Fossil Diatoms of the Kobiwako Group viz. Ancient Deposits of Lake Biwa

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Lake Biwa is the biggest lake in Japan, having an area of 674 sq. km. and the maximum depth of about 103 m. Not only it is the biggest, but also the oldest lake in this country. The birth (appearance) of this lake is estimated from the fission track dating and the paleomagnetism at about 4.5–5.0 million years ago. Namely Lake Biwa has its origin in Pliocene of Tertiary.

Because of the geological elevation of the southern ground, the ancient lake has performed during the past some million years the gradual transposition toward the north, while constructing the lacustrine deposits in its water bottom, and finally arrived at the location of the recent lake. For a long period of this translocation the ancient lake had sometimes the great dimension which was two or three times larger than the surface area of the recent lake.

The ancient lake deposits are now preserved in a state of perfection as the hills around Lake Biwa, especially in its southern region and their thickness in all is about 1500–1800 m. The first report on the ancient deposits of Lake Biwa was published in 1930 by geologist Prof. S. Nakamura of Kyoto University, who called these sediments "the Kobiwako Group".

The Kobiwako Group is with the fossils of the endemic shellfishes chiefly composed of clays, sands, and gravels. All of them were deposited in fresh waters; namely, they are lacustrine or fluvial in origin. Tens sheets of thin or thick volcanic ash layers are intercalated between such sediments and some of the thick and widely distributed ash layers are useful for the comparison of the level of the geological strata and are called therefore "the Key-Layers".

The Kobiwako Group is divided into six formations in ascending order, namely from south to north; Shimagawara, Iga-Aburahi, Sayama, Gamo, Yokaichi, and Katata Formations, as shown in Table 1 and Figure 1 (T. Yokoyama, 1969).

In November of 1978, I received from Dr. Yoshio Tomoda, a research worker of

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June, 1981

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Table 1. Stratigraphy of the Kobiwako Group (after T. Yokoyama, 1969).

<table>
<thead>
<tr>
<th>Geologic Age</th>
<th>my.</th>
<th>Stage</th>
<th>Main volcanic ash</th>
<th>Formation (thickness)</th>
<th>Member and rock facies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td>-0.4</td>
<td>Manchidani stage</td>
<td>Kamiogi</td>
<td>Katata formation 370 m</td>
<td>Ryuge sands and gravels, Zeze alternations</td>
</tr>
<tr>
<td></td>
<td>-0.9</td>
<td>Hacchoike stage</td>
<td>Azuki</td>
<td></td>
<td>Minamisho clays</td>
</tr>
<tr>
<td></td>
<td>-1.2</td>
<td>Nara stage</td>
<td></td>
<td></td>
<td>Wani sands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle Gravel stage</td>
<td>Yokaichi formation 90 m</td>
<td></td>
<td>Seta gravels II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Zinryo sands</td>
</tr>
<tr>
<td></td>
<td>-2.0</td>
<td>Gamo stage</td>
<td>Sakuradani</td>
<td>Gamo formation 500 m</td>
<td>Sakuradani sands and clays, Hino clays, Nubobikiyama sands and gravels</td>
</tr>
<tr>
<td>Tertiary</td>
<td>-3.0</td>
<td>Sayama stage</td>
<td>Kosaji</td>
<td>Sayama formation 100 m</td>
<td>Kosaji-Iwamuro clays, Sunazaka sands, Nojiri clays, Kazuraki sands and Ichiuno clays, Wata clays</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sagami</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Masugi</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Yubune</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>-4.5</td>
<td>Iga-Aburahi stage</td>
<td>Makiyama</td>
<td>Iga-Aburahi formation 350 m</td>
<td>Aburahi sands, Iga sands and gravels</td>
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<tr>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Seto stage</td>
<td>Shimagawara formation 100 m</td>
<td>coaly clays, sands, sands and gravels with clays</td>
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</tr>
</tbody>
</table>

fish-fossils, of the National Science Museum (Tokyo), some specimens of the sediment mass of the Kobiwako Group. Through his kindness I have been enabled to examine the fossil diatoms in the deposits of Lake Paleo-Biwa (Ancient Lake Biwa). Here I express my hearty thanks to Dr. Tomoda.

