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RESEARCH ARTICLE

Epitypification of the Linnaean name *Lemna arrhiza* (\equiv *Wolffia arrhiza*), *Araceae*

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Abstract. During our research on the genus *Wolffia* (*Araceae*) in Ukraine, we have investigated the typification status of the Linnaean name *Lemna arrhiza* (\equiv *Wolffia arrhiza*). This name was typified twice, first using a “neotype” proposed by Landolt in 1994, and then a lectotype designated by Iamonico and Iberite in 2014. The “neotype” (a herbarium specimen preserved at FI) does not meet the requirements of Art. 9.8 of the *International Code of Nomenclature for algae, fungi, and plants (ICN)*, because it is not part of the original material for *Lemna arrhiza* and, therefore, cannot be considered for the lectotypification purpose (Art. 9.3 and 9.4 of the *ICN*). On the other hand, the lectotype designated by Iamonico and Iberite (an illustration in the book by Micheli) fully complies with the provisions of the *Code*. However, Micheli’s illustration is demonstrably ambiguous and cannot be critically identified for purposes of the precise application of the name of *Lemna arrhiza*; therefore it was advisable to designate an epitype, following Art. 9.9 of *ICN*. The specimen from Micheli’s Herbarium (barcode FI123857) is thus designated here as the epitype.

Keywords: *Araceae*, *Lemna arrhiza*, *Wolffia arrhiza*, epitype, lectotype, neotype, typification

Introduction

Wolffia Horkel ex Schleid. (*Araceae* Juss. s. l. / *Lemnaceae* Gray s. str.) belongs to the monophyletic group that was usually known as the family *Lemnaceae* Gray (see e.g., Les et al., 2002; Bog et al., 2019). However, recent molecular phylogenetic studies demonstrated that this clade is phylogenetically rooted within the family *Araceae* (Rothwell et al., 2004; Cabrera et al., 2008; Henriquez et al., 2014), and thus should not be recognized as a separate family

because that recognition would make the family *Araceae* paraphyletic. Because of that, it was downgraded to the subfamily rank, *Araceae* subfam. *Lemnoideae* Bab. (Mayo et al., 2013; Appenroth, Sree, 2019). Despite that, an alternative taxonomic decision is possible for the continued recognition of *Lemnaceae* as a monophyletic group taxonomically corresponding to a family: the segregation of another monophyletic group as a family *Orontiaceae* Bartl. (see Tippery et al., 2021). Thus, both placements of duckweeds, either in *Araceae* s. l. (as

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Araceae subfam. Lemnoideae) or in traditionally circumscribed Lemnaceae s. str., are alternatively acceptable, depending on a particular taxonomic decision.

Wolffia arrhiza (L.) Horkel ex Wimm. is the most common representative of the genus *Wolffia* in Europe (Uotila, 2009+). This species is naturally occurring in slow-flowing and still water bodies of Europe, Africa, and Southwest Asia in tropical, subtropical, and temperate zones (Landolt, 1994; Bog et al., 2019; POWO, 2024–onward). As an introduced species, *W. arrhiza* is reported for the northern part of Central Europe, Baltic countries, Asia (Korea, Japan(?)), North America (California in the USA), and South America (southern Brazil) (Landolt, 1994; Mito, Uesugi, 2004; Balsevičius, 2011; Armstrong, 2012; Lourenço, Bove, 2019; Son et al., 2019; POWO, 2024–onward), and may also occasionally occur in other region.

