On a New Genus *Nymphar* and a Fossil Leaf of *Nuphar* from the Early Miocene Nakamura Formation of Gifu Prefecture, Japan

By

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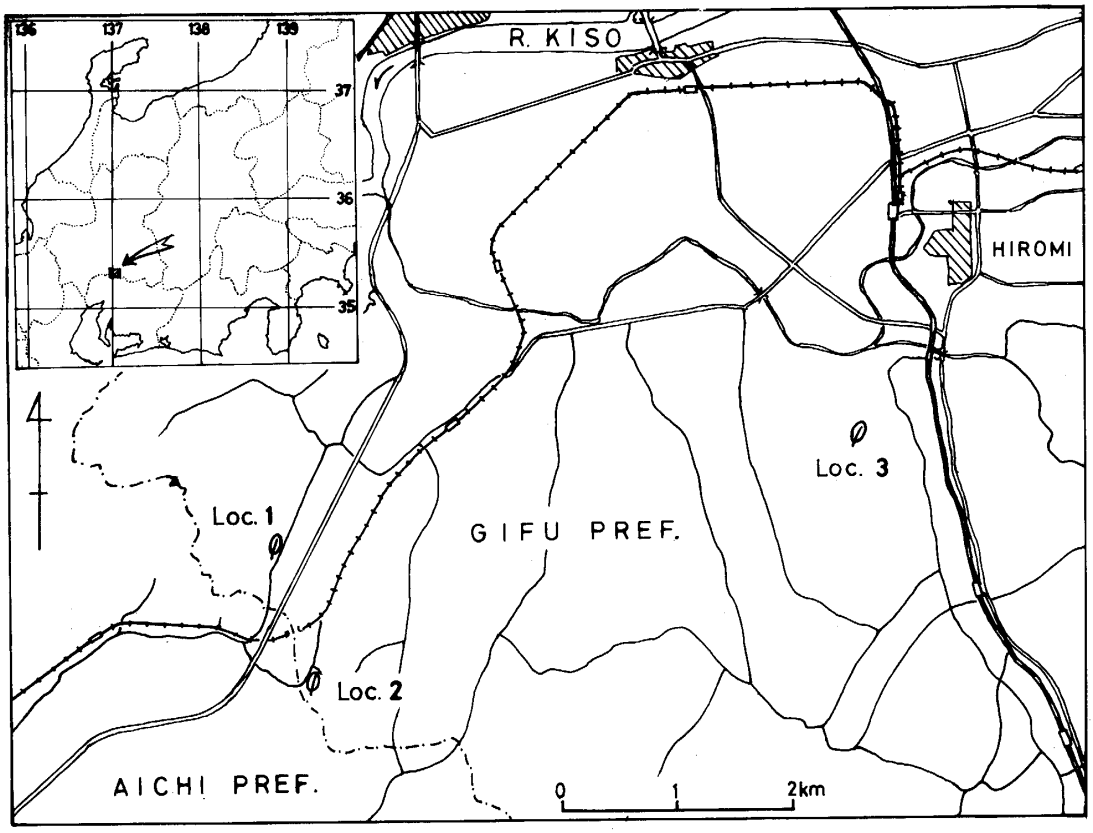
Introduction and Acknowledgements

The early Miocene Nakamura Formation of the Mizunami Group is distributed mainly in the southern part of Gifu Prefecture and contains many mammalian and plant fossils.

On the plant fossils from this formation, TOKUNAGA and ONOE (1960) listed 25 species together with some pollen and spores. TANAI (1961) assigned the plant fossils from the Nakamura Formation to the southern type of the Aniai-type



Text-fig. 1. Showing fossil localities. Loc. no. 1. Sugekari, Loc. no. 2. Minoda, Loc. no. 3. Miyasaka.

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flora on the basis of 20 species. Huzioka (1964) described 44 species from the Nakamura Formation, in which *Nuphar ebae* was included as a new species of the Nymphaeaceae.

I collected many plant fossils from the Nakamura Formation in the above-mentioned area, while recently T. HUKUOKA collected some plant fossils from the same formation in the western part of Gifu Prefecture, which include an interesting new *Nuphar* and many leaves of *Nuphar ebae* HUZIOKA.

This paper deals with a systematic description of the new fossil specimen of *Nuphar* and reinvestigation of "*Nuphar ebae*".