The results of my examination are as follows:

1. Iga-Aburahi Formation (at Nakamura)

This specimen of sediment was taken from a cliff near Nakamura Bridge in the upper course of the Hattori River, a branch of the Tsuge River. The place is located 9 km. east of Ueno City, Mie Prefecture. The pharyngeal teeth of a fish belonging to Cyprinidae and many snail-fossils were found. The specimen is certainly the lacustrine sediments which was formed at about 3.5 million years old.

The following diatoms were found by me in this ancient deposits:

*Melosira islandica-group, Stephanodiscus caronensis Grun.*, *Fragilaria construens* (Ehr.)

Grun. var. *subsalina* Hust. *Melosira* is the most abundant. *Fragilaria* is very rare. Many spicules of freshwater sponge were also found.
Fig. 1. Geological map of the Quaternary system around Lake Biwa (after T. Yokoyama, 1969).
June, 1981


(2) Iga-Aburahi Formation (at Hirata)
From the river-bed in the lower course of the Hattori River, in the vicinity of Hirata Village, only 2 km. downstream from the former place (Nakamura). The shell fossils of Anodonta, Viviparus (Sinotaia) etc. were here abundantly collected. The sediment is probably as same old as the former specimen. Although spicules of freshwater sponge were found, none of diatom-shells was examined in it.

(3) Sayama Formation (at Nojiri)
In the upper course of the Yasu River, at Nojiri, Koka-cho, Shiga Prefecture. The stratum of a cliff of the river-bank, from which the present specimen was taken, yielded many fossils of freshwater shellfishes and is equivalent to 2.5–2.6 million years old.
My examination revealed that the following diatoms and spicules of freshwater sponge were abundantly found in the specimen.

Melosira islandica-group, Stephanodiscus carconensis GRUN., S. carconensis GRUN. fo. maxima FRICKE, Fragilaria construens (EHR.) GRUN. var. triundulata REICHELT, Achnanthes lanceolata BREB.

(4) Sayama Formation (at Ichiuno)
The specimen was taken up from the deep ditch under construction in front of a field office of golf links at Ichiuno, Koka-cho. Fossils of backbones of a Cyprinidae fish were here found.

The fossils of the following diatoms were examined by me in this specimen:

Melosira islandica-group, M. italica (EHR.) KÜTZ. var. valida GRUN., Stephanodiscus carconensis GRUN., S. carconensis GRUN. fo. maxima FRICKE, Fragilaria construens (EHR.) GRUN., F. construens (EHR.) GRUN. var. subsalina HUST., Campylodiscus sp.

The stratum from which the present specimen was taken, is placed somewhat under the Sagami volcanic ash layer, whose age was determined by the fission track method as 2.9 million years old.

(5) Gamo Formation (at Mikumo)
From the river-bank in the upper course of the Yasu River, at Mikumo, Kosei-cho, Shiga Prefecture, were taken fossils of a snail belonging perhaps to Tulotomoides which was reported from China in 1935. The geological age of the stratum is yet uncertain, but it is thought that the stratum corresponds perhaps to the middle layer of the Gamo Formation, therefore is about 1.7–1.8 million years old.

Only one diatom, Melosira undulata (EHR.) KÜTZ. and spicules of freshwater sponge are fairly abundant.

