Plant fossils from the Lower Cretaceous Tetori Group in the Itoigawa area, Niigata Prefecture, central Japan

Yusuke SAKAI*, **, Tsuyoshi ITO***, Yousuke IBARAKI**** and Atsushi MATSUOKA*****

Abstract

Sterile fern fronds comparable to *Birisia onychioides* (Vassilevskaja and Kara-Mursa) Samylina [sense Kimura] and assignable to *Cladophlebis* sp. were found from the Lower Cretaceous Tetori Group near Ichiburi in the Itoigawa area, Niigata Prefecture, central Japan. This paper describes these specimens with photographs and line drawings for the first time in Niigata Prefecture. *Birisia* is one of the important elements indicative of the Siberian paleofloristic province. It is common in the Oguchi and Akaiwa floras of Barremian–Aptian age but has not been found in the younger Kitadani (or Tamodani) Flora of Aptian age in the Tetori Group. Lithostratigraphic assignment of the plant fossil-bearing sequence in the study area is discussed.

Key words: *Birisia*, *Cladophlebis*, plant fossil, Mizukamidani Formation, Shiritakayama Formation, Tetori Group, Itoigawa area.

Introduction

The Tetori Group (Oishi, 1933; Yamada and Sano, 2018) consists of Lower Cretaceous terrestrial and shallow marine sediments in the Inner Zone of Southwest Japan. Abundant

* Graduate School of Science and Technology, Niigata University, Niigata 950-2181, Japan
** Ono City Board of Education, Ono 912-8666, Japan
*** Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, Tsukuba 305-8567, Japan
**** Fossa Magna Museum, Itoigawa 941-0056, Japan
***** Faculty of Science, Niigata University, Niigata 950-2181, Japan
Corresponding author: Y. Sakai,
ysuk.sakai@gmail.com
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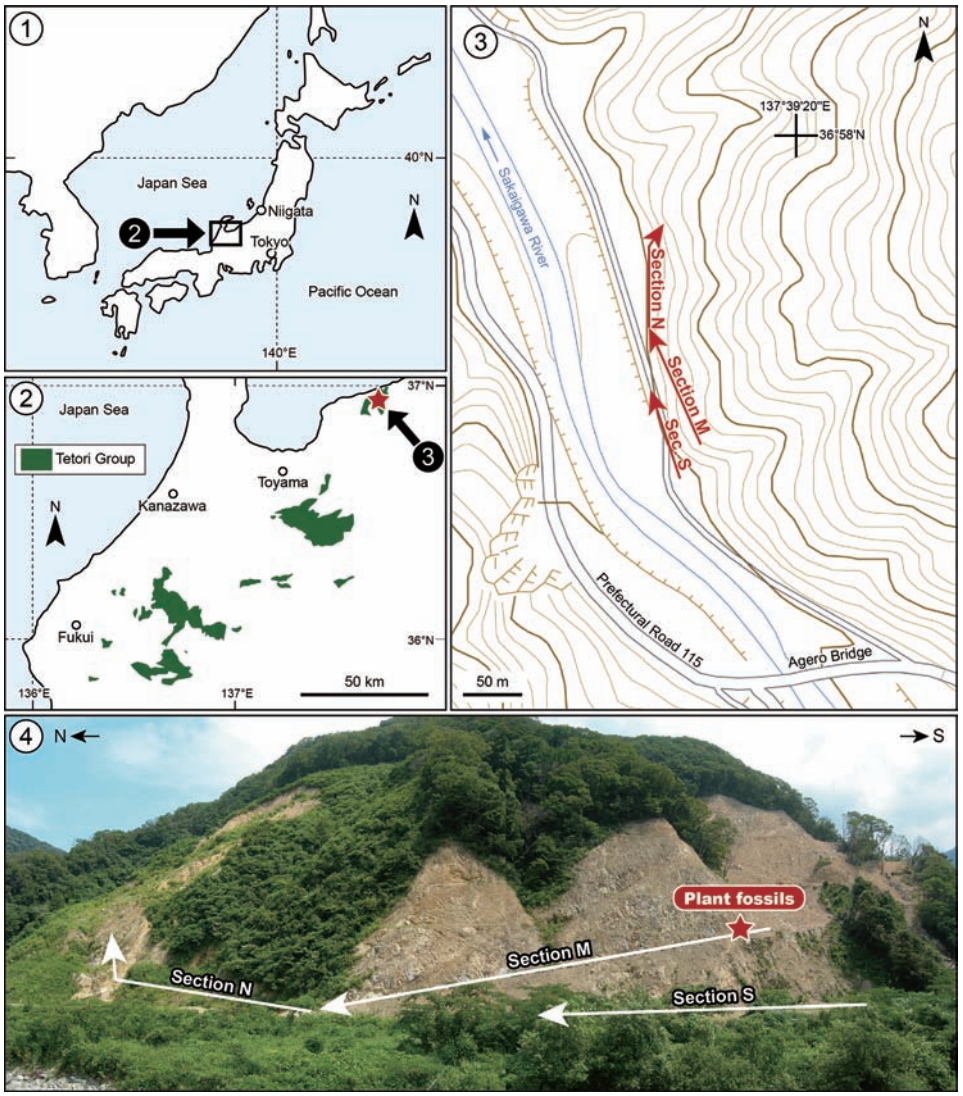