I wish to express my deep gratitude to Dr. Kazuo HUZIOKA, Professor Emeritus of Akita University, for his valuable advice. My cordial thanks are extended to Mr. Kazuhiko UEMURA of the Palaeobotany Section of the National Science Museum in Tokyo, who kindly afforded many facilities and suggestions, and to Mr. Tokio HUKUOKA for his kind presentation of his collection.

Geologic Setting

In the southern part of Gifu Prefecture along the border of Gifu and Aichi Prefectures, early to middle Miocene sediments (the Mizunami Group) are distributed mainly in three sedimentary basins.

Miocene stratigraphy in this region was first announced by H. YABE (1921), and then have been investigated by many workers. The stratigraphy of the western sedimentary basin (Kani basin), yielding numerous Nymphaeaceous leaves, was reported by T. MATSUZAWA et al. (1962) and S. YOSHIDA (1963, 1965) and others.

The lower part of the Mizunami Group (Nakamura Formation) lies unconformably upon Palaeozoic and granitic rocks and is mainly of terrestrial origin. The Nakamura Formation in the Kani basin is divided into Shio and Katabira Members in ascending order. The Shio Member is composed mainly of volcanic breccia, subordinately of tuff breccia, tuffaceous sandstone and conglomerate with a few intercalations of lava flows. The Katabira Member is subdivided into lower and upper parts. The lower part is somewhat variable in lithology laterally, but is composed of basal conglomerate, tuffaceous sandstone and siltstone; the sandstone contains some plant fossils in some localities. The upper part consists mainly of thick alternation of sandstone and siltstone, intercalated with several seams of lignite, and includes many palants in the siltstones. The Nakamura Formation in the Kani basin is covered unconformably by the Hiramaki Formation, which is also of terrestrial origin.

