *Bibradya* in the subfamily Endothyranopsinae Reitlinger, 1958, but these genera do not show planispiral coiling, nor nautiloid tests, nor thick agglutinated wall, nor quadratic chambers (except in the juvenarium), and nor a simple and basal aperture, missing mostly typical features of this subfamily, whereas, their initial skewed coiling, nautiloid tests, microgranular wall, convex chambers, and cribrate apertures are typically observed in the family Janischewskinae.

The validity of the genus *Rhodesinella* is problematic based on its definition. The genus was described by Conil and Longerstaey in Conil et al. (1980) as *Rhodesina* (preoccupied) for the forms with granular to coarsely granular wall with agglutinated grains, using *Criborespira pansa* Conil and Lys, 1965 as the type species. However, those authors also described a new species *Rhodesina avonensis*, which owns its particular chamber shape and coarsely granular to agglutinated wall, and was later selected as the type species of *Holkeria* Strank, 1982. *Holkeria* has been included in the subfamily Mstiniinae Lipina, 1989 by Rauser-Chernousova et al. (1996), or the family Mstiniidae Lipina, 1989 nom. transl. and emend. Hance et al., 2011 (as also followed by Vachard and Le Coze, 2022), which belongs to the tournayellids/lituotubellids, not to the endothyrids. Apart from the completely different chambers and septa, the wall in *Holkeria* is more coarsely granular, and agglutinated grains are relatively common (Conil et al., 1980, plate XI, fig. 6, holotype; see also Figure 4C), whereas in *Criborespira pansa* is microgranular, slightly granular, and with some sparse grains (agglutinated or recrystallization?) (Conil and Lys, 1965, plate III, fig. 24; see also Figure 4D–E). These features are observed in all the primitive *Criborespira* and *Bibradya* (e.g., Strank, 1983, plate 54, figs. 6–8, plate 55, figs. 1–2; Rauser-Chernousova, 1948c, plate 7, figs. 7–8). If the small difference in the wall is admitted to be of generic value, then, the most primitive species of the genus should be considered certainly as *Rhodesinella*. Similarly, this progressive transition into purer microgranular walls is observed in the most evolved forms of *Bibradya*, which should be ascribed to a different new genus, to distinguish them from typical *B. inflata* Strank, 1983 and *B.*

grandis Strank, 1983 (Figure 4A, 4F). This variation from those more granular to typical microgranular walls differentiated with tectum is considered as an intrageneric variation herein, and thus, the genus *Rhodesinella* is considered as a junior synonym of *Criborespira*.

The validity of the genus *Parajanischewskina* has been questioned by some scholars (e.g., Pille et al., 2010; Vachard and Le Coze, 2022). And even, the establishment of the genus has been attributed to a possible misinterpretation of the wall nature due to oblique sections of the cribrate apertures present in the last three chambers of some *Janischewskina* (Gibshman et al., 2020). However, the keriotheca documented in the type species *P. brigantiensis* Cózar and Somerville, 2006 is more marked in the new species (*P. nautiliformis*) described from South China. The differentiation of the wall is used herein to justify the validity of the genus as independent of *Janischewskina*.

Genus *Janischewskina* Mikhailov, 1939

Type species. *Janischewskina typica* Mikhailov, 1939.

Diagnosis. Janischewskinae with interseptal space in some cases with sutural apertures, and development of pre- and post-septal lamellae in the most advanced species.

Description. Test free, nautiloid to compressed laterally, with a juvenarium endothyroid only in the first whorl, passing to planispiral. Coiling follows a progressive increase of the spire. Secondary deposits absent. The most common septa are simple, curved backward. Presence of pre- and post-septal lamellae in the most advanced species, and sutural apertures in the interseptal space. Cribrate aperture in the final whorl, rarely present in the penultimate chambers. Wall microgranular (Figure 5D).

Composition. *Janischewskina adtarusia* Gibshman, Zaytseva, and Stepanova in Gibshman et al., 2020; *?J. banphitensis* (Saurin, 1960); *J. calceus* (Ganelina, 1956); *J. compressa* Sosnina in Sosnina and Nikitina, 1976 (= *?J. delicata*); *J. delicata* (Malakhova, 1956); *J. gibshmanae* Cózar et al., 2016; *J. isotovae* Lebedeva in Grozdilova et al., 1975; *J. lusca* (Saurin, 1960), *J. minuscularia* (Ganelina, 1956); *J. perretae* (Vachard and Cózar in Vachard et al., 2016); *J. rovnensis* (Ganelina, 1956); *J. typica* Mikhailov, 1939 (= *Samarina operculata* Rauser-Chernousova and Reitlinger in Rauser-Chernousova et al., 1940; = *J. inflata* Wang, 1982).

Remarks. Composition of the genus differs notably from that listed in Pille et al. (2010) and Gibshman

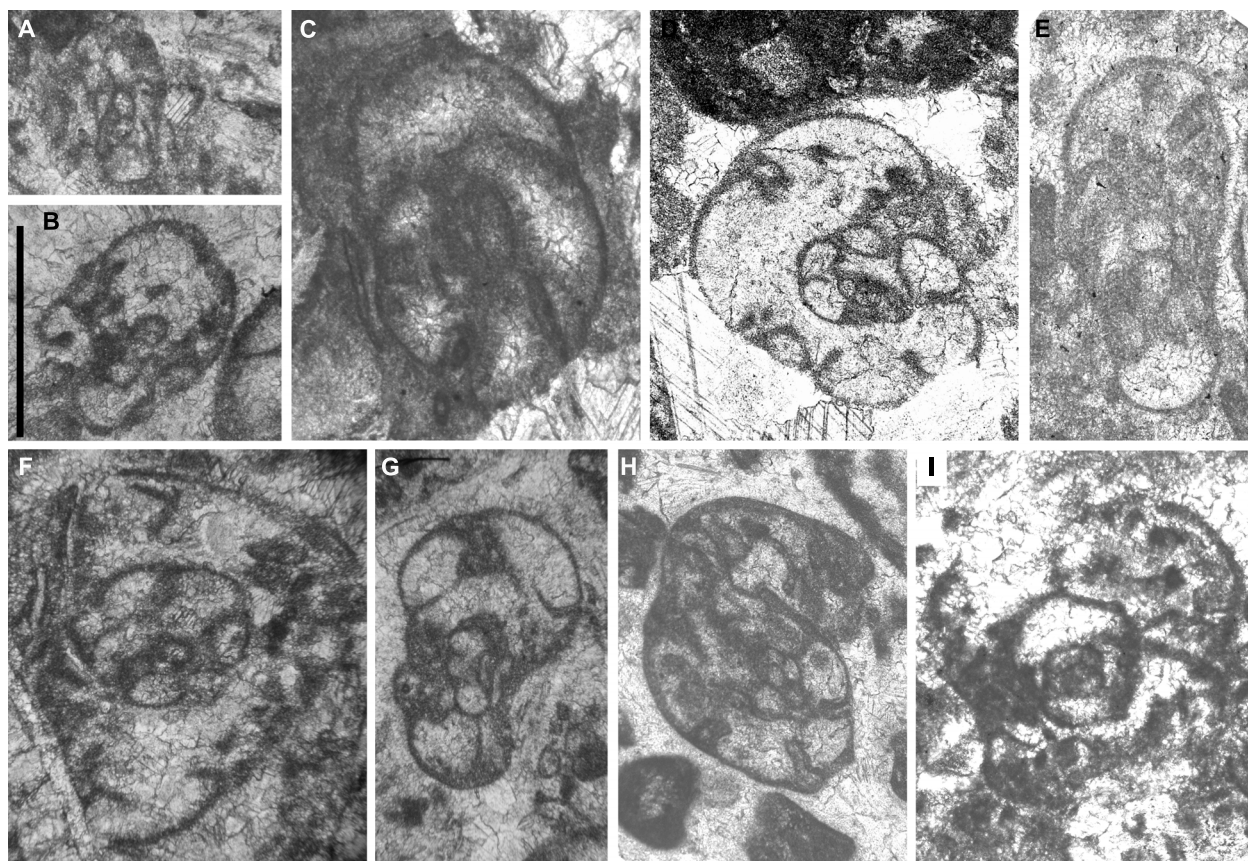


FIGURE 5. Typical representatives of the genus *Janischewskina* recorded in South China. **A–B.** *Janischewskina minuscularia?* (Ganelina, 1956), HPU-SDB160-278, DPM-PC-SDB143-181. **C.** *Janischewskina rovnensis* (Ganelina, 1956), HPU-KC45-7. **D.** *Janischewskina typica* Mikhailov, 1939, HPU-KC107-3. **E.** *Janischewskina isotovae* Lebedeva in Grozdilova et al., 1975, HPU-KCT4-5. **F.** *Janischewskina calceus* (Ganelina, 1956), HPU-SDB160-277. **G.** *Janischewskina delicata* (Malakhova, 1956), HPU-KC75-378. **H.** *Janischewskina gibshmanae* Cózar et al. 2016, HPU-KC104-3. **I.** *Janischewskina adtarusia* Gibshman, Zaytseva and Stepanova in Gibshman et al., 2020, HPU-SDB283-1. (Scale bar equals 1 mm). [HPU- corresponds to the Henan polytechnic University collections in the School of Resources and Environment, KC or SDB to the Kacai or Shuidong sections, respectively, followed by the number of the thin-section, and the final number corresponds to the number of specimens].