Fig. 1. 1: Locality map of the study area, 2: Distribution of the Tetori Group (modified from Maeda, 1961), 3: The study sections which outcrop along the right bank of the Sakaibgawa River, 4: Panoramic view of the study sections from the left bank of the Sakaigawa River.

non-marine faunas and land plants have been reported from the group in Fukui, Ishikawa, Gifu, and Toyama prefectures (e.g., Maeda, 1961; Fujita, 2003; Yabe et al., 2003; Matsukawa et al., 2006; Sano, 2015; Sano and Yabe, 2017). The Itoigawa area is located at the southwestern end of Niigata Prefecture, central Japan. The Tetori Group in the area occupies the easternmost part of its entire extent (Fig. 1). Fossil records from the Tetori Group in the Itoigawa area are very limited: *Onychiopsis elongata* (Geyler) Yokoyama was the only plant fossil record hitherto reported in the area (Goto, 1983, 1986).

We have investigated the Tetori Group in the Itoigawa area since 2010 to establish the stratigraphy and to accumulate fossil records (Ito et al., 2012, 2014; Sakai et al., 2012, 2013). Our research has been concentrated on the sequence exposed at a quarry (36° 57' 54. 5" N, 137° 39' 14. 9" E) on the right bank of the Sakaigawa River near Ichiburi in the Itoigawa area, Niigata Prefecture (Fig. 1). Sakai et al. (2012) showed detailed geological columnar sections of the Tetori Group and preliminarily reported the occurrence of plant fossils. In this paper, we describe cf. *Birisia onychioides* (Vassilevskaja and Kara-Mursa) Samylina and *Cladophlebis* sp. collected at the quarry. This is the first report on both species from the Tetori Group in Niigata Prefecture. The specimen of cf. *Birisia onychioides* from the quarry was provisionally reported as *Onychiopsis elongata* by Sakai et al. (2013). We discuss stratigraphic correlation of the Tetori Group in the Itoigawa area on the basis of the occurrence of *Birisia* species.