Description of diatoms

Melosira islandica-group (Pl. I, Figs. 1–4; Pl. II, Figs. 5–8)
The majority of Melosira, abundantly found in the deposits of the Iga-Aburahi and the Sayama Formations (Pliocene), belongs to the Melosira islandica-group, as the rows of puncta on the valve-mantle are always parallel to the pervalval axis, although the frustules
Table 2. Dimension of frustules in the *Melosira islandica*-group

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Height</th>
<th>H : D</th>
<th>Rp</th>
<th>Formation</th>
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<tbody>
<tr>
<td>38.5</td>
<td>11.5</td>
<td>0.29</td>
<td>7</td>
<td>Sayama at Ichiuno</td>
</tr>
<tr>
<td>30.0</td>
<td>9.3</td>
<td>0.31</td>
<td>7</td>
<td>Iga-Abruahi at Nakamura</td>
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<tr>
<td>21.6</td>
<td>7.6</td>
<td>0.35</td>
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<td>8.3</td>
<td>0.62</td>
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<td>Iga-Abruahi at Nakamura</td>
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<td>1.53</td>
<td>7</td>
<td>Sayama at Nojiri</td>
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<td>13.3</td>
<td>2.66</td>
<td>8</td>
<td>Iga-Abruahi at Nakamura</td>
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</tbody>
</table>

Diameter: Diameter of valve (Breadth of frustule)
Height: Height of valve (About a half of frustule-length)
H:D: Ratio height to diameter
Rp: Number of rows of puncta in 10 μm.

are considerably variable in dimension. But puncta are very large, round (1.0 × 1.0 μm) or oblong (1.0 × 1.7 μm), and rows arrange 7–8 in 10 μm. Therefore the species is in an external appearance fairly far from the ordinary forms occurred in the present inland-waters. The species refers perhaps to the following forms: *Melosira canadensis* HUSTEDT, *M. pensacolae* A. SCHMIDT, *M. Goetzeana* O. MÜLLER, *M. nyassensis* O. MÜLLER, etc. Although some of the *Melosira islandica*-group are also similar to *M. Agassizii* Ostenfeld var. *malayensis* HUSTEDT, the end-valves with long spines are never found in our specimens.

The variations in dimension of the frustule of *Melosira islandica*-group are shown in Table 2.

I should like to show for a while these diatoms as the *Melosira islandica*-group.

The *Melosira*-valves, which seem to me the same as my specimens, are abundantly found in the Miocene or the Pliocene deposits of North America (Montana, Oregon). But Sam L. VANLANDIGHAM (1964, 1967, 1970, 1972) has identified the majority of these *Melosira*-diatoms as *M. granulata* (EHR.) RALFS.

*Melosira italicA* (EHR.) KÜTZ. var. *valida* GRUN.; HUST. (1930), Bacill., S. 91–92, Fig. 51; HUST. (1930), Kieselalg., S. 260–261, Fig. 109a. (Pl. V, Fig. 17).

Syn.: *Melosira valida* MEISTER, 1912: *M. polymorpha* subsp. *distans* var. *valida* BETHGE,
Plate I. Fig. 1. *Melosira islandica*-group in the Sayama Formation at Nejiri. Fig. 2. *Melosira islandica*-group in the Sayama Formation at Ichiuno. Fig. 3. *Melosira islandica*-group in the Iga-Aburahi Formation at Nakamura. Fig. 4. *Melosira islandica*-group in the Iga-Aburahi Formation at Nakamura (Ascale mark under the figure corresponds to 10 μm.)

1925.

Frustules with a thick wall. Breadth of frustule (diameter of valve) 8–9 μm, length 8.6–11.0 μm. Striae 13–14 in 10 μm.
Plate II. Fig. 5. *Melosira islandica*-group in the Sayama Formation at Ichiuno. Fig. 6. *Melosira islandica* group in the Iga-Aburahi Formation at Nakamura. Fig. 7. *Melosira islandica*-group in the Sayama Formation at Nojiri. Fig. 8. *Melosira islandica*-group in the Sayama Formation at Ichiuno.

(A scale mark under the figure corresponds 10 μm.)

Rare in the Sayama Formation at Ichiuno.