Descriptions of the Species

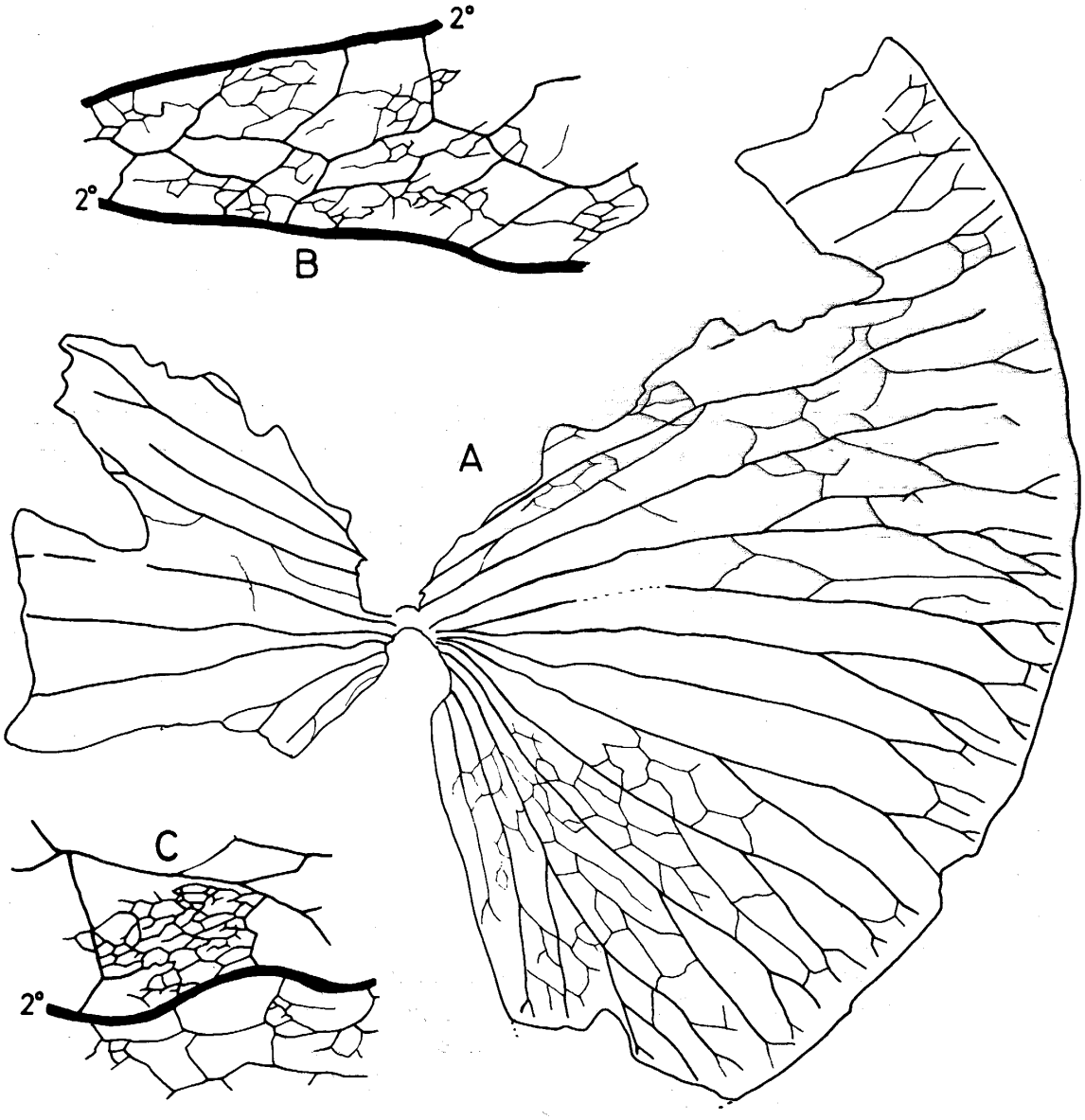
Family Nymphaeaceae

Genus *Nuphar* SMITH

Nuphar sp.

(Pl. 1, fig. 2; Text-figs. 2A–C)

Description: Leaf large, more than 13 cm long and 16 cm wide (estimated); basal lobes angulate with almost straight inner margin though lacking its distal part; midvein not preserved; secondary veins numerous, fine, rather closely



Text-fig. 2. Showing the sketch and fine venation of *Nuphar* sp. Loc. no. 2. A. (×1). B, C. (×7.5).

spaced, dichotomizing at about 30° in its middle to peripheral part and at 40° to 50° in the marginal part without joining each other on the way; among the secondaries about 10 basal pairs converging on the basal point, while more than 5 pairs probably extending from the midvein in the upper part; tertiary veins forming elongately quadrangular to hexagonal meshes among intercostal area, while those connecting with neighboring secondaries in the marginal area; finer veins making also quadrangular to hexagonal areoles within the large meshes; margin entire.

Discussion: This fragmentary specimen is presumed to be nearly orbicular with saggitate base in shape and more than five pairs in number of the upper secondary veins, which extend without joining each other on the way. The leaves of the living *Nuphar* show such venation character with a few exception.

Among the fossil leaves of Nymphaeaceae, my leaf specimen somewhat resembles *Nymphaeites diatoma* (MACGINITIE) ARNOLD (MACGINITIE, 1933, pl. 8, fig. 1; ARNOLD, 1937) from the Miocene Trout Creek flora of southwestern Oregon in the characteristic secondary veins, which extend nearly to the margin without joining. But *N. diatoma* is distinguishable from my specimen by the broadly opened base, very pronounced veins and the number of the veins. *Nymphaea rotunda* (ARNOLD) GRAHAM (ARNOLD, 1937, p. 84, fig. 1; GRAHAM, 1963) from the Miocene Trout Creek flora is somewhat similar to my specimen, but it is distinguishable in rounded basal lobes and the secondary veins which form networks on the way.

Among the living species of *Nuphar, N. luteum* (LINN.) SM. of Europe and *N. japonica* DC. of Japan are similar to my specimen in number of the radiating lateral veins of lower part, though the extant leaves are longer.

This is the oldest record of genus *Nuphar* in Japan.

Collection: NSM PP 16350. The Katabira Member of the Nakamura Formation (early Miocene). Loc. 2, Minoda, Kani-cho, Kani-gun, Gifu Prefecture.

