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"Dimorphic pairs" of Albaillellaia (Late Paleozoic radiolaria), Japan

Hiroaki ISHIGA

Department of Geology, Faculty of Science,
Shimane University Matsue 690, Japan
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Dimorphic pairs occurred in Permian radiolarians which are normal form of domiant numbers called the N type and deformed shell characterized by an swollen of apical cone called the S type. Dimorphic pairs appeared in Albaillellaria of a bilaterally symmetry and covered by imperforated shell wall, such as *Albaillella, Pseudoalbaillella, Follicucullus* and *Neoalbaillella.*

Dimorphic pairs were examined in bedded chert sequences, and within a single bed of chert with respect to radiolarian blooming of the Permian time. In general occurrence rate of the S type from the single bed of the bedded chert, is about 3% of total number of species, however the S type of *Pseudoalbaillella ornata* of which the species is the biggest and mostly ornamented shell among species of *Pseudoalbaillella* as well as other Albaillellaria exceeds 20%.

Introduction

Aside the biostratigraphic potential, one of our facination in the radiolarian research is comprehension of their shell morphology. Most radiolarian shell construction is symmetry of ornamentation by geometric patterens. However, some group of the Late Paleozoic are organised by an unique shell construction which aids to connect paleontography to biology eventhough a morphologic description for paloentology.

Kling (1971) in Anderson (1983) pointed the possibility of dimorphic reproduction in radiolarian species, of which suggestion has deserved an additional observations.

A swollen apical cone (apex of shell) is known from the Permian Albaillellaria and this form was regarded in case, as a different species from the normal type form. However, the deformed shell occurred with the normal one and probably most species of Albaillellaria show this dimorphism.

Bedded cherts sequence produced excellently preserved and continuous occurrence of speciemens which accords an investigation of morphology, stratigraphic distribution, and mode of occurrence of the "dimorphs" of Albaillellaria.

Morphology of Albaillellaria

Albaillellaria shows a bilaterally symmetric form characterized by basic 2 spines connecting at the shell apex covered by imperforated shell with or without small pores.

Among the genera of Albaillellaria, *Albaillella* Deflandre, *Pseudoalballella* Holdsworth and Jones, *Follicucullus* Ormiston and Babcock and *Neoalbaillella* Takemura and Nakaseko are more or less undulated shell and the stronger undulation divides the shell into apical cone, pseudothorax and pseudoabdomen in the speciemens of *Pseudoalbaillella, Follicucullus* and *Neoalbaillella*.

Apical cone is strong, pointed distally, and usually composed of thick wall. However, the specimens of an swollen apical cone is known.

The S type of Albaillellaria

Frequent reports giving SEM photos of the S type, swollen type have been appeared, however they are sometimes treated as independent species. The S type known hitherto from Japan are listed below.

Neoalbaillella

Among the species of *Neoalbaillella,* the S type appeared in the specimens of *Neoalbaillella ornithoformis* Takemura and Nakaseko and *N. gracilis* Takemura and Nakaseko from the bedded cherts of the Mino-Tamba Belt. The S type has not been found in the species of *N. optima* Ishiga et al. and *N. grypus* Ishiga et al. The appearence of S type in these species is expected to be related to their own unique construction of shell which manifestes characters. For example if, in species of *N. optima,* silica for shell construction is supposed to be expended in forming the laddar shaped complicated wing (Ishiga et al., 1982a), then the swelling of apical cone recognisable is less or not. Furthermore in specimens of *N. grypus,* which is characterized by bending of apical cone, the character of swelling is supposed to be denied by the stronger appearence of this bending character.

Reference.

Neoalbaillella sp. A Takemura and Nakaseko, 1981, pl. 34, figs. 2, 3

Unpublished data from the specimens of the bedded cherts of the Mino-Tamba Belt examined by Ishiga et al. (1982a), which is given in this paper.

Remarks.

The specimen illustrated by Takemura and Nakaseko (1981), is characterized by strongly inflated apical portion, which resembles "temple bell". The width of lower part of apical portion is nearly same as that of pseudothorax.