et al. (2020). Some of the characters used by Gibshman et al. (2020) as distinctive for the genus *Janischewskina*, such as test shape, coiling symmetry, number of whorls, and wall thickness, are variable characters at species level, but in general, similar in all the genera included in the family Janischewskiniidae. Only the interseptal spaces and the lamellae (in the most evolved species) are typical features of the genus, which are not observed in *Samarina orbiculata* Ganelina, 1956, nor in *Janischewskina ladeinaensis* Stephanova and Gibshman, 2017 (= *Janischewskina compressa* Grozdilova and Lebedeva in Grozdilova et al., 1978), and thus, they are considered herein as *Cribrospira*. It is noted that some specimens identified as *Janischewskina orbiculata* (Gibshman et

al., 2020, pl. 1, fig. 7) are reinterpreted as oblique sections of *J. typica*.

Janischewskina compressa seems to be a junior synonym of *J. delicata*, although the type material shows very poor orientation as to confirm this synonymy (Gibshman et al., 2020). *Janischewskina inflata* shows a wide nautiloid test, with umbilical areas depressed, and secondary apertures in the interseptal space, and herein, it is considered as a junior synonym of *J. typica*. This overall shape was also observed in *Janischewskina* sp. in Groves et al. (2012), which is considered also to be this species.

The identification of *J. minuscularia* in older strata, for instance in the Aleksinian of the Moscow Basin, is a more robust identification than that in younger strata, because for those older rocks,

there is no large *Janischewskina*, of which, its juveniles could be confused. However, in younger levels, the ontogenic evolution of the *Janischewskina* species has been never studied, and the juveniles of some species seem to be rather similar with those of *J. minuscularia*. Therefore, the identifications of this species in intervals co-existing with other large *Janischewskina* are questionable.

Occurrence. Late Viséan-Serpukhovian, northern Palaeotethyan (Vachard and Le Coze, 2022). The disappearance of the genus commonly occurred in the late Serpukhovian (e.g., Pazukhin et al., 2002; Mazuno and Ueno, 1997), which could allow the recognition of the biostratigraphy for the upper part of the Shuidong section, below the Severokeltmian top (Figure 2). However, the genus has been recorded in strata assigned to the Krasnopolynian in the Saharan Platform, southern Morocco (Cózar et al., 2014a), and the Cantabrian Mountain, North Spain (Cózar et al., 2018), although the conditions in the former region are unusual, and a longer existence of some genera of benthic organisms was recognized (Cózar et al., 2014b).

Distribution in the Bama Platform. The first occurrence datum of the genus is equivalent to the Mikhailovian Substage, nearly from the base of the Kacai section (Figure 3). However, from the base, large species are recorded (as oblique sections), as well as *J. rovnensis* (Figure 5C) and *J. aff. typica*, whereas *J. minuscularia* (Figure 5A–B) take place in intermediate positions within the Mikhailovian. The occurrence of large species of *Janischewskina* from the base of this interval suggests that it cannot discard the occurrence of *J. minuscularia* from older levels, as occurs in the Russian Platform. Only in the upper part of the Viséan, *J. typica* and *J. isotovae* are first recorded (Figure 5D–E). The abundance of *Janischewskina* increases notably from the base of the Serpukhovian, and in addition to *J. delicata*, *J. calceus* and *J. gibshmanae* also first occur (Figure 5F–H). Other species previously recorded in the Kacai section (Figure 3) commonly appear from the base of the Serpukhovian in the Shuidong section (Figure 2), where a late occurrence of some species is observed, i.e., *J. gibshmanae* only occurs from the early-late Serpukhovian transition, together with *Bradyina cribrostomata* Rauser-Chernousova and Reitlinger in Rauser-Chernousova and Fursenko, 1937 and *Eostaffellina* ex gr. *paraprotvae* (Rauser-Chernousova, 1948d). In the Shuidong section, *J. adtarusia* (Figure 5I) is first recorded from the Zapaltubian, although the species is rare.

Genus *Cribrospira* Möller, 1878

Type Species. *Cribrospira panderi* Möller, 1878.

Diagnosis. Globose Janischewskiniidae with a marked small skew-coiled juvenarium, low number of chambers, and short septa, curved backward, with swollen extremes or straight pointed. Wall granular in the primitive species, becoming microgranular to porous in more advanced forms. Cribrate aperture in the final chamber.

Composition. *Cribrospira auriculata* (Lin, 1981), *C. baliamadani* Pille, Vachard and Argyriadis in Pille et al., 2010; *C. denticulata* Strank, 1983; *C. evoluta* sp. nov.; *C. knetschi* Omara and Conil, 1966; *C. lebedevae* Vachard and Cózar in Vachard et al., 2016 (= *Janischewskina ladeinaensis* Stepanova and Gibshman, 2017 = *Janischewskina compressa* Grozdilova and Lebedeva in Grozdilova et al., 1978), *C. lianxianensis* Lin, 1981; *C. micula* Vdovenko, 1982; *C. mikhailovi* Rauser-Chernousova, 1948c; *C. mira* Rauser-Chernousova, 1948c; *C. orbiculata* (Ganelina, 1956); *C. panderi* Möller, 1878; *C. pansa* Conil and Lys, 1965; *C. paradenticulata* sp. nov.; *C. rara* Rauser-Chernousova, 1948c.

Remarks. As mentioned previously, the most primitive species of the genus show a more granular wall with some agglutinated grains, and thus, they could be considered by some scholars as *Rhodesinella*, such as *C. denticulata*, *C. knetschi*, *C. micula*, *C. pansa*, *C. paradenticulata*, and *C. rara*. In contrast, more evolved species of the genus show a typical microgranular to porous wall (e.g., *C. panderi*, *C. baliamadani*, and *C. orbiculata*).

Occurrence. Middle Viséan to late Serpukhovian in the Russian Platform, Urals, Belgium, Spain, England, Morocco, Ireland, Poland, Southern France and Ukraine. The genus has been also described in the same interval in Turkey, “Central Asia”, China, Laos, Viet-Nam, and Japan (Hance et al., 2011). Although as mentioned above, the First Occurrence Datum of the genus is usually in the middle Viséan or its equivalents, the First Appearance Datum (FAD) of the most primitive species of the genus, considered as *Rhodesinella* auct., is in the uppermost lower Viséan in Europe, upper Moliniacian in Belgium (Laloux, 1987), and upper Arundian in Britain (Figure 4D–E; see also Fewtrell et al., 1981).

Distribution in the Bama Platform. The genus is rare below the Mikhailovian, and only *Cribrospira paradenticulata* has been recorded in the Bama Platform in strata equivalent to the Tulian, and *Cribrospira mira* (Figure 6B) from the upper part of the Aleksinian. The base of the Mikhailovian is marked by the first *C. panderi* (together with

