

Nymphaea nilotica Fawzi & Azer *sp. nov.* (Nymphaeaceae), a New Aquatic Species from Nile Region, Egypt

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Received: 04 Sept. 2017 / Accepted: 19 Oct. 2017 / Publication date: 27 Nov. 2017

ABSTRACT

Nymphaea nilotica Fawzi & Azer *sp. nov.* is illustrated and described as a new species to science. *N. nilotica* is related to *N. mexicana* Zucc. It differs from *N. mexicana* by the following characters: petals 30-32, carpels 13-14 and stamens about 98. *N. nilotica* is a rhizomatous perennial aquatic herb. It colonizes in the shallows of slow streams from a several localities in Nile region beside Waraq Island in Giza governorate. Morphological and anatomical features, distribution map, and notes on ecology of the new species are given. A key is provided to differentiate among species of *Nymphaea* in Egypt.

Key words: *Nymphaea nilotica*, Nymphaeaceae, taxonomy, morphological and anatomical characters.

Introduction

The family Nymphaeaceae is comprised of six genera namely: *Nymphaea*, *Nuphar*, *Victoria*, *Euryale*, *Baraclaya* (*Hydrostemma*), *Ondinea* (Slocum, 2005; Christenhusz and Byng, 2016). The genus *Nymphaea* (water lily) is the largest genus of Nymphaeaceae, with approximately 50 species occurs almost worldwide (Borsch, *et al.*, 2007). *Nymphaea* species are highly phenotypically plastic and possibly hybridize. This situation is clarified by the occurrence of many garden cultivars of hybrid origin (Slocum, 2005). Moreover, Volkova and Shipunov (2007) mentioned that, many *Nymphaea* species have numerous subspecies, chromosomal races, and forms of hybrid and artificial origin. This situation is caused by a high level of interspecific polymorphism, and intensive interspecific hybridization as suggested by (Heslop-Harrison, 1955; Uotila, 2001 and Papchenkov 2003). Moreover, *Nymphaea* species have high morphological flexibility. The quantitative and qualitative characters of leaves and flowers are strongly depended on hydrological (especially temperature) and edaphic conditions. (Heslop-Harrison, 1955; Kupriyanova, 1976 and Dubyna, 1982).

Conard (1905) classified *Nymphaea* into five subgenera (Anecphyta, Brachyceras, Hydrocallis, Lotos, and Castalia "Nymphaea"). Conard included the subgenera Anecphyta and Brachyceras in the Apocarpiae, with carpel walls are partially fused. He grouped the subgenera Hydrocallis, Lotos and *Nymphaea* in the Syncarpiae, with complete carpel wall fusion. Borsch *et al.* (2007) recorded that the following subgenera have its own characteristic distribution: Anecphyta is restricted to Australia and New Guinea; Brachyceras has a pantropical range and Hydrocallis is restricted to the Neotropics. In addition, Lotos is palaeotropical; while *Nymphaea* distributed in temperate regions throughout the Northern Hemisphere.

In Egypt, the genus *Nymphaea* is represented by 2 species namely: *N. caerulea* Savigny and *N. lotus* L. (Täckholm, 1974 and Boulos, 1995, 1999 and 2009). The third species *N. micrantha* Guill & perr. was recorded as a weed in rice fields and irrigation canals in Nile valley (Delta) by El Hadidi and Fayed (1995). The blue lotus (*N. caerulea*) was usually the lotus of ancient Egyptian art. *N. lotus*, has toothed leaves and long stalks that rise above the water surface to support white flowers that bloom at night and stay open until midday.

In June 2016 and during fieldwork at Waraq Island of Giza governorate, we collected interesting specimens of *Nymphaea* in the shallows of slow streams of the Nile region. As a result of the detailed morphological study, we concluded that the collected *Nymphaea* specimens differ from all other

Nymphaea species in morphological characters. It was considered as a new species that shows some morphological similarities with *N. mexicana* Zucc. and belong to subgenus *Nymphaea* (*Castalia*).