Follicucullus

The S type of *Follicucullus* occurs in *F. scholasticus* Ormiston and Babcock morphotype II of Ishiga (1984) and this genus was the last one of which the S type has been reported by Ujiie and Oba (1991). The S type has not been found in species of

Follicucullus monacanthus, F. charveti, F. bipartitus and *F. ventricosus* (of topotypes from the Texas) eventhough 300 specimens had been examined in each species.

Reference.

Follicucullus scholasticus (=*F. scholasticus* morphotype II), Ujiie and Oba, 1991, pl. 3, fig. 2

Remarks.

The upper part of the apical cone is swollen and broad constriction dividing swallen part from the pseudothorax.

Pseudoalbaillella

The S type of the species of this genus occurs frequently among the species of *Pseudoalbaillella,* especially in Permian ones. The S type of *P. ornata* is illustrated in Plate 1 of this paper.

Reference.

Pseudoalbaillella lomentaria, Ishiga and Imoto, 1980, pl. 2, figs. 14, 15
Pseudoalbaillella sp. A (=*P. sakmarensis*), Ishiga and Imoto, 1980, pl. 3, fig. 2
Haplodiacanthus anfractus Nazarov and Rudenko, Panasenko and Rudenko, 1987, pl. 2, figs. 1–16.
Pseudoalbaillella sp. aff. *P. longicornis,* Ishiga et al., 1982c, pl. 2, figs. 5, 7

Remarks.

The S type has not been reported from the Late Carboniferous *Pseudoalbaillella* such as *Pseudoalbaillella bulbosa* Ishiga, *P. elegans* Ishiga and Imoto, *P. nodosa* Ishiga etc. (Ishiga et al., 1982c, Ishiga, 1984). Noteworthy is the lack of S type in *Pseudoalbaillella globosa* which is characterized by strongly swollen pseudoabdomen, while the S type occurs in *P. ornata* as mentioned above.

Ontogenic change of forms in specimens of *Haplodiacanthus anfractus* has been reported and dimorphic pairs (normal and abnormal types in the literature) were illustrated by photos (Panasenko and Rudenko, 1987). According to them, swollen type of the early stage of ontogeny appeared in the *H. anfractus* group. This supports the idea that radiolaria may have sexual reproductive stages with dimorphic alternating generations analogous to the dimorphic, sexual and asexual, alternating generations in benthic foraminifers.

As illustrated in Plate 1, *P. ornata* is the most complicately ornamented species among the *Pseudoalbaillella* species: the biggest shell, barrel shaped pseudothorax and ornamented pseudothorax by two types of pores, moreover, the bigger pores (windows with spines). An idea comes to a solution of the dimorphism, if we compare appearence of S type of *P. ornata* and absence of S type in *P. globosa.* Swelling of apical cone

may have requested excess deposition of silica in organism. As suggested in *Neoalbaillella* species, swelling belongs to a character of formation of shell especially apical cone. Probable consumption of silica to form a strongly swollen pseudothorax may obstract swelling of apical cone. Thus during the provision of the fixed volume of silica to the organic parts (such as apical cone, pseudothorax, pseudoabdomen and wings), the stronger character should conclude the formational process of shell. The next question is that why disappearence of S type in Carboniferous Albaillellaria, especially *Pseudoalbaillella*. *Pseudoalbaillella* occurred in Late Carboniferous from some form of *Protoalbaillella,* trends in development of shell in the population swung at this early stage of the evolution. Their main concern could be a formation of a basic shell construction as a bilaterary symmetry and covering of a imperforated shell wall.

Albaillella

Although the S type of the Middle Permian *Albaillella* is well known as listed below. That of the Late Permian *Albaillella* species has not been reported and also has been unknown through the author's examination. Species of this genus were greatly diversified and numerous species were appeared in Carboniferous time (Cheng, 1986, Gourmelon, 1987). At present *Albaillella sinuata* and *A. asymmetrica* are probable exception of *Albaillella* in carrying dimorphic pairs.

Reference.

Albaillella asymmetrica Ishiga et al., 1982c, pl. 3, figs. 10, 11
Albaillella sp. D. (=*A. sinuata*), Ishiga et al., 1982c, pl. 4, fig. 4
Gen. et. sp. indet. (=*Albaillella sinuata*), Ujiie and Oba, 1991, pl. 4, figs. 8–10

Remarks.