Geological setting and stratigraphic position of plant-bearing beds

The Mesozoic sequences in the Itoigawa area are composed of the Lower Jurassic Kuruma Group and the overlaying Lower Cretaceous Tetori Group. The Tetori Group in the area consists of the Mizukamidani Formation (Kobayashi et al., 1957) and the Shiritakayama Formation (Yoshimura and Adachi, 1976). The stratigraphic relationship between these two formations is not well understood yet. The Mizukamidani Formation was originally considered to be the uppermost part of the Kuruma Group (Kobayashi et al., 1957). It has been included in the Tetori Group since Chihara et al. (1979) revised its lithostratigraphic assignment on the basis of lithologic features. The Shiritakayama Formation was defined by Yoshimura and Adachi (1976) designating its type locality around Mt. Shiritakayama, 6.0 km east of the study section. Kishigami (2000) presented a geological map of the Shiritakayama Formation in the Mt. Shiritakayama area.

The Mizukamidani Formation is well exposed at the quarry (Fig. 1). Sakai et al. (2012) measured three columnar sections, namely S, M, and N from south to north (Fig. 1). Lithostratigraphy of these sections is presented in Fig. 2. The uppermost part of Section S (S-11 to S-13) can be correlated to the lowermost part of Section M (M-01 to M-03), which directly underlies Section N. The strata in the sections approximately strike N80° W and dip 35° N. There are some faults and dikes in the sections. The sections are composed mainly of feldspathic-arenite and conglomerate including chert, sandstone, siliceous mudstone, orthoquartzite, granite, andesite, and mudstone pebbles. Mudstone clasts are included in the conglomerates. Fining-upward cycles are repeated in the sections. Ito et al. (2012, 2014) reported three horizons of radiolarian-bearing chert pebbles in the sections (Fig. 2).

We collected plant fossils from M-02 in Section M (Figs. 2, 3). A fining-upward cycle is observed from M-01 to M-02 in the section. M-02 consists of sandstone-dominated alternating