The aim of the research is to distinguish and characterize the structural features of the new discovered species (*Nymphaea nilotica* Fawzi & Azer) and to create a dichotomous key to identify the Egyptian *Nymphaea* species.

Materials and Methods

The plant materials collected from the Nile region beside Waraq Island at Giza governorate during June 2016 to June 2017 (Fig. 1). The holotype and several isotypes of *Nymphaea nilotica* were kept in the herbarium of flora and Phytotaxonomy researches department (CAIM), Agricultural Research Center, Giza, Egypt (Plate 1). The leaves, flowers and fruits of ten individuals have been examined. The number and shapes of sepals, petals, stamens and carpals were recorded. Transverse and longitudinal sections of flowers and transverse section of petioles and peduncles were prepared. Fruit and seeds examined with the use of Leica stereo microscope. The following morphological features of fruit and seeds were examined: the shape and size, the nature of the stigma disc, the number of seeds in a fruit; the shape, size and colour of the seeds. All parts of the plant were photographed. The material of the new species was compared with herbaria specimens of *Nymphaea* in CAIM, and Botany department, Cairo University CAI. In addition, the presented monographs of genus *Nymphaea* (Conard, 1905 and Slocum, 2005) and the relevant literatures (Täckholm, 1974 and Boulos, 2009) as well as African Plant Database (www.ville-ge.ch/musinfo/bd/cjb/africa/) were revised.

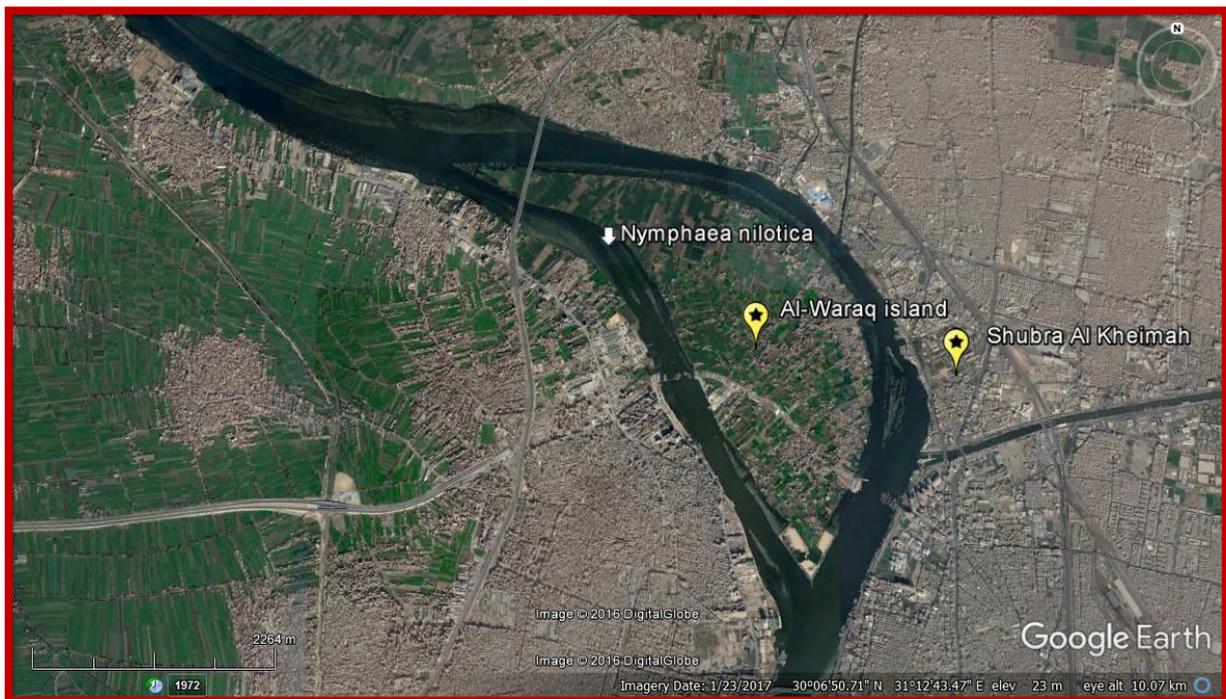


Fig. 1: Satellite image showing the location of *N. nilotica* Fawzi & Azer beside Waraq Island at Giza governorate, Egypt. (Source: Google Earth)

Results and Discussion

Nymphaea nilotica Fawzi and Azer *sp. nov.* :

Type: Egypt, Giza governorate: Waraq Island, in River Nile, 18.06.2016, Nael M. Fawzi & Safwat A. Azer, 301 (Holotype: CAIM).