In specimens of *Albaillella,* no division of posture has been settle because of the different shape of shell construction from other Albaillellaria. However, *A. sinuata* sometimes bears the swollen apical portion, which varies its mode of inflation. Specimens of *A. sinuata* of Ishiga et al. (1982c) listed above, show inflation at dorsal side of shell, while those of Ujjie and Oba (1991) show strong swell like that of "bell" shaped part originated from 2 or 3 segments of apical portion. The S type of *Albaillella asymmetrica* also shows varied mode of swollen apical portion (Ishiga, et al. 1982c).

Mode of occurrence of the S type in the population

The ratio of the S type (swollen type)/total population of the species has been examined from the specimens of the Mino-Tamba Belt. The specimes examined here and ratio of S type/total population (S type+N type individuals) are listed below.
Neoalbaillella ornithoformis 1, sample number 23 of Nabejiri-yama area (Ishiga et al., 1982a). S type (4), N type (190), ratio 2.1%.

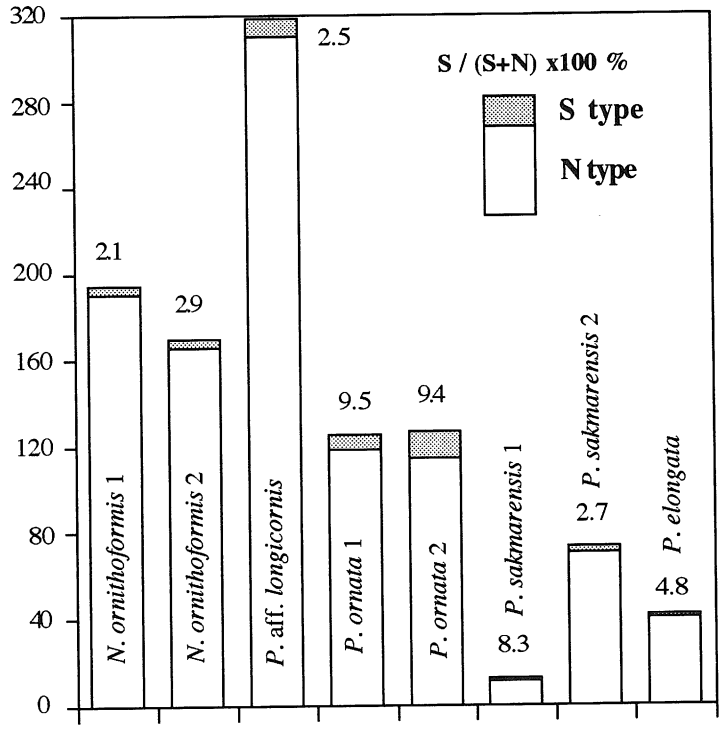

Fig. 1. Frequency diagram of dimorphic pairs in species of *Pseudoalbaillella* and *Neoalbaillella* examined in the Permian bedded cherts of the Mino-Tamba rocks.

Neoalbaillella ornithoformis 2, sample number 23 of Nabejiri-yama area (Ishiga et al., 1982a). S (5), N (165), ratio 2.9%.

Pseudoalbaillella sp. aff. *P. longicornis* sample 15 in the Ashimidani section in the Ashimidani area (Ishiga, 1982c). S (8), N (311), ratio 2.5%.

Pseudoalbaillella ornata 1, sample 4–1 of the Sasayama area (Ishiga and Imoto, 1980). S (7), N (119), ratio 9.5%.

Pseudoalbaillella ornata 2, sample 4–1 of the Sasayama area (Ishiga and Imoto, 1980). S (12), N (115), ratio 9.4%.

Pseudoalbaillella sakmarensis 1, sample 4–38 of the Sasayama area (Ishiga and Imoto, 1980). S (1), N (11), ratio 8.3%.

Pseudoalbaillella sakmarensis 2, sample 4–19 of the Sasayama area (Ishiga and Imoto, 1980). S (2), N (71), ratio 2.7%.

Pseudoalbaillella elongata, sample 4–38 of the Sasayama area (Ishiga and Imoto, 1980). S (2), N (40), 4.8%.