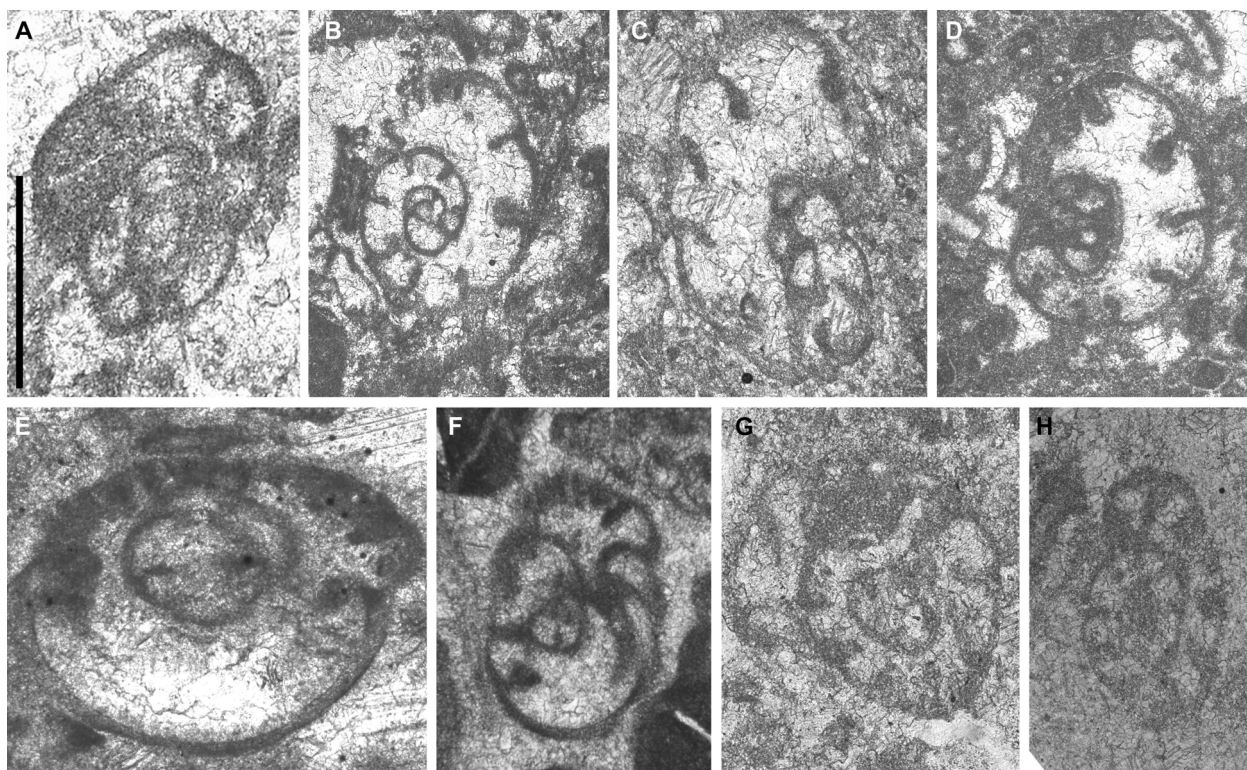


FIGURE 6. **A.** Typical representatives of the genus *Cribrospira* recorded in South China. *Cribrospira mikhailovi* Rauser-Chernousova, 1948c, HPU-SDB140-5. **B.** *Cribrospira mira* Rauser-Chernousova, 1948c, HPU-KC10-2. **C.** *Cribrospira panderi* Möller, 1878, HPU-SDB137-3. **D.** *Cribrospira baliamadeni* Pille, Vachard and Argyriadis in Pille et al., 2010, HPU-KC66-2. **E.** *Cribrospira orbiculata* (Ganelina, 1956), HPU-SDB144-9. **F.** *Cribrospira lianxianensis* Lin, 1981, HPU-SDB147-528. **G–H.** *Cribrospira paradenticulata* sp. nov., G. HPU-SDB114-2 (holotype), H. HPU-SDB144-1. (Scale bar equals 1 mm, except for Figure G equals 0.5 mm).

Eostaffella ikensis Vissarionova, 1948) (Figure 6C). These species are present in the entire Mikhailovian in the Shuidong section and only at the top of this substage *C. orbiculata* and *C. mikhailovi* first occur (Figure 6A, E). In the Kacai section, *C. mikhailovi* is also first recorded from the base of this substage.

More diversified species are recorded from the Venevian, including *C. evoluta*, *C. baliamadeni*, and *C. lianxianensis* (Figure 6D, F). However, this

increase in the diversity does not coincide with an increase in its abundance, which is mostly concentrated in levels assigned to the Serpukhovian.

Cribrospira paradenticulata sp. nov.

Figure 6G–H

zoobank.org/090413BF-19F5-4E87-B059-D1B7BA103028

Derivation of the Name. For its similarity with *C. denticulata*.

TABLE 1. Measurements of the types in *Cribrospira paradenticulata* sp. nov. (in microns). Abbreviations: D — diameter of the test; W — width of the tests; Iprol — inner diameter of the proloculum; Nw — number of whorls; NcLw — number of chambers in the last whorl; Hlc — height of the last chamber; Wt — Wall thickness in the last whorl.

		Specimen	D	W	Iprol	Nw	NcLw	Hlc	Wt	Hlc/D
83	SDB17(5)-3	HPU-SDB17-3	670	—	—	>2	9	190	20	0.283
84	SDB114(5)-2	HPU-SDB114-2	770	—	—	>2	10	130	30	0.168
88	SDB144(2.5)-1	HPU-SDB144-1	1210	605	—	2	10.5	200	45	0.165
90	SDB173(5)-5	HPU-SDB173-5	950	—	60	>2	11	280	25	0.294
148	KC76(5)-1	HPU-KC76-1	1225	—	—	2.5	10.5	175	35	0.143

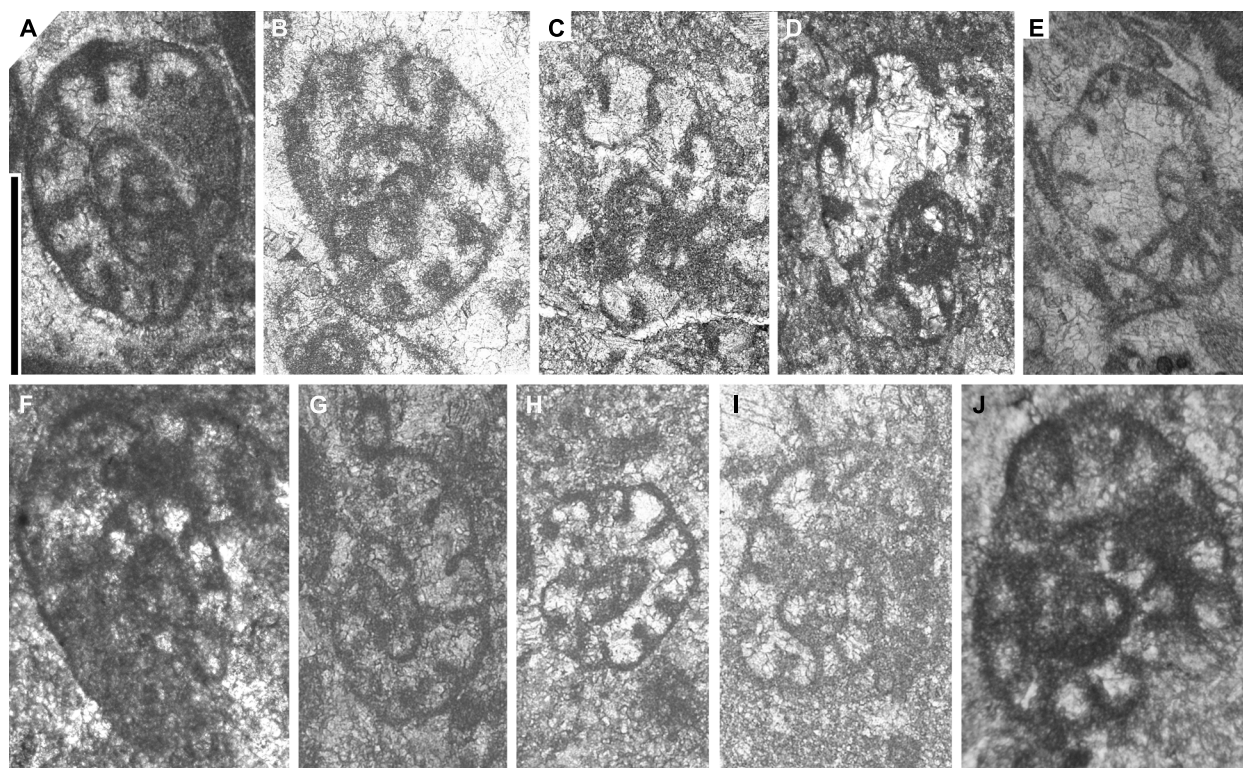


FIGURE 7. Illustrations of the new species *Cribrospira evoluta* sp. nov. **A.** HPU-KC58-7 (holotype), **B.** HPU-KC77-1, **C.** HPU-SDB155-2, **D.** HPU-SDB181-4, **E.** HPU-SDB191-215. (Scale bar equals 1 mm).

Material. Holotype (HPU-SDB114-2, Figure 6G) and four paratypes (Table 1).

Repository. School of Resources and Environment, Henan polytechnic University (HPU).

Type Locality and Horizon. Shuidong section, Mikhailovian (late Viséan).

Occurrence. Middle Viséan to early Serpukhovian in the Shuidong section, and early Serpukhovian in the Kacai section.

Diagnosis. *Cribrospira* of moderate-small size with tooth-like septa and moderate evolution rate between whorls.

Description. Test free, composed of 2–2.5 whorls, of which, coiling initially irregular in a different plane, and the final or final 1.5 are planispiral, with a diameter (D) between 670 and 1200 μm . Wall granular, calcareous. Septa slightly directed backward, short, pointed to swollen. The evolution rate increases between whorls slowly and uniformly. Height (H) of the lumen in the final chamber is 130–280 μm , with a low H/D ratio of 0.14–0.29. Number of chambers is moderate, ranging in the last whorl between 9 and 11. Thickness of the wall in the last chamber is 20–45 μm . Rudimentary cribrate aperture composed of a few holes concentrated in the lower part of the apertural face.