This plant is found in the shallows of slow streams in the Nile region of Egypt (Fig. 2). The long rhizomes creep along the mud bottom of the River Nile in a depth of water from 1 to 1.5 meter. It has tuberous stem, which buried in the mud. From the stem many fibrous roots pass downward and fix the plant in mud, while the leaves and flowers rise upward.

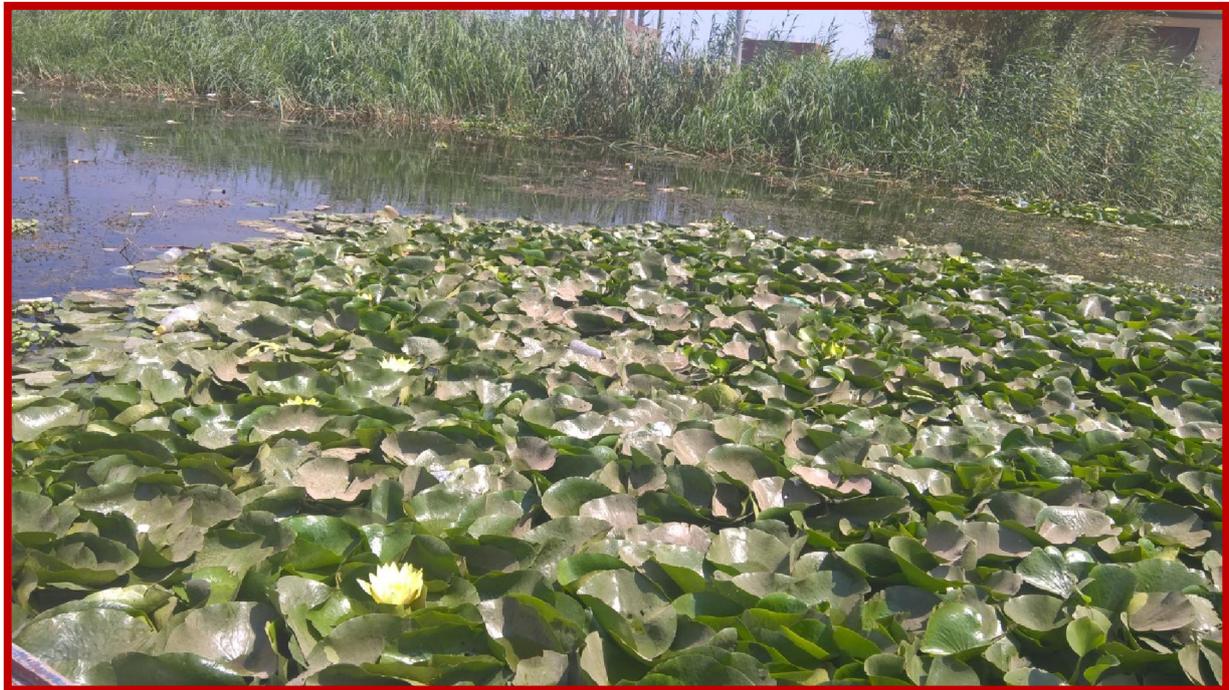


Fig. 2: The habit and habitat of *N. nilotica* Fawzi & Azer collected from Waraq Island at Giza governorate.