The expansion of the secondary range and penetration of *W. arrhiza*, as well as some other duckweed species, into new regions is increasingly closely related to expanding the spheres of use of these plants. At present, duckweeds became not only the objects of taxonomic and ecological studies (Les et al., 2002; Rothwell et al., 2004; Wang et al., 2010; Iberite et al., 2011; Henriquez et al., 2014; Ceschin et al., 2016; Shiyan, 2017; Bog et al., 2019; Tippery et al., 2021; Ziegler et al., 2023; Shiyan et al., 2024; <https://www.mobot.org/mobot/research/apweb/>), but are also widely used for various human needs and applications. In fact, due to their small size and ability to quickly increase their biomass, duckweeds have found wide uses in the food, agricultural, and pharmaceutical industries, and are increasingly used in, or studied for, bioenergetics, bioprocessing, phytoremediation, etc. (Pagliuso et al., 2018; Acosta et al., 2021; Romano, Aronne, 2021; Taghipour et al., 2022; Krzywonos et al., 2023; López-Pozo et al., 2023; Zhou et al., 2023; Minich, Michael, 2024; etc.). In this regard, the reliable taxonomic identification of species of this group that have found use in industry requires special attention, which is impossible without establishing the adequate nomenclature types of names of duckweed species.

The basionym of the name *W. arrhiza* is *Lemna arrhiza* L., which was established for the species by Linnaeus (1771: 294) in his *Mantissa Plantarum*. When describing the taxon, he relied on the monograph of the Italian botanist and mycologist P.A.

Micheli (1679–1737), who described this species from Central Italy under the name “*Lenticularia omnium minima, arrhiza*” and provided its image (Micheli, 1729: 16, tab. 11, fig. 4; Fig. 1a, b). According to the protologue of *L. arrhiza*, the Italian locality of the species was supplemented by Linnaeus with the results of research by the French botanist and gardener A.N. Duchesne (1747–1827). Since no holotype of *L. arrhiza* was indicated in the protologue (a common situation with Linnaean names), according to Art. 9.3 and 9.4 of the *International Code of Nomenclature for algae, fungi, and plants* (Turland et al., 2018), hereafter referred to as “ICN”), a lectotypification was necessary. The original material for this name consists of the following elements: (a) Micheli's illustration provided for the name (“*Lenticularia omnium minima, arrhiza. Mich. Gen. 16 t: 11. 4*”) cited by Linnaeus as a synonym of his *Lemna arrhiza*; (b) one or more specimens collected by Duchesne from France, as indicated by Linnaeus in the protologue (“*Habitat ... Galliae aquis. Du Chesne*”). Note that specimens from Italy which were used by Micheli to describe his “*Lenticularia omnium minima, arrhiza*” cannot be considered for the lectotypification of *Lemna arrhiza* because they have never been seen by Linnaeus and he was probably even unaware of the existence of the relevant herbarium specimens.

The first attempt at typification of *Wolffia arrhiza* (≡ *Lemna arrhiza*) was made by E. Landolt (1986: 453), who, however, did not find any original material after his examination of the Linnaean collections at H, LINN, and S-LINN (herbarium acronyms are given according to *Index Herbariorum*: Thiers, 2009–onward). Later, Landolt (1994: 148), during his research of Micheli's Herbarium in the Italian Central Herbarium (FI), found two samples of *Wolffia arrhiza* collected by Micheli. Despite the fact that none of them were identified, according to the available data, an assumption was made about their origin from the outskirts of the city of Pisa (Italy), where there “... is a well-known station of *W. arrhiza*” (Landolt, 1994: 148). As a result of this typification, the smaller sample of *Wolffia arrhiza* in Micheli's Herbarium (currently at FI) was designated as a “neotype”. This is evidenced by the *notae criticae* on the specimen FI123857 and the results of “neotypification” that Landolt published in his overview of the section *Wolffia* of the genus *Wolffia*, where he clearly mentioned the “neotype” of



Fig. 1. Original material of *Lemna arrhiza* L. (\equiv *Wolffia arrhiza* (L.) Horkel ex Wimm.). A: the page from a monograph by P.A. Micheli with the original figure of “*Lenticularia omnium minima, arrhiza*” (Mich. Gen. 16 tab: 11, fig. 4); B: enlarged picture of the lectotype *L. arrhiza* designated by Iamónico and Iberite (2014: 1314); C: specimens of “*Lenticularia omnium minima, arrhiza*” (FI123857 and FI1096309) from the Micheli’s Herbarium (FI); D: epitype *L. arrhiza* (FI123857) designated here

W. arrhiza and its storage location (Landolt, 1994: 148; Fig. 1c, d). We emphasize that the note of Landolt to specimen FI123857 was added after the article had been published.