Remarks. The species differs from *C. denticulata* by a higher number of chambers for similar number of whorls, larger diameter, more rudimentary aperture, thicker wall, and the occurrence of some swollen septa. It differs from other species of the genus by the shape of the septa and the granular wall.

Cribrospira evoluta sp. nov.

Figure 7A–E

zoobank.org/4E4E8AC1-3316-4FFE-9A0D-B60FFF00D9C3

Derivation of the Name. From the evolute final whorl.

Material. Holotype (HPU-KC58-1, Figure 7A) and ten paratypes (Table 2).

Repository. School of Resources and Environment, Henan polytechnic University.

Type Locality and Horizon. Kacai section, Tarusian (early Serpukhovian).

Occurrence. Upper part of the Mikhailovian (late Viséan) to basal Zapaltubian (late Serpukhovian) in the Shuidong section and Venevian–Tarusian in the Kacai section.

Diagnosis. Large *Cribrospira* with a high evolution rate in the final whorl, a mixture of septa (curved, furrowed, swollen), inner whorls irregularly coiled, and only the final whorl trends to be planispiral.

TABLE 2. Measurements of the types in *Cribrospira evoluta* sp. nov. (in microns). Abbreviations as in Table 1.

		Specimen	D	Nw	NcLw	Hlc	Wt	Hlc/D
62	KC58(5)-7	HPU-KC58-7	1380	3	10	450	>40	0.326
163	P1010364	HPU-KC66-364	1590	3	12	550	30	0.345
109	KC77(5)-1	HPU-KC77-1	1330	2.5	9	370	20	0.278
86	SDB127(5)-4	HPU-SDB127-4	940	>1.5	6.5	360	35	0.382
152	P1010185	HPU-SDB153-13	1290	>1.5	9	430	50	0.333
131	SDB153(5)-13	HPU-SDB153-185	1550	2.5	>11	600	40	0.387
171	SDB155(5)-3	HPU-SDB155-3	1420	>2	>9	600	20	0.422
219	SDB181(5)-4	HPU-SDB181-4	1490	>3	12	600	40	0.402
169	P1010215	HPU-SDB191-215	1240	>2	11	450	20	0.362
124	P1010311	HPU-SDB191-311	940	2.5	11	280	30	0.297
125	P1010312	HPU-SDB191-312	970	2.5	11	300	30	0.309

Description. Free large test with a diameter of 1200–1600 μm for specimens of 2.5–3 whorls. A juvenile specimen measures 940 μm in diameter for 1.5 whorls. Coiling irregular nearly up to the final whorl that becomes planispiral. The final whorl is located in a plane about 90° from the first whorl. Septa are usually blunt, swollen, and furrowed, but in the final chambers, they can be pointed, containing a relatively high number of chambers (9–12 in the final whorl), with marked sutures in the final chambers and smooth inner ones. The evolution rate progresses uniformly in the inner whorls, and rapidly in the final whorl, which a height of the lumen in the final chamber between 450 and 600 μm , with high H/D ratios of 0.33–0.40. Wall microgranular, comparatively thin, 20–50 μm in the final chamber. Cribrate aperture in the entire apertural face.

Remarks. The species presents intermediate features between *Cribrospira* (nearly planispiral final coiling and curved septa) and *Bibradya* (more skew-coiled inner whorls and furrowed/swollen septa), allowing to distinguish from other species of *Cribrospira* and *Bibradya*.

Genus *Bibradya* Strank, 1983

Type Species. *Bibradya inflata* Strank, 1983.

Diagnosis. Janischewskinae with irregular coiling up to the final whorl, septa bifurcated, swollen, and furrowed.

Composition. *Bibradya densicamerata* sp. nov.; *B. grandis* Strank, 1983 (= ?*Mirifica mirifica* part); *B. inflata* Strank, 1983; *B. maxima* sp. nov.; *B. moldensis* (Strank in Somerville and Strank, 1984); *B. primitiva* sp. nov.; *B. subita* sp. nov.; *B. tenella* (Ye et al., 1987).

Remarks. The composition of this genus has been usually restricted to the original species described by Strank (1984), although Cózar et al. (2022) also included *B. moldensis*, the type species of the monospecific genus *Groessensella*, and some ancestral forms (*Bibradya*? sp. 1) from the base of the Asbian in Britain. This latter form is included herein in *B. primitiva*. In addition, *B. tenella*, originally described as a *Cribrospira*, is also included in the genus due to the more marked skew-coiled whorls.

Similar to the case of *Cribrospira*, it is possible to observe an intragenus variability of the wall structure in *Bibradya*, and thus, species such as *B. primitiva*, *B. inflata*, *B. grandis*, and *B. moldensis* show a more granular wall with some sparse agglutinated grains, whereas *B. densicamerata*, *B. maxima*, *B. subita*, and *B. tenella* have a typical microgranular wall. This variation seems to exist at intraspecies level, because comparing '*Mirifica*' *mirifica* in Rauser-Chernousova (1948b, plate 5, fig. 18) and Aizenverg et al. (1968, plate 8, fig.3), both specimens are homeomorphs, belonging to the same species, but the former specimen from Russia contains some agglutinated grains, whereas the latter specimens from Ukraine shows a typical microgranular wall.

Occurrence. Late Asbian to Serpukhovian in Britain, Ireland, and China, Serpukhovian in the Sahara Platform, and in the Aleksinian from the Russian Platform (Cózar et al., 2014a; Cózar and Somerville, 2020).

Distribution in the Bama Platform. The genus occurs from the Aleksinian (Figure 3). Surprisingly, the first recorded species is *B. tenella* (Figure 8G–I), a fact which suggests that the stratigraphic record of *Bibradya primitiva* is not complete in the

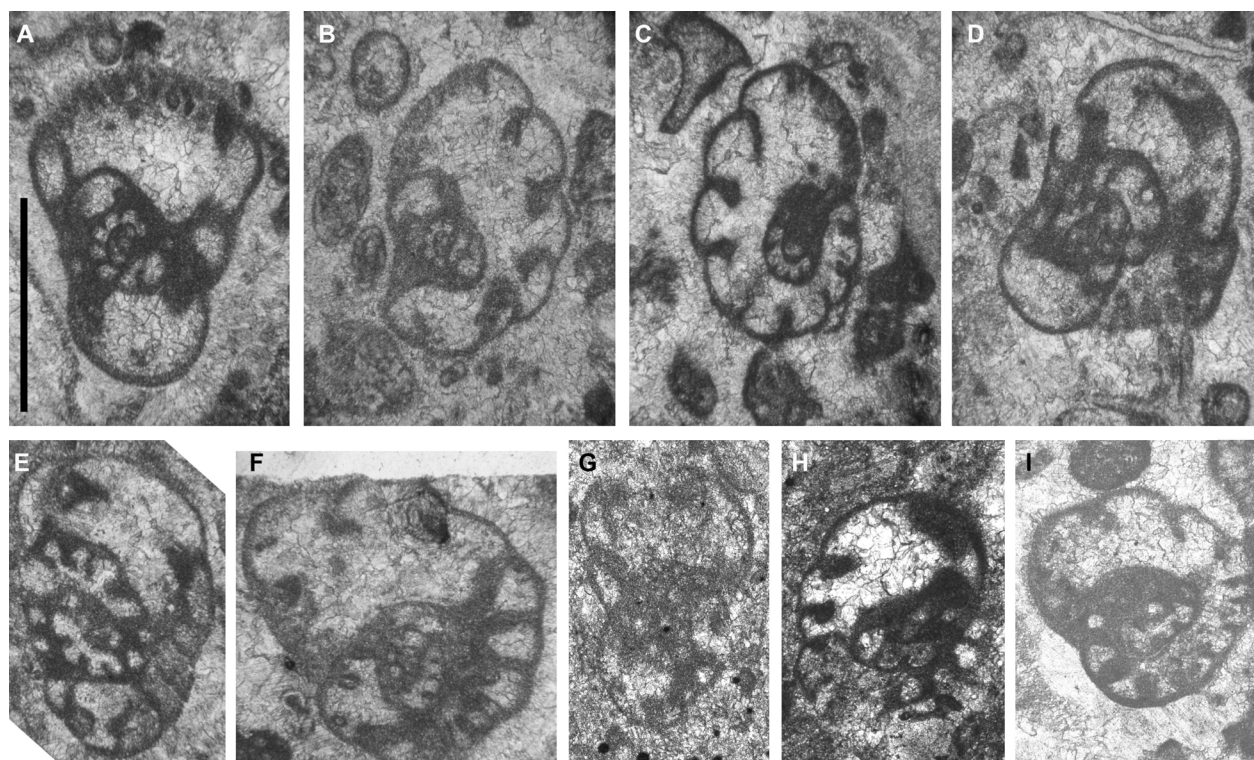


FIGURE 8. Illustrations of *Bibradya tenella* (Ye et al., 1987) and the new species *Bibradya densicamerata* sp. nov. **A–F.** *Bibradya densicamerata* sp. nov. A. HPU-KC90-406, B. HPU-KC75-488 (holotype), C. HPU-KC75-510, D. HPU-KC75-380, E. HPU-SDB155-188, F. HPU-KC75-503. **G–I.** *Bibradya tenella* (Ye et al., 1987). G. HPU-SDB179-27, H. HPU-SDB182-7, I. HPU-SDB184-11. (Scale bar equals 1 mm).

platform, a species which only occurs in strata assigned to the Mikhailovian upwards. In the upper part of the Mikhailovian, *B. densicamerata* and *B. maxima* are first recorded. The first occurrence of *B. subita* coincides in the two sections at the base of the Serpukhovian, and it could be considered as a regional marker.