The leaves lay flat upon the water surface, somewhat rounded, 18-27 cm in diameter, leathery, the upper surface dark green and exposed to the air, the lower surface green with small dark purple or brownish blotches. Leaf apex: usually rounded. Leaf base: cordate, the two lobes may overlap or just touch or divaricated. Leaf margin entire or slightly wavy. Leaf venation generally palmate, but there is a distinct midrib with pinnate branching (Figs. 3, 4 and 5).



Fig. 3: The upper leaf surface of *N. nilotica* Fawzi & Azer.



Fig. 4: The lower leaf surface of *N. nilotica* Fawzi & Azer.



Fig. 5: Close up view of the lower leaf surface of *N. nilotica* Fawzi & Azer.

The leaf petioles are cylindrical. The petioles length ranged between 1-1.5 m according to the depth of water in which the plant grows. The petioles diameter about 0.9 cm. Transverse section of petiole showed that it has two greatly predominant air-canals and two lesser ones at each end of these (Fig. 6). The air-canals of petiole and peduncle have attracted the attention of botanists on account of their size and arrangement such as (Mackintosh, 1876; Masters, 1902; Moseley, 1961 and Richards, *et al.* 2012). Two types of air-canals may be distinguished in petioles of mature plants; (1) species with four nearly equal, large canals placed in a square near the middle of the petiole, two anterior and two posterior, and (2) species with two greatly predominant canals and two lesser ones at each end of these (anterior and posterior). Conard (1905), reported that the air-canals of aquatic plants are for the purpose of internal breathing.

Flowers are produced individually from stout peduncles. Peduncles are similar to petioles in the length, diameter, colour, glabrous, and number of air-canals. But it has four nearly equal, large air-canals arranged symmetrically in the middle. Many smaller scattered air-canals are always present as in petiole (Fig. 7).

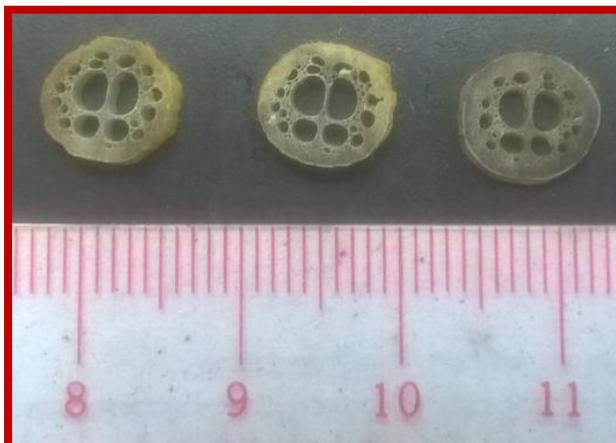


Fig. 6: Transverse sections of *N. nilotica* Fawzi & Azer petiole showing the air canals

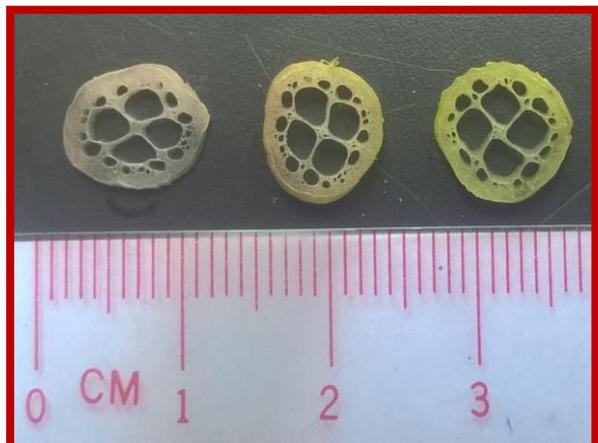


Fig. 7: Transverse sections of *N. nilotica* Fawzi & Azer peduncle showing the air canals.

Flowers diameter is 13-16 cm and open about 5-10 cm above the surface of the water. Flower has four sepals of which one is outer. The outer sepal covers one edge of the two lateral sepals. The two lateral sepals cover the inner sepal. Sepals are light green outside except the covered margins are white to light pinkish and white inside. The shape of the sepals is elliptic to lance-ovate, with acute apex and about 8 cm long (Figs. 8 and 9).