Much later after Landolt's publication, Iamónico and Iberite (2014) during their nomenclatural investigation of two Linnaean taxa of *Araceae* subfam. *Lemnoideae* occurring in Italy correctly designated the lectotype of the name *Lemna arrhiza*. As the text of the publication indicates, the authors believed that the typification of the name *L. arrhiza* had not been carried out before them: "*Lemna arrhiza* and *L. spirodela* appear to be as yet untypified..." (Iamónico, Iberite, 2014: 1314). The list of references in their article shows that they did not consider Landolt publication of 1994, but relied on his publications from 1986 and 2000. As a result, guided by the available data of the protologue, Iamónico and Iberite (2014: 1314) chosen the original image of Micheli of 1729 as the lectotype of *L. arrhiza*: "[illustration in] Micheli, Nov. Pl. Gen.: t. 11, *Lenticularia* fig. 4. 1729. — Image of lectotype available at <http://bibdigital.rjb.csic.es/ing/Libro.php?Libro=2801&Pagina=269>".

Thus, it has been found that at different times a lectotype (Iamónico, Iberite, 2014: 1314) and a "neotype" (Landolt, 1994: 148) for the name *Lemna arrhiza* (\equiv *Wolffia arrhiza*) were selected. Unfortunately, Landolt, following the widespread tradition of choosing a type among existing herbarium specimens, may not have taken into account the fact that in the *International Code of Botanical Nomenclature* (ICBN, the *Tokyo Code*: Greuter et al., 1994: 11), there was a note to Art. 7.4 with a detailed explanation of the concept of "original material". In particular, it was noted: "original material comprises: (a) those specimens and illustrations (both unpublished and published either prior to or together with the protologue) upon which it can be shown that the description or diagnosis validating the name was based; (b) the holotype and those specimens which, even if not seen by the author of the description or diagnosis validating the name, were indicated as types (syntypes or paratypes) of the name at its valid publication; and (c) the isotypes or isosyntypes of the name irrespective of whether such specimens were seen by either the author of the validating description or diagnosis, or the author of the name" (Greuter et al., 1994: 11). Thus, according to the rules existing at that time, Landolt had to

designate a lectotype from the available original material indicated in the protologue. Considering this, the designated by Landolt "neotype" does not meet the requirements of the *Code*.

Provisions of Art. 9.8 of the *ICN* indicate that a "neotype" can be selected only "if no original material exists, or as long as it is missing". If we do not consider the specimens from the Micheli's Herbarium (FI) as belonging to original material because of their uncertain origin and no evidence of their association with Linnaeus, then we still have another extant element of the original material, the illustration in Micheli (1729: tab. 11, fig. 4). According to Art. 9.4(a) of the *ICN*, this image belongs to original material of *L. arrhiza*. Thus, the designation of a "neotype" for *L. arrhiza* by Landolt (2017) has no standing (see a similar nomenclatural case of the "neotype", lectotype, and epitype designations for the name *Veronica menthifolia* H. Schott ex Roem. & Schult., as discussed in Mosyakin et al., 2024: 150–151).

The lectotype (illustration) of *Lemna arrhiza* (\equiv *Wolffia arrhiza*) designated by Iamónico and Iberite (2014: 1314) fully complies with the provisions of Art. 9.3 of the *ICN* (Turland et al., 2018).