Dimorphic pairs in relation to radiolarian blooming investigated in a single bed of bedded chert sequence

Lithology of bedded cherts

Ratio of dimorphic pairs has also been examined in a single bed of bedded chert sequence of the Sasayama section mentioned above (sample 14–13a same horizon to 4–38 of Ishiga and Imoto, 1980). Before going on to the results of experiment, lithologic feature of bedded cherts examined is briefly described.

The bedded chert sequence is composed of two distinct types of chert, one biogenetic and the other from the accumulation of siliceous mud including excellently preserved radiolarian skeletons (Ishiga and Imoto, 1980). This lithology is characteristic of the Late Carboniferous to Permian bedded cherts of Southwest Japan, while those of the Triassic to Jurassic bedded cherts are usually composed of the former type cherts (see Imoto, 1983).

The hand specimen of chert bed of the latter type (about 6 cm×8 cm square and about 20.4 cm thick) was collected and etched by HF solution of about 5% for 6 to 10 hours and after washing by current water, radiolarian skeletons were observed. When

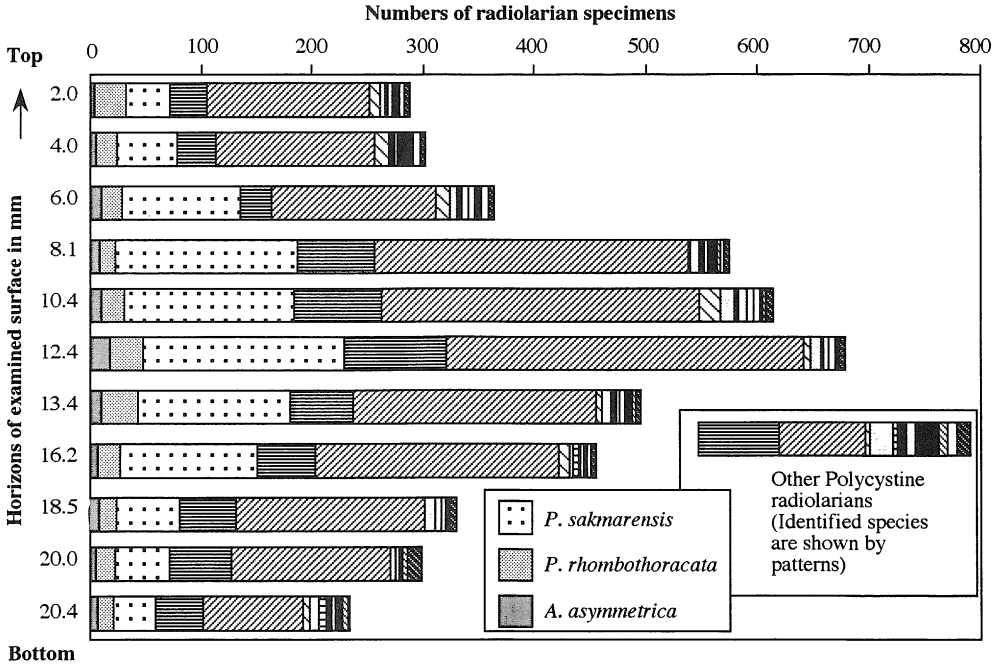

Fig. 2. Frequency diagram showing numbers of radiolarian species within a single bed representing blooming of radiolarians. Sample from 4–38 of Sasayama area of Ishiga and Imoto (1980).

both identification and picking up of radioalrian specimens were finished, the chert surface were grinded for about 2 mm thick nearly parallel to the bedding plane. This treatment was repeated by 10 times and 11 horizons (including both top and bottom surfaces) within a single bed were prepared for this examination. Identified radiolarians are listed in Fig. 2 and ratio of dimorphic pairs are calculated (Fig. 3).

Frequency of dimorphic pairs

Dimorphic pairs of species *Pseudoalbaillella sakmarensis, P. rhombothoracata* and *Albaillella asymmetrica* were examined in the sample about 2 mm by 2 mm thick mentioned avove. Among these species, no S type form were found in *A. asymmetrica* because of the least amount of numbers of this species were produced in the examination. *P. sakmarensis* was dominantly yielded and total numbers of this species gradually increase from bottom to the middle part of the bed and decrease their numbers toward the top. The S type form appeared in the middle part from the 16.2 mm to 6.0 mm horizons and the ratio $S/(S+N)\times100$ ranges from 0.6 to 1.9%. Although the numbers of *P. rhombothoracata* are less in the sample, frequence of appearence of S type of this species shows much larger than that of *P. sakmarensis* ranging from 3.3 to 6.2%.