This subalpine species is known from Lake Kizaki, Lake Aoki, Lake Ikeda, the bogs in the Oze Highmoor and on Mt. Hakkoda in Japan.
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**Melosira undulata** (EHR.) KÜTZ. HUST. (1930), Kieselalg. 1. Teil, S. 243-244, Fig. 102a, c.: VAN HEURCK (1881), Synopsis, Pl. 90, Fig. 8, 9: A SCHMIDT (1893), Atlas, Tafel 180, Fig. 1-14. (Pl. III, Fig. 11, 12)  


A very robust species with frustules 32-35 μm in diameter of valve. Punctate striae radial, not spiral, 3-5 in 10 μm near the margin of valve. These radiating striae disappear toward the center, at which are numerous coarse puncta. Valve with several internal projections forming a polygonal figure within the circumference.

Fairly abundant in the Gamo Formation at Mikumo. *Melosira undulata* is reported from Lake Aoki, Lake Biwa, Lake Ikeda, Lake Ashi etc. in Japan. As a fossil it is also known from Saga Prefecture.

The diatom is living now only in the tropics, but is found as a fossil in the Tertiary deposits of the whole Europe.

**Stephanodiscus carconensis** GRUN. SKVORTZOW (1936), Lake Biwa, p. 256, Pl. 1, Fig. 19, 23: FRICKE (1901), A. SCHMIDT’s Atlas, Tafel 228, Fig. 5, 6, 9, 10: VAN HEURCK (1880-1881), Synopsis, Pl. XCV, Fig. 1. (Pl. III, Fig. 9, 10)

Valve circular, 28-34 μm in diameter, strongly marked with coarse beads, which form 15-18 radiately disposed bundles. One bundle consists of 7-8 beads-columns near the margin of the valve. In the center of the valve, beads are disposed irregularly.

I have identified in my preliminary reports this diatom as *Stephanodiscus niagarae* EHR. var. *intermedia* (FRICKE) OKUNO, but my specimen is very similar to the figures (especially Fig. 10) of *S. carconensis* GRUN., designated in SCHMIDT’s Atlas. Consequently I re-identify this diatom as *Stephanodiscus carconensis* in this report.

Abundant in the Sayama Formation at Nojiri and Koga.

This fossil form is resemble in the living form of Lake Biwa. The living diatom of this taxon lives together with variety *pusilla* GRUN. abundantly in Lake Biwa and Lake Yogo in Middle Japan. Lake Yogo is a small lake, located only 1.5 km distant from the northern shore of Lake Biwa. The discus of this living form has a diameter of 25-45 μm (mostly 30-40 μm) and 23-26 radiate beads-bundles on its valve-surface. The variety has a small frustule (7-15 μm in diameter) and 10-13 beads-bundles on the valve-surface.

The species is known from Shasta Country, California and var. *pusilla* from Klamath Lake, Oregon, U.S.A.

**Stephanodiscus carconensis** GRUN. fo. *maxima* FRICKE FR. FRICKE (1901), A. SCHMIDT’s Atlas, Tafel 228, Fig. 1-4. (Pl. IV, Fig. 13-16)

A taxon with great discus. Diameter of valve 52-68 μm, radiate beads-bundles very broad, 10-13 μm wide, being composed of 12-20 beads-columns. One valve has 12-18 beads-bundles. At the center of valve there is a round area which has scattered beads. Known from Klamath Lake, Oregon, U.S.A.
Plate III. Figs. 9, 10. *Stephanodiscus caronensis* GRUN. in the Sayama Formation at Nojiri. Figs. 11, 12. *Melosira undulata* (Ehr.) Kütz. in the Gamo Formation at Mikumo. (A scale mark under the figure corresponds to 10 μm)

Abundant in the Sayama Formation at Nojiri.

Plate IV. Figs. 13–16. Stephanodiscus carconensis GRUN. f. maxima Fricke in the Sayama Formation at Nojiri (A scale mark under the figure corresponds to 10 μm.)