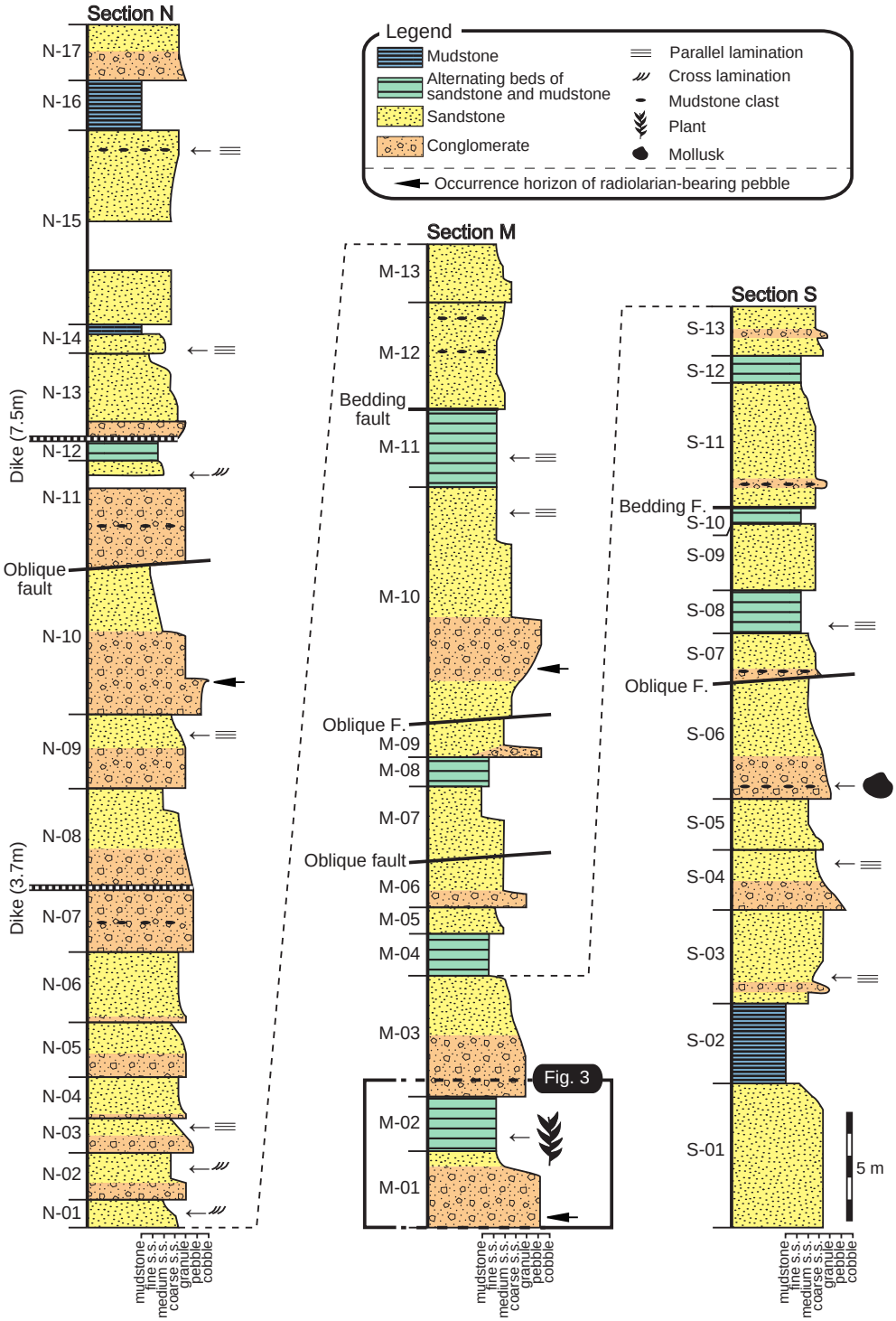

Fig. 2. Columnar sections of the Mizukamidani Formation in the right bank of the Sakaigawa River (modified from Sakai et al., 2012).

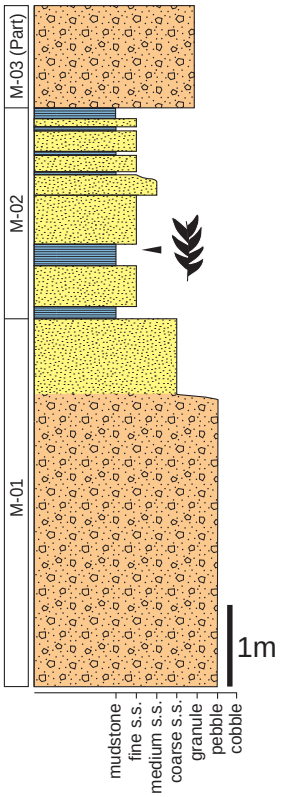

Fig. 3. Detailed columnar section of the lower part of Section M (Fig. 2). Legend is the same as that of Fig. 2.

beds of fine- to medium-grained sandstone and mudstone. The mudstone beds include many small plant fragments and coal. Two plant specimens were taken from a horizon 0.8 m higher than the base of M-02.

Plant fossils

The two plant specimens are fern fronds of cf. *Birisia onychioides* (FMM6179: Figs. 4A–B) and *Cladophlebis* sp. (FMM6180: Figs. 4C–D). They co-occurred in the bed composed mainly of light gray sandy mudstone that changed laterally to light gray well-laminated sandy mudstone. The fern fronds comparable to *B. onychioides* were included in the light gray sandy mudstone bed. *Cladophlebis* sp. was included in the light gray well-laminated sandy mudstone bed. These specimens are stored in the Fossa Magna Museum (FMM), Itoigawa City, Niigata Prefecture.