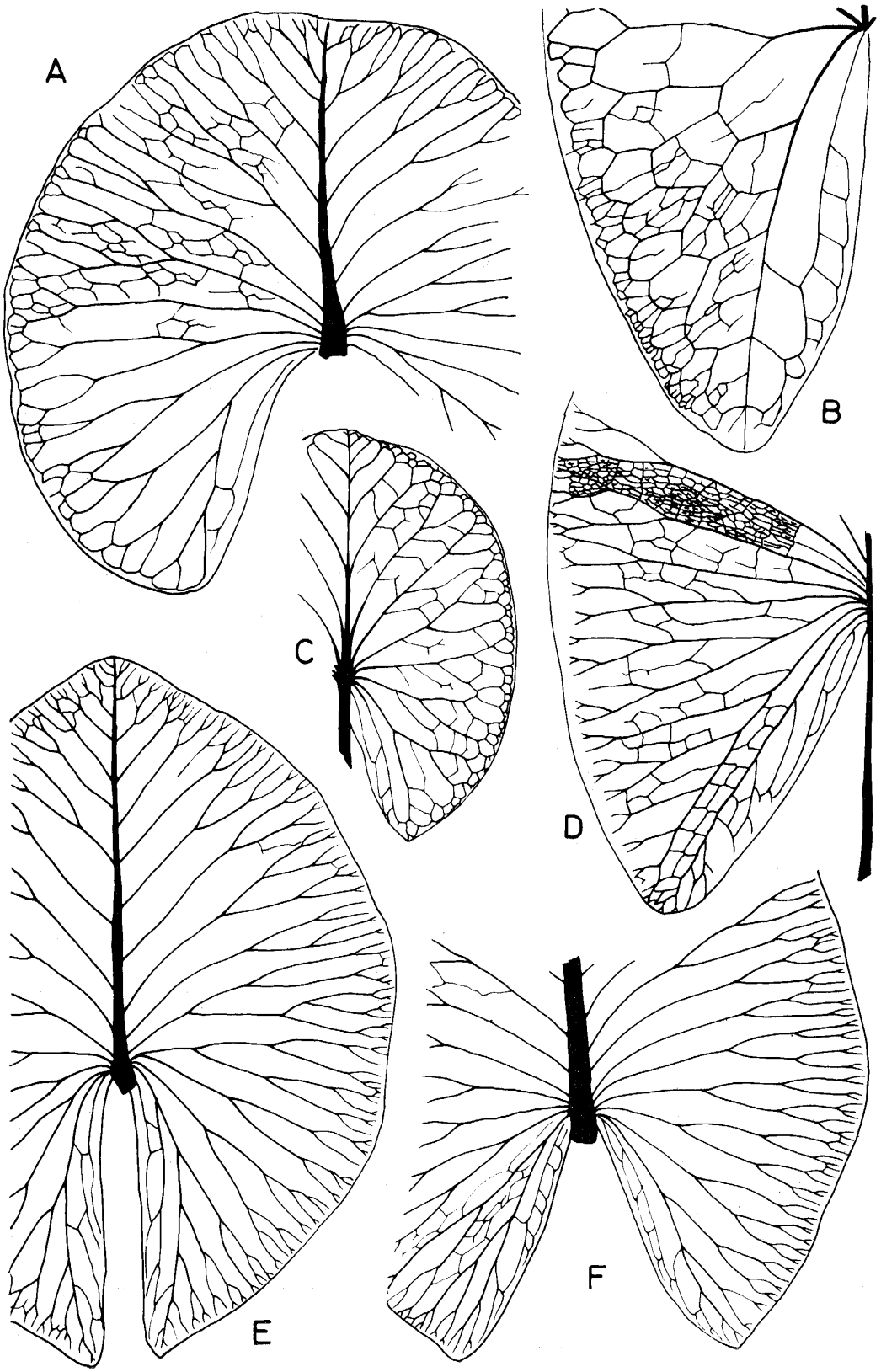
Genus *Nymphar* OZAKI, new genus

Type species: *Nymphar ebae* (HUZIOKA) OZAKI

Description: Leaves small to medium, ovate to oval; apex acute to rounded; base saggitate, somewhat inequilateral; margin entire; midvein generally straight; secondaries fine, about 10 pairs, diverging from the midvein at nearly same acute

Text-fig. 3. Showing the venation character of some living species of *Nuphar* and *Nymphaea*. (all natural size unless otherwise stated)