Water Alg. of the United States. Second Ed., p. 463–464, Fig. 372: H. van Heurck (1881), Synop. Diat. Belg., Atlas, Pl. XCV, Fig. 13, 14. (Pl. V, Fig. 18)

Plate V. Fig. 17. Melorina italica (EHR.) Kütz. var. valida GRUN. in the Sayama Formation at Ichiuno. Fig. 18. Stephanodiscus niagarae EHR. in the Iga-Aburahi Formation at Nakamura. Fig. 19. Campylodiscus sp. in the Sayama Formation at Ichiuno. Fig. 20 & 21. Fragilaria construens (EHR.) GRUN. in the Sayama Formation at Ichiuno. Fig. 22. Fragilaria construens (EHR.) Kütz. var. triundulata REICHELT in the Sayama Formation at Nojiri. Figs. 23 & 24 Fragilaria construens (EHR.) Kütz. var. subsalina HUST. in the Sayama Formation at Ichiuno. Fig. 25. Achnanthes lanceolata BREB. in the Sayama Formation at Nojiri.

(A scale mark under the figure corresponds to 10 μm)
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Rare in the Iga-Aburahi Formation at Nakamura.

This species is known mainly from North- and Middle-America, especially as a plankton-form in some great lakes of Canada. Grunow has also reported this species from Franz-Josef-Land.

The nomenclator EHRENBERG has found this species for the first time from the bottom-mud of the Niagara Falls. This diatom was found by HUSTEDT in moss-vegetation nearby a waterfall of West-Java.

In Japan this species has been often found in many diatomaceous earths of the fresh-water origin.

Fragilaria construens (Ehr.) GRUN. HUST. (1930), Bacill., S. 140, Fig. 135. (Pl. V, Fig. 20, 21)


This species is widely distributed in fresh waters.

Common in the Sayama Formation at Koga.

Fragilaria construens (Ehr.) GRUN. var. subsalina HUST. HUST. (1930), Bacill., S. 141, Fig. 139. (Pl. V, Fig. 23, 24)

Valve linear-lanceolate with obtuse ends. Length 20–24 µm, breadth 4.3–4.6 µm. Striae 17–18 in 10 µm.

This variety is known from the coastal region of the Northern Europe and is found in Japan from Lake Kizaki, Lake Ashi, Lake Yunoko, Lake Suwa etc. As a fossil, this taxon is also reported from Wamura and Shichimenzan.

Common in the Iga-Aburahi Formation at Nakamura, and in the Sayama Formation at Koga.

Fragilaria construens (Ehr.) GRUN. var. triundulata REICHELT HUST. (1930), Bacill., S. 140, Fig. 136. (Pl. V, Fig. 22)

Valve lanceolate, triundulate, with rostrate ends. Length 21.3 µm, breadth 2.5 µm. Striae 14–15 in 10 µm.

Known from Lake Kizaki and Lake Yunoko, and as a fossil from the Yufuin Diatomite Deposit, Oita Prefecture.

Rare in the Sayama Formation at Nojiri.

Achnanthes lanceolata BREB. HUST. (1930), Bacill., S. 207–208, Fig. 306a. (Pl. V, Fig. 25)

Valve elliptic-lanceolate, with obtuse ends. Length 14.6 µm, breadth 6.6 µm. Lower valve with a rectangular central area. Striae 20 in 10 µm.

Rare in the Sayama Formation at Nojiri.

Known from Lake Aoki, Lake Kizaki, Lake Biwa etc. As a fossil it is also reported from Shiobara, Tochigi Prefecture.

This species is common in fresh waters of the world.
Campylodiscus sp. (Pl. V, Fig. 19)

A broken piece of the valve was found from the Sayama Formation at Ichiuno. The identification of the species is not possible.