Unfortunately, the illustration of Micheli (Fig. 1A, B) gives only general ideas about *Lemna arrhiza* (\equiv *Wolffia arrhiza*). Therefore, for example, the description of Micheli does not indicate the exact dimensions of the plants, and his figure lacks any scale. Thus, we can get an idea of the size of *Lemna arrhiza* (\equiv *Wolffia arrhiza*) only by comparing it with other duckweed species depicted in the table (Micheli, 1729: tab. 11). In addition to this, the figure does not detail other morphological structures of a separate frond (for example, width, length, height of fronds; number of stomata, presence/absence of papules), which makes it difficult to unambiguously apply the name of a taxon as compared to other species related to it [for example, *Wolffia borealis* (Engelm. ex Hegelm.) Landolt ex Landolt & Wildi or *W. globosa* (Roxb.) Hartog & Plas] (Art. 9.6 of the *ICN*). In addition, the figure cannot be used for any biochemical, molecular, or other experimental studies.

Because of this, with the purpose of the precise application of the name to a taxon (Art. 9.9 of the *ICN*), I propose to designate the specimen FI123857 from Micheli's Herbarium (FI) that was identified by Landolt (1994: 148; Fig. 1C, D), as the epitype of the name *Lemna arrhiza* (\equiv *Wolffia arrhiza*).

Wolffia arrhiza (L.) Horkel ex Wimm., 1857. Fl. Schles. ed. 3, 140, nom. cons.

≡ *Lemna arrhiza* L., 1771, Mant. Pl.: 294.

≡ *Lenticala arrhiza* (L.) Lam., 1779. Fl. Franç. 2: 190.

≡ *Horkelia arrhiza* (L.) Druce, 1890. Fl. Berkshire: 511.

Type (Lectotype, designated by Iamonico and Iberite (2014: 1314): Illustration in Micheli, 1729. Nov. Pl. Gen.: t. 11 *Lenticularia* fig. 4. — Image of lectotype available at <http://bibdigital.rjb.csic.es/ing/Libro.php?Libro=2801&Pagina=269>).

Epitype, designated here: [the specimen of *Lenticularia omnium minima*, *arrhiza* without label, from Micheli's Herbarium (FI)], Notae criticae: "Neotypus *Lemna arrhiza* L. = *Wolffia arrhiza* (L.) Horkel in the smaller sample in Herb. Micheli, Landolt, 1994. See Landolt, Ber. Geobot. Inst. ETH, 60, 148", FI123857.

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ETHICS DECLARATION

The author declares no conflict of interest.

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Епітипіфікація ліннеївської назви

Lemna arrhiza (≡ *Wolffia arrhiza*), *Araceae*

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Реферат. Під час досліджень роду *Wolffia* (*Araceae*) в Україні ми вивчали питання типіфікації ліннеївської назви *Lemna arrhiza* (≡ *Wolffia arrhiza*). Встановлено, що ця назва була типіфікована двічі, спочатку як "неотип", запропонований Landolt у 1994 р., а потім як лектотип, запропонований Iamónico та Iberite у 2014 р. "Неотип" (гербарний зразок, що зберігається в FI) не відповідає вимогам ст. 9.8 *Міжнародного кодексу номенклатури водоростей, грибів і рослин (ICN)*, оскільки він не є частиною оригінального матеріалу для *Lemna arrhiza*, а тому не може розглядатися для цілей лектотипіфікації (ст. 9.3 і 9.4 *ICN*). Проте, лектотип, визначений Iamónico та Iberite (ілюстрація в книзі Micheli), повністю відповідає положенням *Кодексу*. Однак ілюстрація Micheli явно неоднозначна і не може бути критично ідентифікованою для цілей точного застосування до назви *L. arrhiza*, тому виникла необхідність призначити епітип назви цього таксону відповідно до ст. 9.9 *ICN*. Таким чином, зразок із гербарію Micheli (штрих-код FI123857) позначено тут як епітип.

Ключові слова: *Araceae*, *Lemna arrhiza*, *Wolffia arrhiza*, епітип, лектотип, неотип, типіфікація