A. *Nuphar subintegerrimum* (CASP.) MAKINO (×3.5)
B. *Nymphaea tetragona* GEORGE var. *pygmaea* (SALISB.)
C. *Nymphaea lutea* LINN. (×0.5)
D. *Nuphar japonicum* DC.
E. *Nuphar ograense* MIKI
F. *Nuphar pumilum* DC. var. *ozeense* MIKI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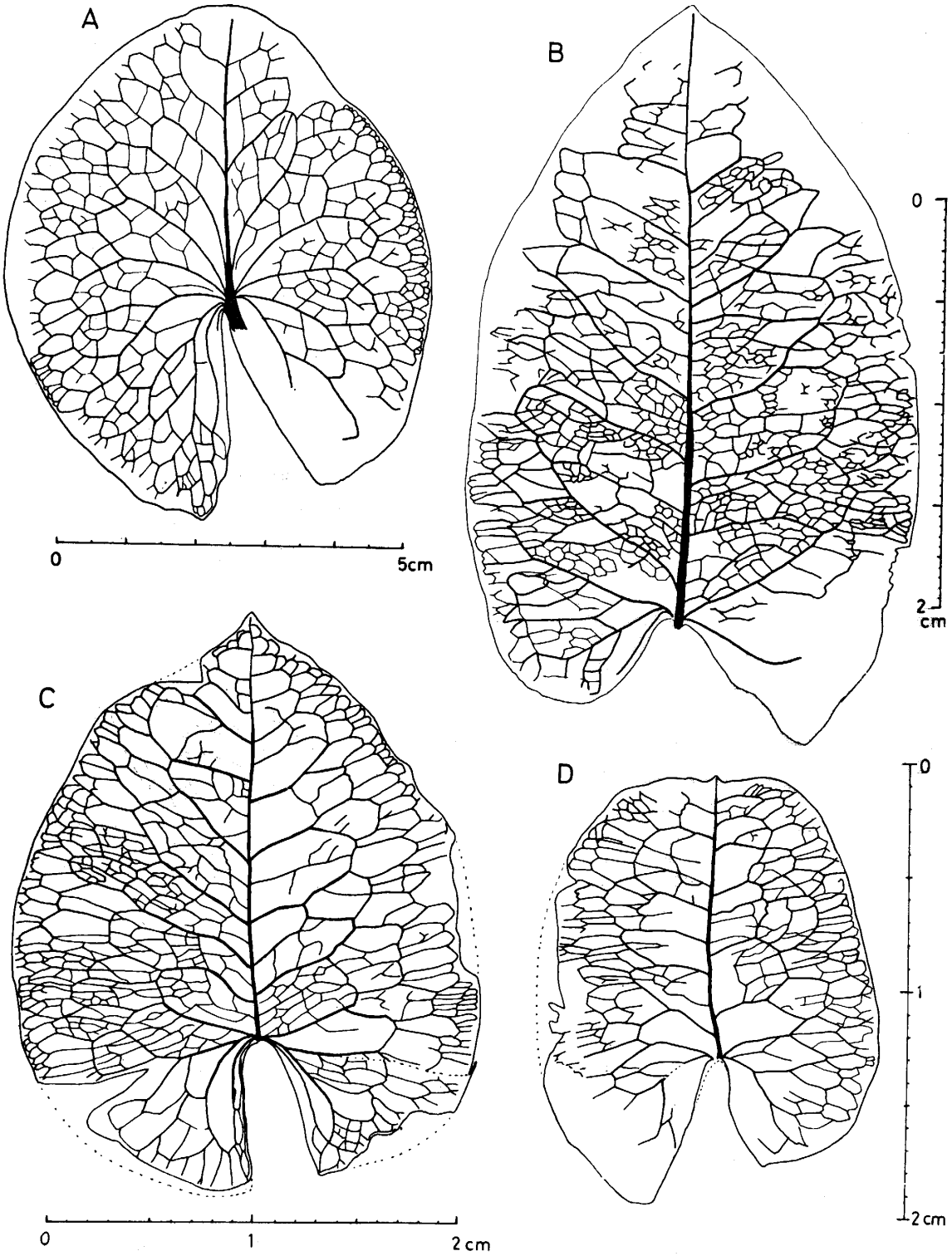


Text-fig. 4. Showing the venation character of *Nymphar ebae* (HUZIOKA), comb. nov. and related living species.