Fig. 8: Close up view showing the inner sepal (a), outer sepal (c) and lateral sepals (b and d) of *N. nilotica* Fawzi & Azer.

Petals are bright yellow and their number varies from 30 to 32. The four outermost petals are largest, elliptic to lance-ovate, with acute apex and alternate with the sepals; over each interval between these is a pair of smaller petals, making a whorl of 8. The innermost petals are smallest and narrowly obovate, rounded at apex (Figs. 10 and 11).

Stamens are about 96-98, golden yellow, stout, grading inward from petaloid to typical stamens. The innermost stamens are short, with anther as long as or shorter than its filament (Fig. 12).



Fig. 9: Close up view of the lower surface of the flower showing petals alternate with the four outermost sepals in *N. nilotica* Fawzi & Azer.



Fig. 10: Close up view of flower showing the arrangement of petals in *N. nilotica* Fawzi & Azer.



Fig. 11: Close up view showing the different shapes of petals from outermost (left) to innermost (right) in *N. nilotica* Fawzi & Azer.



Fig. 12: Different shapes of stamens arranged from outermost to innermost starting from left to right, in *N. nilotica* Fawzi & Azer.

Carpels are fused at sides and its number is 13 or 14 (Fig. 13). Styles are short, fleshy and form crown around the top of ovary. Conard (1905) showed that the back of each carpel is prolonged into a stylar process. Stigma is deeply curved (concave) and funnel-shaped. The exposed portions of the ventral sutures of carpels are united into a broad, round funnel stigma Conard (1905). The ovoid floral axis projects at the centre of stigmatic surface (Figs. 14 and 15).

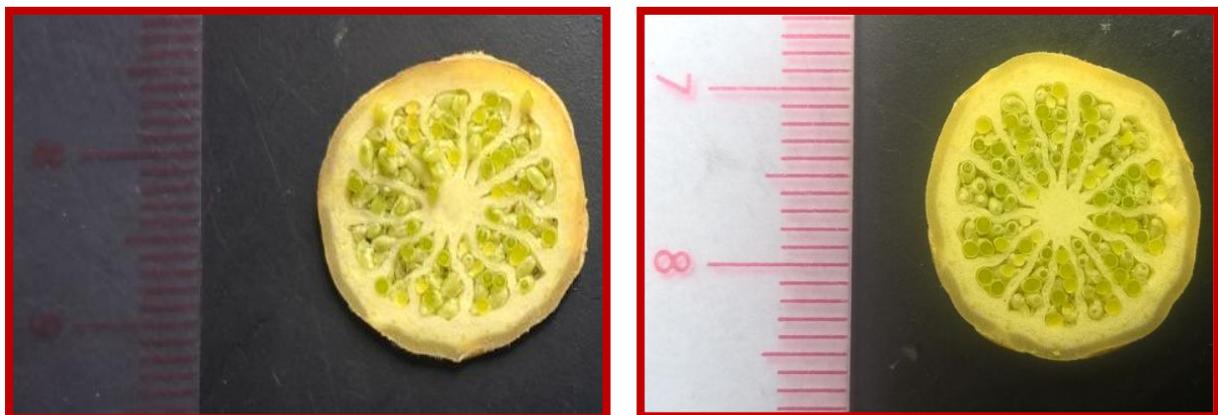


Fig. 13: Transverse section in ovary showing 13 carpels (left) and 14 carpels (right) of *N. nilotica* Fawzi & Azer.