Bibradya densicamerata sp. nov.

Figure 8A–F

zoobank.org/CC448745-8DBE-4E77-923B-DBDF19EC8679

Derivation of the Name. For the numerous chambers in the juvenarium.

Material. Holotype (HPU-KC75-488, Figure 8B) and twenty-five paratypes (Table 3).

Repository. School of Resources and Environment, Henan polytechnic University.

Type Locality and Horizon. Kacai section, Tarusian (early Serpukhovian).

Occurrence. From the top of the Mikhailovian to the top of the Serpukhovian.

Diagnosis. Large *Bibradya* with a juvenarium densely packed composed of numerous quadratic chambers and a rapid expansion in the final 1.5

whorls composed of more rounded and irregular chambers.

Description. Large test composed of 3–4 whorls for mature specimens, ranging from 1300–1500 μm . Coiling is irregular throughout, changing progressively the plane, and increasing rapidly the evolution rate in the final 1.5 whorls. The height of the lumen in the final chamber reaches 320–720 μm , with a H/D ratio of 0.2–0.41. Chambers are numerous in the inner whorls, approximately 7–8 in the second whorl, and 8–12 in the fourth whorl. Septa are straight in the inner whorls and blunt with an incipient bifurcation in the final whorl. Wall microgranular. Cribrate aperture composed of multiple elements present in the entire apertural zone.

Remarks. Species differs from *B. tenella* (Figure 8G–I) by the distinctively compressed juvenarium, more chambers, and higher number of whorls.

Bibradya primitiva sp. nov.

Figure 9A–F

zoobank.org/81CE4253-CD52-455B-B1AC-494ABFA71371

2022 *Bibradya?* sp. 1—Cózár et al., fig. 10M.

Derivation of the Name. From its primitive features.

TABLE 3. Measurements of the types in *Bibradya densicamerata* sp. nov. (in microns). Abbreviations as in Table 1.

Specimen	D	W	l _{prol}	Nw	NcLw	Hlc	Wt	Hlc/D
HPU-KC37-3	1490	—	—	>2.5	10	540	30	0.362
HPU-KC37-345	1310	700	—	2.5	—	550	30	0.419
HPU-KC44-5	1310	—	—	>2	7	280	20	0.213
HPU-KC44-358	1460	—	—	>2	12	300	40	0.205
HPU-KC60-4	1460	—	—	>2	8	340	40	0.232
HPU-KC72-2	1450	—	—	>2	8	290	40	0.2
HPU-KC75-379	1380	—	—	>2.5	—	500	50	0.362
HPU-KC75-380	1400	—	—	>3	—	410	40	0.292
HPU-KC75-488	1440	—	50	>4	9.5	530	40	0.368
HPU-KC75-503	1520	—	—	>4	10.5	710	50	0.467
HPU-KC75-510	1350	—	—	>3	9	520	40	0.385
HPU-KC90-404	1290	—	—	>3	—	400	35	0.310
HPU-KC90-406	1510	—	70	3.5	—	400	60	0.264
HPU-KC93-516	1350	—	—	3.5	—	470	50	0.348
HPU-KC93-415	1350	—	—	>3	—	430	50	0.318
HPU-SDB140-18	1470	—	—	2	7	350	40	0.238
HPU-SDB155-188	1450	—	—	2.5	12	410	30	0.282
HPU-SDB155-266	1140	—	—	>2	9.5	320	30	0.280
HPU-SDB155-19	1190	—	—	3.5	12	450	40	0.378
HPU-SDB180-3	1470	—	—	3	11	200	50	0.136
HPU-SDB186-1	1410	—	—	—	—	—	30	—
HPU-SDB186-6	1520	—	—	2	10	390	50	0.256
HPU-SDB186-10	1390	450	—	>2	—	570	20	0.410
HPU-SDB194-4	1370	390	—	3	—	530	30	0.386
HPU-SDB236-7	1460	—	—	2.5	13	370	30	0.253
HPU-SDB247-9	1370	—	—	3	>11	410	30	0.299

Material. Holotype (HPU-KC81-399, Figure 9A) and 11 paratypes (Table 4).

Repository. School of Resources and Environment, Henan polytechnic University.

Type Locality and Horizon. Kacai section, Steshevian (early Serpukhovian).

Occurrence. Mikhailovian (late Viséan) to Steshevian (early Serpukhovian) in the Kacai section and up to the Zapaltyubian in the Shuidong section.

Diagnosis. Small *Bibradya* with swollen, blunt septa, and incipient bifurcation of septa for a low evolution rate of the test.

Description. Test free, small to moderate size, 490–890 μm for specimens of 2–3 whorls. The evolution rate is low and in some of the final chambers is even lower, showing a lower height of the lumen than that in the previous chambers. Height

in the last chamber 70–170 μm , H/D ratio very low, 0.10–0.17 (0.26). Coiling is irregular, changing progressively the plane, and does not present any whorl completely in the same plane. Septa are blunt, swollen, and with incipient bifurcation, separating numerous chambers, usually 9–11 in the last whorl, but 8 chambers in specimens of only 2 whorls. Wall microgranular to granular, comparatively thick for the size of the specimens (20–30 μm). Aperture cribrate.

Remarks. Differs from *B. inflata* (Figure 4F) by a lower evolution rate, higher number of chambers, slightly higher number of whorls, less pronounced bifurcated septa, and more rudimentary cribrate apertures. The primitive characters of the species allow to distinguish it from the rest of more evolved *Bibradya*.

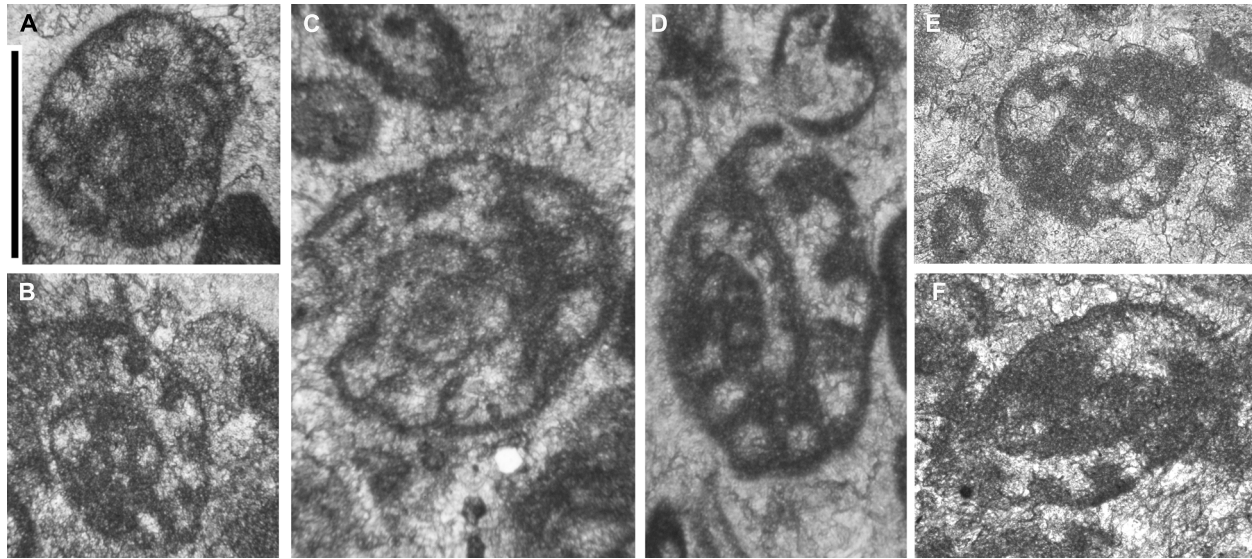


FIGURE 9. Illustrations of the new species *Bibradya primitiva* sp. nov. **A.** HPU-KC81-399 (holotype). **B.** HPU-SDB179-291. **C.** HPU-SDB191-217. **D.** HPU-KC37-341. **E.** HPU-SDB176-6. **F.** HPU-SDB180-19. (Scale bar equals 0.5 mm).

Bibradya maxima sp. nov.