References


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著者は1978年11月に、国立科学博物館の田中健郎博士から古琵琶湖湖層群の比較的古い部分の資料を貸与し、その中から含まれている化石硅藻について研究したところ、約11種のものを見出すことができた。主なものとしては、約350万年前の伊賀油日層群からは Melosira islandica 群と Stephanodiscus carsonensis と、約250万年前の佐山層群からは Melosira islandica 群と Stephanodiscus carsonensis と Stephanodiscus carsonensis fo. maxima が、また約170万年前の蒲生層群からは Melosira undulata が認められた。

Melosira islandica 群と称するのは、現生の Melosira islandica O. MÜLLER とは形態的に共通するものであって、殻茎を大きく点状の列が細胞の上下軸に平行して、10μm 間に 7～8 本の割合に存在するものであるが、現生の琵琶湖の準固有種（semi-endemic species）の Melosira solida EULENSTEIN は、この化石種群が由来したものと思われる。群として示し、種として同定しなかったのは、現在までに記載されているものの中で、M. canadensis HUST., M. pensacolae A. SCHMIDT, M. GOETZEEANA O. MÜLL., M. nyassensis O. MÜLL. などが、古琵琶湖層群の Melosira の各々 1 群に相当するのだが、古琵琶湖層群のものは細胞の大きさと形に相当の差異があるものであって、化石群の混合したものとは認められないからである。

したがって、ここでは群として示したのは暫定的な取扱いであって、将来 1 つの独立した種とし、種として同定することになる可能性のあるものと思って頂きたい。

古琵琶湖層群の Melosira islandica 群と全く同じものと思われるものが、北米の Montana
州やOregon州の新鮮世の堆積物から見出されている。しかしこれを研究したS.L.VAN-LANDINGHAM（1964–1972）は、Mlosis granulataと同定しているが、これは誤りであって、北米のももM.islandica系統のものであることに間違いいないと思われる。

古琵琶湖層群のStephanodiscus carconensisは、現生の琵琶湖の準固有種のそれとは多少異なる。化石化種はStephanodiscus niagarae var.intermediaに近いものであるが、現生種はこの化石種から由来したものと思われる。

Stephanodiscus carconensis fo.maximaは、Stephanodiscus属中の恐らく最大種であろうが、化石化としてのみ存し、現在生きて残っているものはないであろう。

Mlosis undulataは、Mlosis属中の巨大種で、現在は熱帯に生育しているだけであるが、第三紀には北半球全域に広く分布していたものと考えられている。

小山博滋・村田源：タシロヒヨドリの学名

Eupatorium Tashiroi HAYATAは台湾の特産種とされていたが、今回ヒマラヤの資料を検討していたところ、Mikania clematidea WALL.としてDeCANDOLLEが発表したWALLICH Cat.No.3173の標本と非常によく一致することに気付いた。FloraBritish India3:243ではMikania clematideaはCoryza longicaulis WALL.Cat.3073と共にEupatorium Reveesii WALL.exDC.（Prodr.5:179）の異名とされているが、これは正しくない。

E.ReveesiiのTypeはWALL.Cat.No.3168である。これはReveesが中国で採集したもので、E.chinenseL.と同じものと考える。

E.longicaule WALL.exDC.はWALLICHがNepalで採集したCat.No.3073がそのTypeである。これは茎が直立し、上部で多数枝を分かち、頭花が小さく、枝先に密に円錐花序を作って配列され、全体に毛の多い別種である。

Mikania clematideaは枝が非常に細密で長く伸び、原記載にもscandensとある。葉は卵状披針形で先が長く尖尖し、数対の寸小鋸歯があり、ほとんど無毛で、質がよく、基部から3脈が分かれており、ももタシロヒヨドリとよく一致する。1979年8月、村田は台湾の溪頭でタシロヒヨドリを採集した。その時の記憶によると、茎の下部はかなり木化しているが、枝は細密でやわらかく、よく伸びて、ちょっとタイキニギョを考えるように入道番から急斜面にやや下垂気味になってしまい花をつけている。学名は次のようになる。

Eupatorium clematideum（WALL.exDC.）Sch.-Bip.in Pollichia22–24:258（1866）.—Mikania clematidea WALL.[Cat.3173]exDC.Prodr.5:191（1836）。


Distribution：NepalandTaiwan.

（H.Koyama&G.Murata）