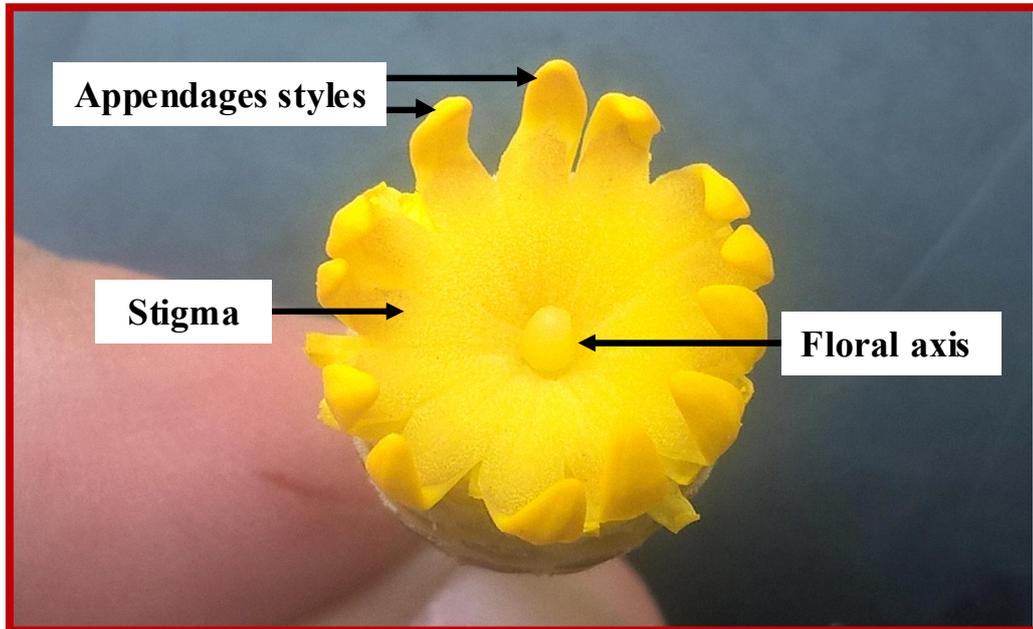


Fig. 14: Close up view showing the appendages styles and stigma disc from above in *N. nilotica* Fawzi & Azer.



Fig. 15: Close up view showing the longitudinal section of ovary in *N. nilotica* Fawzi & Azer.

After fertilization, flowers are drawn down into the water by movements of the peduncle, and here the fruits ripen. Fruit is a spongy berry with numerous seeds (Figs. 16 and 17). During fruit ripping under the water surface some of the floral leaves decayed leaving only small scars. The Ripe fruit dehisces by swelling of mucilage surrounding the seeds. Seeds are floated far and wide by the help of a buoyant aril. Seeds are ovate and about 1-2 mm in diameter.

Taxonomic treatment:

Conard (1905) divided the genus *Nymphaea* into two divisions. Division I (*Nymphaeae apocarpiae*): characterised by free carpels at sides, i. e., walls between ovary cells double. It has two subgenera *Anecphyra* and *Brachyceras*. Division II (*Nymphaeae syncarpiae*): characterised by fused carpels at sides, i. e., walls between ovary cells single. It has three subgenera *Castalia*, *Lotos* and

Hydrocallis. The subgenus Castalia has three sections Chamaenymphaea, Eucastalia and Xanthantha Table 1.



Fig. 16: Fruit of *N. nilotica* Fawzi & Azer covered by some of the rot petals (right) and after removing the rot petals (left).



Fig. 17: Transverse section in fruit of *N. nilotica* Fawzi & Azer showing young seeds embedding in mucilage.

Table 1: Taxonomic ranks of genus *Nymphaea* according to Conard (1905)

Division	Subgenus	Section
Nymphaeae apocarpiae (Carpels free at sides)	Anecphyta Brachyceras	
Nymphaeae syncarpiae (Carpels fused at sides)	Hydrocallis Lotos Castalia (<i>Nymphaea</i>)	Chamaenymphaea Eucastalia (<i>Nymphaea</i>) Xanthantha

N. nilotica Fawzi & Azer seems to belong to the “division Nymphaeae syncarpiae, subgenus Castalia (Nymphaea), section Xanthantha” of Conard (1905): “The waterlilies: a monograph of the genus *Nymphaea*”. The species has carpels completely fused with one another at the sides as in division Nymphaeae syncarpiae. In addition to, flowers are yellow and petioles have two greatly predominant air-canals and two lesser ones at each end of these as in section Xanthantha. *N. nilotica* shows some affinity to *N. mexicana*, which is placed in the same section, and can be easily distinguished from *N. mexicana* by several distinctive features. *Nymphaea nilotica* is characterized by leaf diameter upto 27 cm; petals 30 to 32; stamens about 96; carpels 13 or 14. Details of the differences between *N. nilotica* and *N. mexicana* are listed in Table 2.