The occurrence of dimorphic pairs in a single bed indicates that two forms are intimately related to each other when the numbrs of the specimens are enough to find S type, although there is no way to prove their sexual reproduction.

Blooming of Permian radiolaria and change of paleoenvironment

Variation in numbers of specimens in a bed is supposed to relate the blooming of radiolarians when radioalrian skeletons were deposited with fine siliceous muds in oceanic basin. Within the bed investigated above (Fig. 2), the total and individual numbers of radiolarian specimens gradually increase up to near the central part of the beds, 12.4 mm horizon and they decrease their numbers in 10.4 mm and 8.1 mm horizon stepwisely. However in horizons from 8.1 mm to 6.0 mm sudden change of diminishing in numbers occurred and in the upper part, the gradual changes remain again. If the changes of radiolarian specimen numbers were controlled by the blooming of radiolarians, the chert bed was supposed to be formed where an effect of biogenic activity directly came to the depositional environment of the lower Permian bedded cherts. And the cyclicity of bedded cherts could be expected to coinside the rhythm (Milankovitch's cycle) of environmental change in oceanic region such as the appearence of upwelling by drifting of paleocontinent (cf. Hori and Cho, 1991).

Acknowledgements

The radioalrian specimens were collected by the author who was in Kyoto Universi-

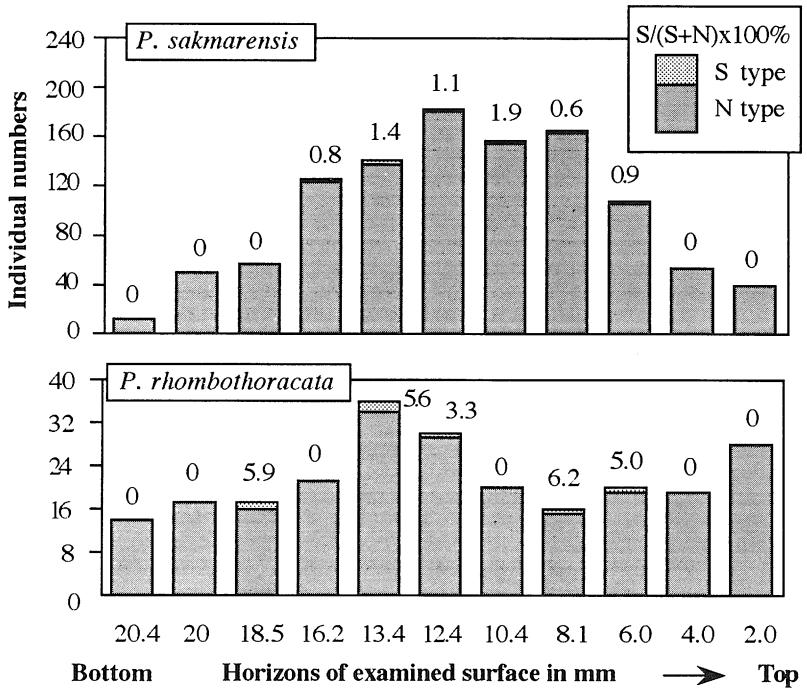

Fig. 3. Frequency diagram of dimorphic pairs of *Pseudoalbaillella sakmarensis* and *P. rhombothoracata* examined in a single bed of bedded cherts. Sample from 4–38 of Sasayama area of Ishiga and Imoto (1980).

ty of Education supervised by Imoto, N. of this university. An idea of examination of radiolarian specific composition by means of bed by bed and lamina by lamina method were originated by Imoto's work on sedimentary feature of cherts. Starting point of an examination of the dimorphic pairs was owing to the question from Ujiie, H. of Ryukyu University who gave valuable suggestion on this phenomena.