Figure 10A–E

zoobank.org/BB49C3FF-9867-4CFA-A3DF-E4C0E1959116

Derivation of the Name. For its large size.

Material. Holotype (HPU-KC87-4, Figure 10D) and eighteen paratypes (Table 5).

Repository. School of Resources and Environment, Henan polytechnic University.

Type Locality and Horizon. Kacai section, Ste-shevian (early Serpukhovian).

Occurrence. From the top of the Mikhailovian to the top of the Serpukhovian.

Diagnosis. Giant *Bibradya* with a progressive evolution rate and furrowed and bifurcated septa in the final chambers.

Description. Large test composed of 2–2.5 whorls, with a diameter ranging from 1600–3000 μm . Coiling plane changes progressively and the final whorl is nearly planispiral, but not completely. Height of the lumen in the final chamber is 500–1000 μm , with high H/D ratio of 0.3–0.44, due to a progressive and rapid evolution rate in the successive whorls. The number of chambers is high, 10–13.5 in the final whorl, whereas about half (5–6) in the previous whorls. Septa in the juvenarium and early chambers of the final whorl are curved,

TABLE 4. Measurements of the types in *Bibradya primitiva* sp. nov. (in microns). Abbreviations as in Table 1.

Specimen	D	Nw	NcLw	Hlc	wt	Hlc/D
HPU-KC11-3	620	2.5	10	80	20	0.129
HPU-KC37-341	560	2	9.5	125	30	0.223
HPU-KC81-399	840	3	11	90	30	0.107
HPU-SDB120-95	560	2.5	9.5	70	30	0.125
HPU-SDB126-161	490	2	8	110	15	0.224
HPU-SDB140-240	890	2.5	10.5	130	30	0.146
HPU-SDB160-276	640	>1.5	9	170	20	0.265
HPU-SDB161-197	690	2.5	11	120	25	0.173
HPU-SDB176-6	675	>2	>10	120	30	0.177
HPU-SDB179-291	590	2	10.5	130	20	0.220
HPU-SDB180-19	710	>2	8	140	20	0.197
HPU-SDB191-217	820	2	10.5	140	20	0.170

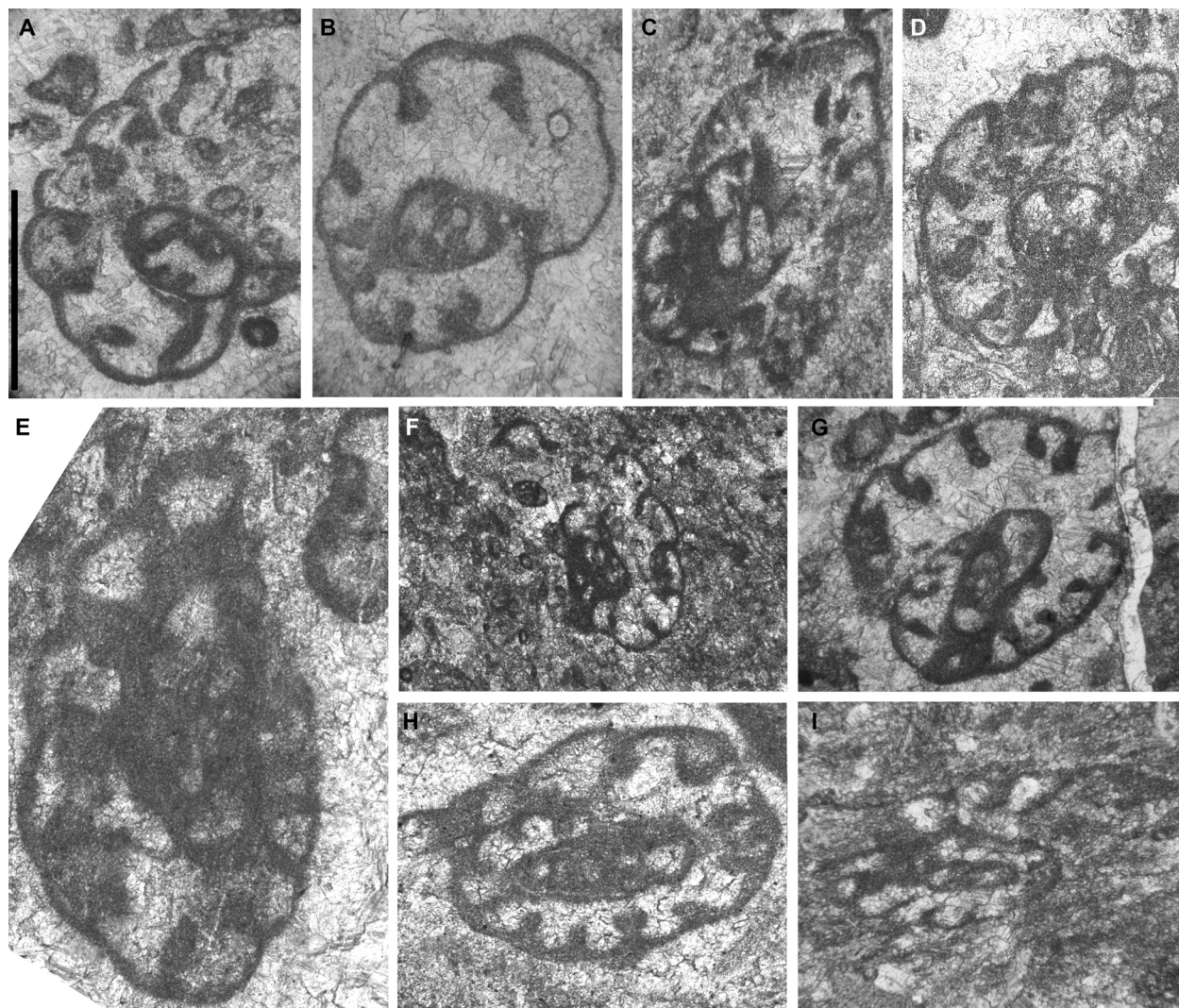


FIGURE 10. Illustrations of the new species *Bibradya maxima* sp. nov. and *Bibradya subita* sp. nov. **A–E.** *Bibradya maxima* sp. nov. A. HPU-KC75-389, B. HPU-KC75-392, C. HPU-SDB155-529, D. HPU-KC87-4 (holotype), E. HPU-KC75-41. **F–I.** *Bibradya subita* sp. nov., F. HPU-SDB182-33, G. HPU-SDB184-301 (holotype), H. HPU-KC81-7, I. HPU-SDB173-533. (Scale bar equals 1 mm).

whereas the final 5–6 chambers are separated by swollen and furrowed septa, which tend to be bifurcated in the final 2–3 chambers. Complex cribrate apertures occupy the entire apertural face.

Remarks. The most similar species is *B. tenella*, which presents similar number of chambers, whorls, septa, and coiling, although *B. maxima* is twice or three times larger.

B. maxima differs from *B. densicamerata* for the larger size, smaller number of whorls, and more expanded juvenarium.

Bibradya subita sp. nov.

Figure 10F–I

zoobank.org/3BB52629-ECA6-44DC-87BD-6CA7C75CD8BC

Derivation of the Name. For the sudden change in the coiling plane of the final whorl.

Material. Holotype (HPU-SDB184-301, Figure 10G) and 17 paratypes (Table 6).

Repository. School of Resources and Environment, Henan polytechnic University.

Type Locality and Horizon. Shuidong section, Protvian (late Serpukhovian).

Occurrence. Tarusian to Protvian (Serpukhovian) in both sections.

Diagnosis. Large *Bibradya* with the inner whorls oscillating and the final whorl changing suddenly 90° the coiling plane.

Description. Large rounded to elongated test, ranging from 900 μm for specimens of 2–2.5

TABLE 5. Measurements of the types in *Bibradya maxima* sp. nov. (in microns). Abbreviations as in Table 1.

Specimen	D	W	lprol	Nw	NcLw	Hlc	Wt	Hlc/D
HPU-KC75-35	2430	1200	—	>3	—	880	100	0.362
HPU-KC75-38	3080	—	—	—	>8	860	70	0.279
HPU-KC75-39	2810	—	—	>2	—	910	90	0.323
HPU-KC75-41	2690	—	—	3.5	13	450	70	0.167
HPU-KC75-382	2010	—	—	>1.5	>10	900	50	0.447
HPU-KC75-389	1750	—	—	>2	>10	710	50	0.405
HPU-KC75-392	1760	—	—	>2	8	600	50	0.340
HPU-KC78-3	1750	875	—	>2	7	—	20	—
HPU-KC79-14	1940	1200	—	2.5	—	820	40	0.422
HPU-KC83-9	3020	—	—	>2	13	1030	100	0.341
HPU-KC83-12	2010	890	—	>2.5	—	720	100	0.358
HPU-KC87-4	1670	—	—	>2	11	650	40	0.389
HPU-KC92-5	2800	—	—	>3	13	1100	100	0.392
HPU-KCT4-6	1600	>630	—	2.5	—	500	30	0.312
HPU-SDB138-12	1830	—	—	—	—	—	—	—
HPU-SDB155-529	1820	—	110	2.5	12	550	40	0.302
HPU-SDB171-284	1860	—	—	—	13.5	460	40	0.247
HPU-SDB186-14	1690	—	—	>2	12	480	40	0.284
HPU-SDB191-26	1900	—	—	—	—	—	40	—

TABLE 6. Measurements of the types in *Bibradya subita* sp. nov. (in microns). Abbreviations as in Table 1.