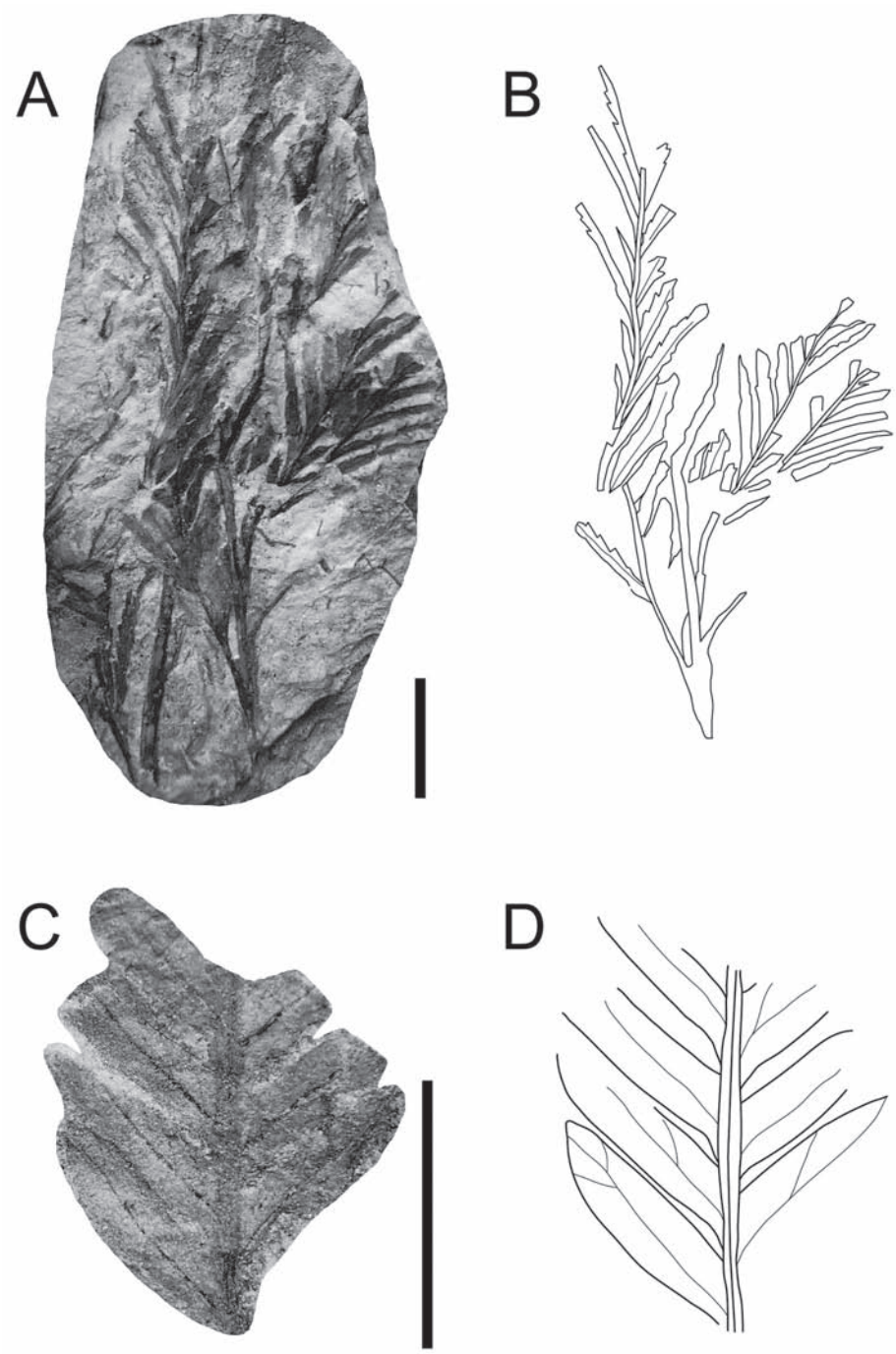

Fig. 4. Plant fossils from the mudstone bed in the Tetori Group distributed in Ichiburi, Itoigawa, Niigata Prefecture. A: Sterile fern fronds comparable to *Birisia onychioides* (Vassilevskaja and Kara-Mursa) Samylina [sense Kimura, 1975] (FMM6179). B: Line drawing of A. C: *Cladophlebis* sp. (FMM6180). D: Line drawing of C. Scale bars are 10 mm.