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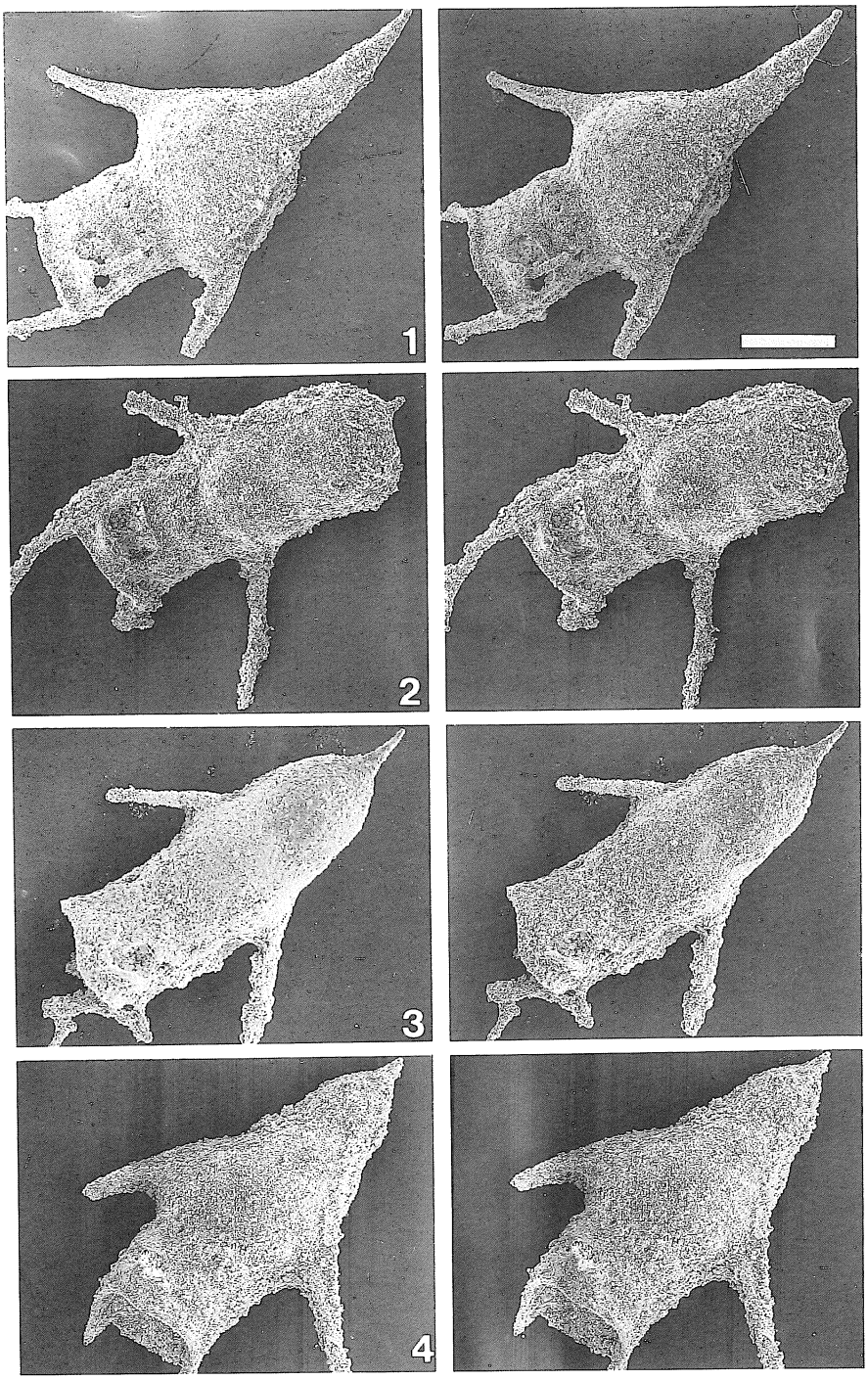
Explanation of Plates

Plate 1

Figs. 1–4. Stereoscopic pairs of *Pseudoalbaillella ornata* Ishiga and Imoto, topotypes from samples 4–38 of the Sasayama area by Ishiga and Imoto (1980).

Fig. 1, N type (Normal type) of *P. ornata*; Figs. 2–4, S type (Swollen type) of *P. ornata*. Note the difference of swelling among the three specimens of illustration. Scale bars; 100 μm.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