A. *Nymphaea tetragona* GEORGE

B–D. *Nymphar ebae* (HUZIOKA) B. Holotype, (AKMG–5163), Loc. no. 3. C. (YNU–1076), Loc. no. 1. D. Paratype, (AKMG–5167), Loc. Hiyoshi, Mizunami City, Gifu Prefecture.

angles, excepting for one or two basal pairs which diverge from the base of the midvein at obtuse angles; secondaries bifurcating to form angular networks by joining each other; tertiaries and finer veins well developed; elongate, polygonal and progressively diminishing tertiary to fifth networks developing in the peripheral area, while tertiaries and finer veins making elongate polygonal meshes among intercostal area; petiole basifixed.

Discussion: The genus *Nymphar* belonging to the family Nymphaeaceae, is proposed for leaves having the above-mentioned characters, and because no extant genera of this family match my specimens in the venation features. The leaves of *Nymphar* resemble those of the living *Nymphaea,* some of which species are shown in the Text-figs. 3B, C and 4A in the secondary venation character, but are different in the uppermost basal pair of the secondaries leaving from the base of the midvein; the pair is nearly parallel to the upper secondary pairs and is not decurrent along the midvein as in the case of the living *Nymphaea.* Furthermore, the leaves of this new genus are distinctly different from those of *Nymphaea* in the well-developed tertiaries and finer veins which make elongate meshes.

On the other hand, the characters by which *Nymphar* is separable from *Nymphaea* suggest that this new genus is also related to the genus *Nuphar.* However, the secondary veins of *Nuphar* extend generally from the midvein toward the margin, and repeatedly dichotomize without formation of angular networks. As shown in Text-figs. 3A and 3C, some leaves of *Nuphar subintegerrimum* and *Nymphaea lutea* are similar in their secondary venation, but are distinguished from the new genus by the basal part of the secondaries and the angles between dichotomized veins, especially in their apical part, and finer veins.

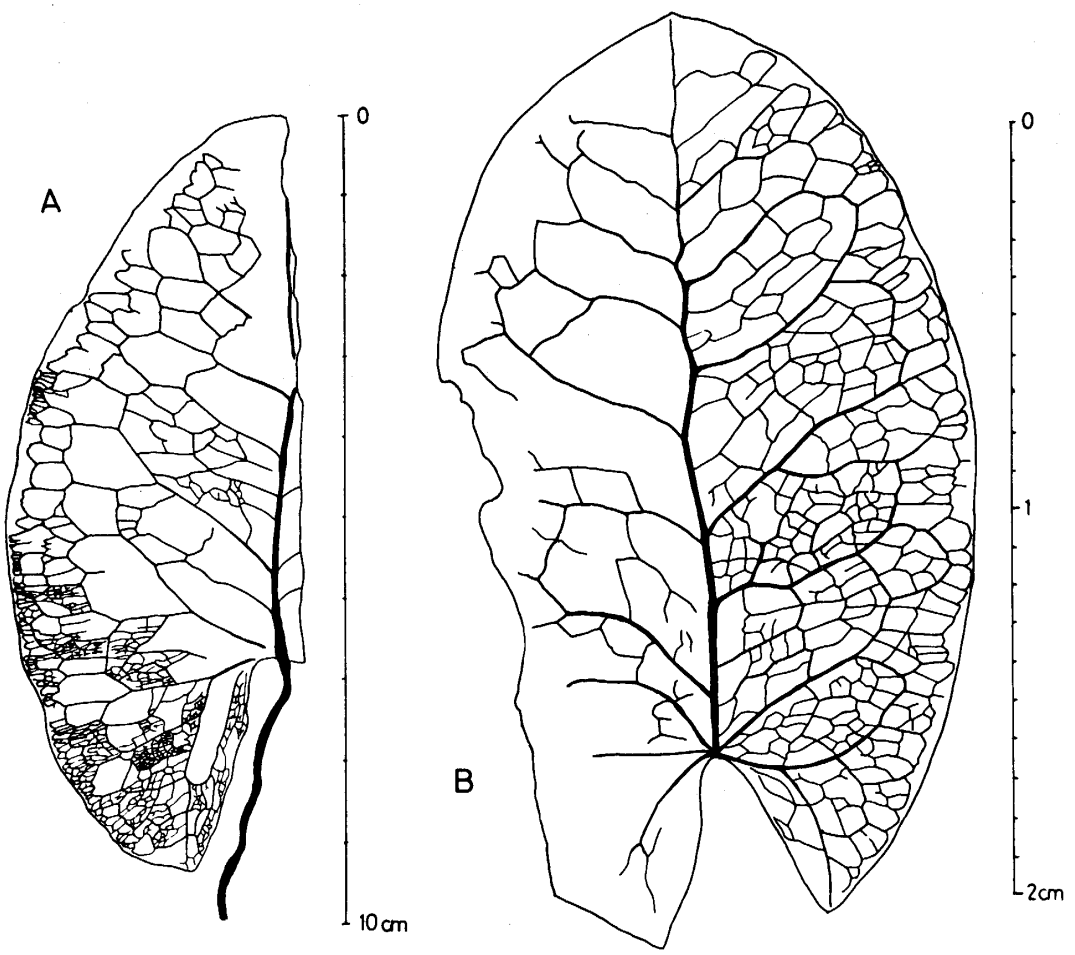
The generic name *Nymphar* is derived from *Nymphaea* and *Nuphar,* because the leaves of the new genus have both characters of the two genera as mentioned above.