Systematic Paleontology

Filicales
Family Dicksoniaceae
Genus *Birisia* Samylina, 1972
Type species.— *Birisia alata* (Prynada) Samylina, 1972

Cf. *Birisia onychioides* (Vassilevskaja and Kara-Mursa) Samylina [sense Kimura, 1975]
Figs. 4A–B

Cf. *Birisia onychioides* (Vassilevskaja and Kara-Mursa) Samylina, Kimura, 1975, p. 71–74, pl. 5, figs. 6–9; pl. 6, figs. 1–4; figs. 4-2a–d.

Material.— FMM6179.

Description.— A few pinnae probably derived from a single frond were obtained. The specimen is 80 mm long and 36 mm wide. The frond is slender and at least bipinnate. Pinnae are elongate, 40 mm long and 18 mm wide at the widest portion. They are alternately arranged and are attached to the rachis at an angle of 20–30°. Pinnules are lanceolate, 20 mm long and 2 mm wide, pinnatifid and are gradually narrowed toward the apex. They are attached to the rachis at an angle of about 32°. The base of pinnules are constricted exmedially and are typically decurrent admedially. The primary veins are conspicuous and nearly straight, persisting almost to the apex (*Cladophlebis*-type). The secondary veins are indistinct. Fertile part of the pinnule is not preserved.

Remarks.— The genus *Birisia* was proposed by Samylina (1972) for fern frond with sterile pinnules of *Cladophlebidium*-type and fertile pinnules of *Coniopteris*-type. Samylina (1972) described four *Birisia* species from the Cretaceous of Siberia., i.e., *B. aculata* Samylina, *B. alata* (Prynada) Samylina, *B. ochotica* Samylina, and *B. onychioides* (Vassilevskaja and Kara-Mursa) Samylina. Two of these *Birisia* species were recorded in the Tetori Group in central Japan: *B. onychioides* and *B. alata* (Kimura, 1975; Kimura et al., 1978; Yabe et al., 2003). Kimura (1975) discussed variation of sterile fronds of *B. onychioides* in detail and synonymized *Cladophlebis shinshuensis* Tateiwa (Tateiwa, 1929; Oishi, 1940) to this species. Although our specimen (FMM6179) does not yield fertile part, it is inseparable from *B. onychioides* [sense Kimura, 1975] including *C. shinshuensis* in the shape and derivation angle of pinnules, especially decurrent basal side forming wings. Therefore, we followed the treatment by Kimura (1975) and compared our specimen to *B. onychioides*.

This species has been reported from fossil localities of the Tetori Group in Ishikawa, Gifu, and Toyama prefectures (Kimura, 1975; Kimura et al., 1978; Kunimitsu and Nakashima, 1987; Yatsuo Town Board of Education, 1996; Matsuura, 2001). It is common in these localities.

Form-genus *Cladophlebis* Brongniart, 1849

Cladophlebis sp.
Figs. 4C–D

Material.— FMM6180.

Description.— An ultimate part of a sterile fern frond with four pairs of pinna was obtained. The specimen is 12 mm long and 10 mm wide. Pinnules are narrow triangular with acute apex, and 6 mm long and 1.5 mm wide at the widest portion. They are arranged alternately and are attached to the rachis at an angle of 40°. The base of the pinnules are constricted exmedially and are decurrent admedially. The primary veins are conspicuous and nearly straight, persisting almost to the apex (*Cladophlebis*-type). The secondary veins are unclear and not forked. The secondary veins are attached to the primary veins at an angle of 30–35°, reaching the margin.