Specimen	D	W	lprol	Nw	NcLw	Hlc	Wt	Hlc/D
HPU-KC75-375	1200	—	—	—	—	580	60	0.483
HPU-KC81-7	1800	—	—	4	12.5	—	30	—
HPU-KC93-8	2000	—	—	3.5	11	420	40	0.21
HPU-KC93-412	1780	—	—	3.5	—	510	60	0.286
HPU-SDB155-189	1800	—	—	>2	—	550	30	0.305
HPU-SDB160-8	1160	—	—	>1	>9	260	40	0.224
HPU-SDB173-6	1350	—	—	>2	10.5	320	30	0.237
HPU-SDB173-204	2030	—	—	>2	12.5	550	50	0.270
HPU-SDB173-533	1840	—	—	>3	12	430	40	0.233
HPU-SDB182-17	940	—	—	3	—	320	40	0.340
HPU-SDB182-33	1000	—	—	2.5	>11	300	30	0.3
HPU-SDB184-8	875	—	—	2.5	11.5	210	30	0.24
HPU-SDB184-16	1360	—	—	>2	>10	—	30	—
HPU-SDB184-301	1470	—	60	3.5	12	450	50	0.306
HPU-SDB186-4	1600	—	—	>2	11	560	30	0.35
HPU-SDB186-18	1310	—	—	2.5	12	230	30	0.175
HPU-SDB187-7	1100	—	—	—	—	—	—	—
HPU-SDB189-2	1200	—	—	>2	—	410	50	0.341

whorls, up to 2000 μm for 3.5–4 whorls. The inner whorls are nearly planispiral, with slightly oscillations, and the final whorl turns approximately 90° rapidly. This sudden change in the coiling axis is also observed in the smaller specimens (e.g., Figure 10F, I). The rate of evolution of the juvenarium is slow, and high rates for the final whorl. Height of the lumen in the final chamber is 210–580 μm , with a moderate to high H/D ratio of 0.24–0.48. Septa furrowed, swollen, and bifurcated in the final whorl, curved in the juvenarium. Chambers are numerous, 11–13 in the final whorl, with marked final sutures. Wall microgranular, 30–60 μm thick. Cribrate apertures occupy the entire apertural face.

Remarks. The arrangement of the final whorl with the sudden turn in the coiling plane distinguishes this species from other *Bibradya*.

Genus *Parajanischewskina*
Cózar and Somerville, 2006

Type Species. *Parajanischewskina brigantiensis* Cózar and Somerville, 2006.

Diagnosis. Janischewskinae with slightly endothyroidal inner whorls and planispiral final whorls. Cribrate aperture in the final chambers and secondary sutural apertures with large pores. Thin, dark, and microgranular wall in most whorls, possibly formerly perforate, with an outer, darker layer. Keriotheca composed of an outer dark microgranular layer and an inner alveolar layer is present in the final septa and in the wall of the final chambers.

Composition. *Parajanischewskina brigantiensis* Cózar and Somerville, 2016; *P. nautiliformis* sp. nov.

Remarks. The genus *Parajanischewskina* was interpreted by Cózar and Somerville (2006) as an intermediate form between *Bradyina* and *Janischewskina*, mostly due to the stratigraphic record of these three genera in Britain. However, the biostratigraphy of these genera in other basins does not support the phylogenetic lineage. *Parajanischewskina* is restricted in Britain to the uppermost Asbian to the lowermost Brigantian (Cózar and Somerville, 2004; Waters et al., 2017; Cózar et al., 2022), whereas the first *Janischewskina* (*J. typica*) occurred in the late Brigantian (= early Serpukhovian) (Cózar and Somerville, 2021), as a result, there is a significant gap without any representatives of both genera. Richer Janischewskinae assemblages from the Russian Platform show small species of *Janischewskina* from the Aleksinian (FAD), at coeval levels with *Bradyina*, whereas the large species of *Janischewskina* occur from the Mikhailovian (Kabanov et al., 2016; Gibshman et al., 2020). *Parajanischewskina* has been never

reported from the Russian Platform, and as mentioned previously, it was questioned if the keriotheca might be an artifact of oblique sections over double or triple cribrate apertures. However, the case can be the contrary, and the keriotheca wall in the final chambers might be confused with oblique sections of cribrate apertures (e.g., Gibshman et al., 2020, pl. 1, figs. 11–12). Furthermore, although unrecognized by previous authors, the genus has been recorded by us in the Venevian in the Western Moscow Basin of the Russian Platform (Figure 11A–B).

Occurrence. Latest Asbian to late Serpukhovian in Britain, questionable in the Brigantian of SW Spain, Serpukhovian of Ireland and NW Spain, latest Viséan to late Serpukhovian in France and Sahara Platform, late Serpukhovian in Ukraine (Cózar and Somerville, 2006; Cózar et al., 2014a, 2018; Vachard et al., 2016). Venevian in the western Moscow Basin, questionable in the Serpukhovian (Khudolazian) in the Urals. The FAD of the genus *Parajanischewskina* might be in the late Viséan, equivalent to the Aleksinian or Mikhailovian in the Donets Basin, Ukraine (C₁^{Vf2} horizon) (Cózar and Somerville, 2006). It must be noted that the FAD of *Janischewskina* is located in the Aleksinian (e.g., Gibshman et al., 2020), and thus, it is not clear yet which genera, *Parajanischewskina* or *Janischewskina*, occurred first.

Distribution in the Bama Platform. *Parajanischewskina brigantiensis* (Figure 11C–D) has been recorded from the upper part of the latest Viséan, whereas *P. nautiliformis* only occurs at the base of the Serpukhovian in both sections. The former species disappears at the base of the lower Serpukhovian, whereas the latter extends up to the top of the lower Serpukhovian.

Parajanischewskina nautiliformis sp. nov.
Figure 11E–I

zoobank.org/A5097972-22E2-4A92-AA53-5A69AC993459

2006 *Parajanischewskina*? sp. 1.—Cózar and Somerville, pl. 1, fig. 2.

Derivation of the Name. For the nautiloid form of the test.

Material. Holotype (HPU-KC75-391, Figure 11F) and six paratypes (Table 7).

Repository. School of Resources and Environment, Henan polytechnic University.

Type Locality and Horizon. Kacai section, Tarusian (early Serpukhovian).

Occurrence. Early Serpukhovian.

Diagnosis. *Parajanischewskina* with keriothecal wall presenting in the 4 final septa and chambers.