Nymphar ebae (HUZIOKA) OZAKI, new combination

(Pl. 1, figs. 1, 3–5; Text-figs. 4B–D, 5A, B)

Nuphar ebae HUZIOKA. Jour. Min. Coll. Akita Univ. ser. A. 3 (4): 82–83. *pl. 11, fig. 6, pl. 12, figs. 1–3, 1a, 2a, 3a.* (1964).

Supplementary description: Leaves ovate to oval, 1.9 to 9.5 cm long and 1 to 6.5 cm (estimated) wide, generally 3 to 5 cm long and 2 to 3 cm wide; apex rounded to obtuse; base saggitate, nicked near two-fifths to one-fifth of the leaf length; margin entire; petiole basifixed, preserved for 3.5 cm on a largest specimen; primary vein generally straight, but sometimes sinuous or zigzag on small leaves; secondaries thin, brochidodromous, subopposite to alternate, in 8 to 10 pairs, diverging from the midvein at 90° to 70°, excepting for basal one or two pairs which make obtuse angles with the midvein or curve down toward the basal lobes and dichotomizing in short distance from the origin; secondaries dichotomizing at



Text-fig. 5. Showing the venation character of *Nymphar ebae* (HUZIOKA), comb. nov.
A. (YNU 1074) Loc. no. 3. B. (YNU 1077) Loc. no. 1.

50° to 70° on the half way and connecting with adjacent ones or intersecondaries to form large, elongate meshes; intersecondaries sometimes developing, extending slightly composite course with joining tertiaries on the way; tertiaries forming small, elongate angular meshes in intercostal area, forming angular meshes in the distal side on the secondary meshes; quaternaries forming elongate-quadrangular to hexagonal meshes within the tertiary meshes, covering tertiary meshes with elongate angular meshes in the distal side of the tertiary meshes; fifth-order veins forming elongate mainly quadrangular meshes within higher-order meshes and making small meshes along the margin; ultimate veinlet simple to once branched.

Discussion: Many specimens from the Katabira Member of the Nakamura Formation are not referable to any fossil species of the Nymphaeaceae. *Nymphar ebae* is distinguishable from *Nymphaea leei* (KNOWLTON) BROWN from the Palaeocene Raton Formation, Colorado (KNOWLTON, 1917, pp. 307–308, pl. 79, fig. 3) and *N. arctica* HEER from the Miocene Cap Staratschin of Spitzbergen Islands (HEER, 1870, pp. 64–65, pl. 14, figs. 1, 2) by the foliar shape and venation.

Nympaea rotunda (ARNOLD) GRAHAM from the Miocene Trout Creek Formation (ARNOLD, 1937, p. 84, fig. 1; GRAHAM, 1963) is also separable from *Nymphar ebae* by the rounded basal lobes. *Nymphaea pulchella* KNOWLTON (KNOWLTON, 1930, p. 94, pl. 42, fig. 1; pl. 57, fig. 3) is separable from this new genus by the foliar shape and the undulate margin. *N. pulchella* may belong to the genus *Nymphoides* by the toothed margin and venation.

Collections: Holotype, AKMG–5163, paratypes, AKMG–5164–5167.