Remarks.— Although FMM6180 is poorly preserved, it is referable to the form-genus *Cladophlebis* because of its *Cladophlebis*-type nervation. Six species of *Cladophlebis* have been recorded in the Tetori Group, i.e., *Cladophlebis* ex gr. *denticulata* (Brongniart) Fontaine, *C. hamasakai* Kimura and Sekido, *C. hukuiensis* Oishi, *C. laxipinnata* Prynada, *C.* ex gr. *williamsoni* (Brongniart) Brongniart, and *C.* sp. cf. *C. pseudolobifolia* Vachrameev (Kimura et al., 1978; Yabe et al., 2003). Based on pinnule shape and nervation, our specimen (FMM6180) is distinct from any *Cladophlebis* species reported from the Tetori Group. However, the authors refrain from making a species assignment in this study because our specimen is so fragmental and poorly preserved in venation characters.

Discussion

This study reports a plant fossil specimen comparable to *Birisia onychioides* (Vassilevskaja and Kara-Mursa) Samylina [sense Kimura, 1975] from the Tetori Group in the Itoigawa area. The fossil record represents the northeasternmost occurrence of *B. onychioides* or comparable forms in the Tetori Group. Since Kimura (1974, 1975) reported *B. onychioides* for the first time from the Tetori Group in the Kuzuryu area, Fukui Prefecture, this taxon has been reported from the group in the Shiramine area, Ishikawa Prefecture (Kimura et al., 1978; Matsuura, 2001), in the Shokawa area, Gifu Prefecture (Kunimitsu and Nakashima, 1987), and in the Inotani area, Toyama Prefecture (Yatsuo Town of Board of Education, 1996). Recently Sakai et al. (2020) reported the occurrence of *B. onychioides* in the Itsuki Formation in the Itoshiro area, Fukui Prefecture.

Kimura (1975) proposed three stratigraphically discernible floras in the Tetori Group, namely the Oguchi, Akaiwa, and Tomodani floras in ascending order. *Birisia onychioides* is

common in the Oguchi and Akaiwa floras but has not been found in younger flora represented by the Tamodani Flora (Kimura, 1975; Kimura et al., 1978) or the Kitadani Flora (Sano, 2015). Yabe et al. (2003) suggested that *B. onychioides* was recorded in the Oguchi and Tomodani floras. The locality, where the Tamodani Flora with *B. onychioides* was reported in Yabe et al. (2003), can be correlated to a certain horizon within the Akaiwa Formation or its equivalent based on our own research. This fits well with the idea that the Oguchi and Akaiwa floras of Barremian–Aptian age is different in floral composition from the younger Kitadani Flora of Aptian age (Sano and Yabe, 2017). In addition, Kimura (1975) pointed out that *B. onychioides* is one of the important elements indicative of the Siberian paleofloristic province in the Early Cretaceous.

The plant fossil-bearing sequence in the quarry was originally assigned to the Mizukamidani Formation. Takeuchi et al. (2015, 2017) designated it as the type section of the Shiritakayama Formation based on their research on Mesozoic deposits around the border between Toyama and Niigata prefectures including the Itoigawa area. Takeuchi et al. (2015) reported the youngest detrital zircon U–Pb age of ca. 110 Ma from sandstones in the Mt. Shiritakayama area, the original type area of the Shiritakayama Formation. On the other hand, the youngest peak age of detrital zircon grains in sandstones around the quarry is 191 Ma (Takeuchi et al., 2015), which is much older than those in the Mt. Shiritakayama area. The resetting of the type section does not seem conclusive because the detrital zircon U–Pb age data are discordant. Moreover, the plant fossil evidence presented herein, possibly indicative of Barremian–Aptian age, is not always supportive for the resetting.

Concluding remarks

This paper gives a description of plant fossils with photographs and line drawings from the Tetori Group in the Itoigawa area. *Birisia* species have a potential not only for regional correlation within the Tetori Basin but also for correlation on a global scale because they have been found widely in Asia (Vakhrameev, 1991). Further collection of plant fossils and floral analysis will give a clue to elucidate the stratigraphy of Mesozoic sequences in the Itoigawa area where fossil evidence is still sparse.

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