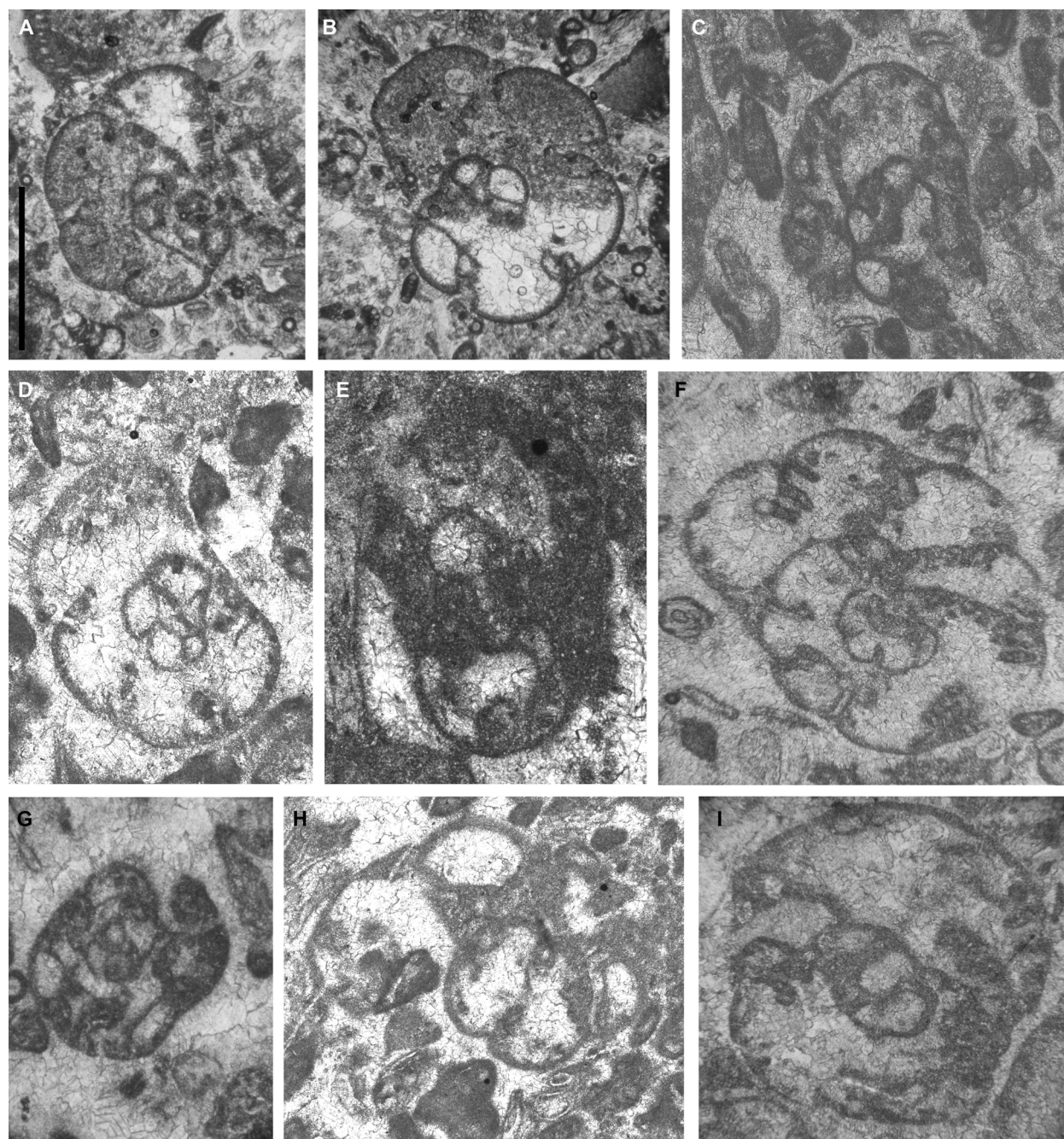


FIGURE 11. Typical representatives of the genus *Parajanschewskina*. **A–B.** *Parajanschewskina brigantiensis* Cózar and Somerville, 2006, **A.** 3889-181, **B.** 3889-182, Limestone A8, top logla Formation, right bank of the Msta River, Western Moscow Basin (see Savitsky et al., 2015 for stratigraphical details). **C–D.** *Parajanschewskina brigantiensis*, **C.** HPU-KC75-5, **D.** HPU-SDB143-16. **E–I.** *Parajanschewskina nautiliformis* sp. nov., **E.** HPU-KC87-26, **F.** HPU-KC75-391 (holotype) **G.** HPU-KC87-487, **H.** HPU-KCT4-4, **I.** HPU-KC75-484. (Scale bar equals 1 mm).

Description. Large nautiloid test with umbilical areas poorly depressed (e.g., Figure 11E), ranging from 1150 μm in diameter for specimens of 2 whorls up to 2150 μm for 3–3.5 whorls. Width of the test in the umbilical region in well-oriented

specimens 1200 μm . Coiling is planispiral throughout, only the first whorl slightly endothyroid. Progressive evolution rate, composed of a low number of chambers per whorl, 6–6.5 in the final whorl. Septa are thin in the inner whorls, curved back-

TABLE 7. Measurements of the types in *Parajanischewskina nautiliformis* sp. nov. (in microns). Abbreviations as in Table 1.

Specimen	D	W	l _{prol}	Nw	NcLw	Hlc	Wt
HPU-KC75-391	2160	—	—	3	6.5	510	40
HPU-KC75-484	1840	1680	—	>2	—	650	50
HPU-KC75-486	1150	—	—	2	5	—	30
HPU-KC87-26	2040	1200	90	3.5	—	440	30
HPU-KCT1-3	1820	—	—	3.5	6	490	40
HPU-KCT4-4	1900	—	—	—	6	700	40
HPU-SDB155-467	2120	—	—	3	6	450	50

ward, passing to thick septa with keriotheca in the final 4–5 chambers, up to 110 µm thick. Normally microgranular wall in the rest of the test, comparatively thin, 30–50 µm thick. Cribrate apertures in the last 3–4 chambers.

Remarks. Differs from *P. brigantiensis* for the occurrence of the keriotheca in more numerous septa and parts of the wall, as well as lower number of chambers per whorl.

BIOSTRATIGRAPHIC AND PALAEOBIOGEOGRAPHIC IMPLICATIONS

The occurrence of *Bibradya* seems to be incomplete in the studied sections, because the first *B. tenella* (more evolved *Bibradya*) from the top of the Aleksinian occurred earlier than other species apparently more primitive from the Mikhailovian. This does not follow a logical phylogenetic lineage. Thus, it is inferred that *B. primitiva* should first occur also from the Aleksinian. *Bibradya densicamerata* and *B. maxima* can be used for the recognition of the upper part of the Mikhailovian and on the other hand, *B. subita* has been documented consistently from the basal Serpukhovian. The disappearance of the genus is at the base of the Zapaltyubian or in the lower levels of this substage, which can be used as another important indicator. The last species recorded in the Zapaltyubian is *B. densicamerata*.

The genus *Cribrospira* shows rather variable first occurrences in the Bama Platform, similar to the Western Palaeotethys. The primitive forms can occur from the middle Viséan (the oldest strata have not been studied in detail in this region of China), whereas the large species were widespread in the late Viséan and Serpukhovian. It can be highlighted the first occurrence of *C. panderi* nearly coinciding with the first large *Janischewskina*, a few meters below the first *Eostaffella ikenis*, and that has been used for the recognition of

the Mikhailovian in the basin. Rare occurrences of *C. orbiculata*, *C. lianxianensis*, *C. baliamadani*, and *C. evoluta* are associated with the Venevian strata.

The occurrence of large species of *Janischewskina* is an index for the Mikhailovian. The first occurrences of *J. delicata* and *J. gibshmanae* can be used as Serpukhovian markers.

Although *Parajanischewskina nautiliformis* is restricted to the Serpukhovian, its rarity prevents considering this species as robust as would be desirable.

Aretz et al. (2014) proposed that foraminiferal assemblages from South China were influenced by the Western European basins and the Russian Platform during the Tournaisian and early–middle Viséan, whereas for the late Viséan and early Serpukhovian, assemblages show more affinities with those from the Russian Platform. The parallel diversity in species of *Cribrospira* and *Janischewskina*, as well as their similar stratigraphic ranges confirm this close relationship with the Russian Platform.

However, the occurrence of *Parajanischewskina* and *Bibradya* in China is more problematic. In previous studies, the genus *Parajanischewskina* was restricted to Britain, Ireland, Spain, Morocco, France, and Ukraine (questionable in Sverdrup Basin, Canada), and thus, in the western Palaeotethys basins. The specimens reinterpreted from the Russian platform, as well as those recorded by us from this region, suggest that the Russian Platform might provide the source for the foraminiferal assemblages recorded in South China. As a result, it can be assumed that *Parajanischewskina* originated in Ukraine, but migrated to China through Russia, and the apparent absence in that region is only a matter of misidentifications with *Janischewskina*. The rarity of *Bibradya*, which is restricted to the western extreme of the Palaeotethys (Britain, Ireland, Sahara), complicates our understanding

on the migration routes to China if specimens of '*Mirifica*' *mirifica* in the Russian Platform and Ukraine are not considered to belong to this genus (see family 'Remarks').

CONCLUSIONS

Rich foraminiferal assemblages from the Bama Platform allow clarification of the systematic, composition, and biostratigraphy of the family Janischewskinae.

The family is considered to be composed of four genera, *Janischewskina*, *Cribrospira*, *Bibradya*, and *Parajanischewskina*. The genera *Rhodesinella* and *Groessensella* are considered as synonyms of *Cribrospira* and *Bibradya*, respectively. Some specimens of the genus *Ugurus* are included under the genus *Bibradya*.

Seven new species have been described: *Cribrospira evoluta*, *C. paradenticulata*, *Bibradya primitiva*, *B. densicamerata*, *B. maxima*, *B. subita*, and *Parajanischewskina nautiliformis*.

The biostratigraphy of the Janischewskinae in South China resembles that in the Russian Platform, i.e., primitive *Cribrospira* are first recorded from the Tulian, primitive *Bibradya* from the Aleksinian, evolved *Cribrospira* (e.g., *C. panderi*) and large *Janischewskina* from the Mikhailovian, *Parajanischewskina* and *Bibradya maxima* from the Venevian, and *Janischewskina delicata*, *J. gibshmanae*, *Bibradya subita*, and *Parajanischewskina nautiliformis* from the base of the Serpukhovian. On the other hand, *Janischewskina adtarusia* is only recorded from the upper Serpukhovian.

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