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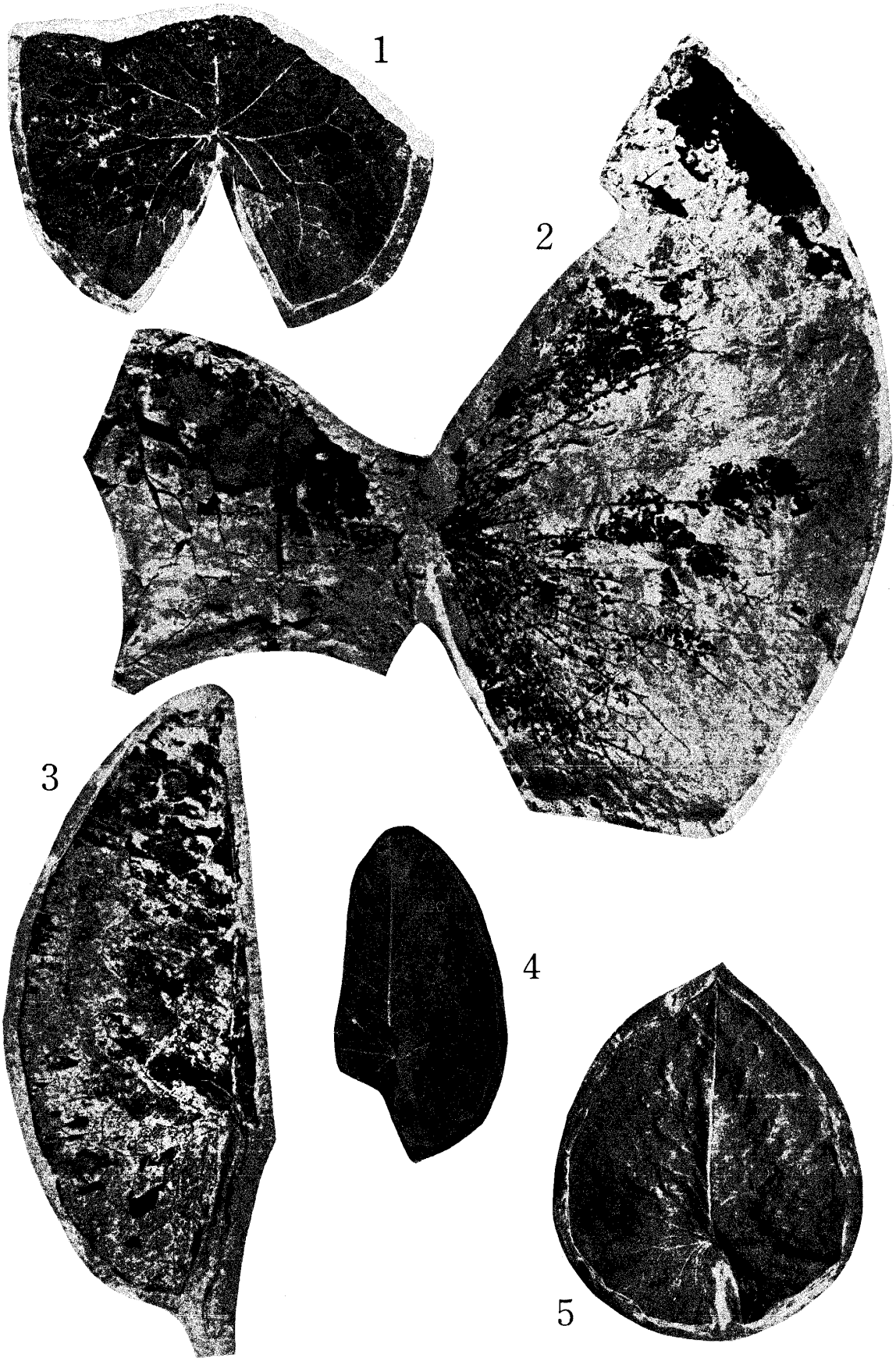
Explanation of Plate

(all figures in natural size)

Fig. 1. *Nymphar ebae* (HUZIOKA) n. comb. YNU 1079. Loc. no. 1.

Fig. 2. *Nuphar* sp. NSM PP 16350. Loc. no. 2.

Figs. 3–5. *Nymphar ebae* (HUZIOKA) n. comb. YNU 1074 (Loc. no. 3), 1075, 1076 (Loc. no. 1).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