Table 2: Morphological differences between *N. nilotica* Fawzi & Azer and *N. mexicana* Zucc.

Characters	<i>N. nilotica</i> Fawzi & Azer	<i>N. mexicana</i> Zucc.
Leaf diameter	18 - 27 cm	10 - 18 cm
Flowers diameter	13 - 16 cm	6 - 13 cm
Petals number	30 - 32	12 - 23
Stamens number	96 - 98	about 50
Carpels	13 - 14	7 - 10
Seeds	Ovoid, brownish-black, 1-2 mm in diameter.	Globose, 4-5 mm in diameter, very finely appressed hairy, greenish-black.

After revising the genus *Nymphaea*; this study stated that there was nothing similar to *N. nilotica* among the genus *Nymphaea*. Moreover, natural hybrids between *N. mexicana* and *N. odorata* have been reported (Ward, 1977 and Wiersema, 1983), which can usually be identified by phenotypes intermediate between the parents.

Key to differentiate among *Nymphaea* species in Egypt

- 1 Leaves dentate *N. lotus*
- + Leaves entire 2
- 2 Flowers bright yellow *N. nilotica*
- + Flowers white or pale blue 3
- 3 Leaves 30-40 cm across *N. caerulea*
- + Leaves 5-7 cm across..... *N. micrantha*

Summarised description in English:

Aquatic rhizomatous perennial herb. Leaves somewhat rounded, 18-27 cm in diameter. Flowers floating, or raised 5-10 cm above the water, 13-18 cm in diameter. Peduncle terete, 3-6 mm in diameter, up to 150 cm long. Sepals 4, elliptic to lance-ovate, with acute apex and about 8 cm long; outer surface green; inner surface white. Petals 30-32, yellow, outermost lance-ovate, with acute apex. Inner ones narrowly obovate, rounded at apex. Stamens about 98, stout, golden yellow, grading inward from petaloid to typical stamens. Innermost stamens short. Carpels 13-14. Styles short, fleshy, with a deep furrow on the inner face. Stigma deeply curved-funnel-shape. Axile process small, rounded, in the bottom of the narrow central pit of the stigma. Fruit ovoid, 2.5 cm in diameter. Seeds numerous, ovate.

Summarised description in Latin:

Aquatilium rhizomatous perennis herba. Foliis aliquantum rotundatis 18 ad 27 cm diametro. Flores volans, et erexit 5 ad 10 cm supra aquam, 13 ad 18 cm in diametro. Pedunculus teres, 3 ad 6 mm diametro, usque ad 150 cm longo. Calycis segmenta 4, ellipticae vel secare-ovatum, apice acuto, 8 cm longum; extus viride, album interiorem superficiem. Petala usque 30 ad 32, flavo, exteriores lanceolato-ovatum, apice acuto. Interiores anguste obovatae, apice rotundatis. Stamina circiter 98, flavo aurea, gradatim ab interiori petaloid ut typical staminum. Intime staminibus brevis. Carpella fere 13 et 14. Stylis brevibus, carnosus, cum profunda sulcus in interiorem faciem tuam. Stigma penitus curvam, infusorium-figura. Pendula processus parva, rotunda, in fundo angustus in media cisterna juxta stima. Fructus ovatis, 2.5 cm diametro. Semina fere, ovatis.



Plate. 1: The holotype (type specimen) of *Nymphaea nilotica* Fawzi & Azer.

Acknowledgments

The authors extend their thanks to the curators of CAIM herbarium, Cairo, Egypt for providing *Nymphaea* material during study. The authors also appreciate Dr. Abdel Halim (Professor of Flora and Plant Taxonomy) for his valuable taxonomic comments.

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