INTRODUCTION

*Neohouzeaua* A.Camus, a little-understood bamboo genus, recently treated as a synonym of *Schizostachyum* Nees by Goh *et al.* (2020), was originally described with two species, *N. mekongensis* A.Camus and *N. dullooa* (Gamble) A.Camus, both of which were partially illustrated together in the same plate. The genus was taken to be typified by *N. mekongensis* by McClure (1957), as he considered this species was treated first by her and therefore taken as her standard of comparison.

A year after the publication of *Neohouzeaua*, the great bamboo monographer Gamble (1923), accepted the genus and described a new species, *N. tavoyana* Gamble, and transferred a species he (Gamble, 1896) had placed in *Teinostachyum* Munro, as *N. helferi* (Munro) Gamble.

Camus (1922) did not indicate a specimen that could be unambiguously taken as the type of *N. mekongensis*. Instead, she only stated “Laos: Ubon, Kemmarath (Thorel)”. During the revision of the bamboo collections from *P* and *K* (Thiers, 2020, continuously updated) we identified specimens determined as *N. mekongensis* by A.Camus, which are stated to be from “Ubon” and “Kemarath”, with disparity in the spelling. Additionally, Thorel’s name is specifically mentioned in those materials in his collections at the *P*, where Camus determined the...
species. Those materials \( M. \text{ Dr Thorel s.n.}, \) 1866–1868, Expédition du Me-kong, Ubon (barcode P03652489); \( M. \text{ Dr Thorel s.n.}, \) 1866–1868, Expédition du Me-kong, Ubon (P03652490); and \( M. \text{ Dr Thorel 2886}, \) Expédition du Me-kong, Kemarath cultivi (P03652491), however, comprise portions of synflorescences, except one (P03652490) in which the synflorescences are attached to a 3 mm diameter culm portion (presumably the distal part), with a 22.2 cm long internode.

Dransfield (1998) collected a non-flowering bamboo (\( S. \text{ Dransfield SD1473 in K} \)) in Phu Ruea National Park, “on the north slopes of the highest point (800 m), facing Hung River, which joins the Mekong River about 100 km to the east.” and identified it as \( N. \text{ mekongensis} \). However, the identification was based on collections post-dating the type material that she considers corresponding to the type material.

There have been no specimens from the Mekong River that we know of, and all of the K and BKF collections have been either of flowering material mostly without leaves and always without culm shoots or sheaths, or just vegetative material consisting leafy branches and culm shoots or sheaths.

Thus, it seems there is little material from those published papers and early specimens that can be relied on to build an assured impression of what this bamboo plant may look like vegetatively, hindering efforts in taxonomic or ecological studies, particularly lectotypification and epitypification.

Still, there is no direct correspondence between the type flowering material and the culm sheaths as documented for other non-flowering collections, and the species has never been recollected along the Mekong River, specifically at the stated type localities Ubon and Kemmarath, since the type material was gathered in the 19th Century.

Considering all these questions we considered the hypothesis of lectotypification and epitypification for \( N. \text{ mekongensis} \) and investigated the field evidence at the type localities, in order to elucidate these questions.

**MATERIALS AND METHODS**

**Field survey and collection**

In order to understand and trace the main characters of \( Neohouzeaua \) and its related genera in the subtribe Melocanniniae Benth., many publications were studied (such as Holttum, 1946; 1956; Xia, 1993; Wong, 1995a; Dransfield et al., 2003; Yang et al., 2008; Sungkaew et al., 2009; BPG, 2012; Goh et al., 2013; Chokthaweewanich, 2014; Kellogg, 2015; Wong et al., 2016). With this background to the general morphology of the Melocanniniae subtribe that could help in field identification and the foregoing insights into the importance of recollecting \( N. \text{ mekongensis} \) from its type provenance, we organized a survey along the Mekong River from Mueang Ubon Ratchathani to Khemmarat, in the Ubon Ratchathani Province (‘Ubon’) in eastern Thailand. The spellings used here for geographical names follow current use according to the Royal Thai General System of Transcription. Over five days (November 14–18, 2017) we travelled along the Mekong River, with stops at and in between Mueang Ubon Ratchathani, Khong Chiam and Khemmarat, altogether surveying 23 sites with bamboos.

The purpose was to collect high quality voucher material of all Melocanniniae taxa we would encounter in the landscape, including that which would closely match the type material of \( N. \text{ mekongensis} \). These materials would provide to better understand the vegetative morphology of the species in order to facilitate identification of living plants.

For each voucher collection made, we managed to obtain and document vegetative material at a range of developmental stages (culm sheaths or shoots more than a meter high so that culm sheaths with well-developed features useful in identification were obtained, midculm branch complements with leafy branches). These were pressed in the field and dried as specimens in the Herbarium of the Faculty of Forestry, Kasetsart University, Bangkok, Thailand (acronym used here KUFF, but not registered as an international herbarium). Rhizome offsets were taken where feasible for subsequent planting at the Forestry Faculty of Kasetsart University, Bangkok, the Baan Sammi Bamboo Garden, Chiang Mai, and the Singapore Botanic Gardens.

**RESULTS AND DISCUSSION**

**Understanding the main characters of \( Neohouzeaua \)**

When Holttum (1958) summarized his knowledge of the bamboos of the Malay Peninsula,
he already had a broad overview of the diversity of Southeast Asian bamboos and their potential classification, based on characters of flowering material, such as the nature of the synflorescence (relatively compact and typically arising first at the apex of a leafy branch, or developing into a much-branched structure), the basic unit of the inflorescence (whether spikelets are unable to proliferate further similar units at their base, or pseudospikelets that have basal gemmiferous bracts and are able to proliferate branch-units to form a cluster of similar units) and the nature of the style (solid and flexible, or essentially with an ovary apex that is attenuate and rigid yet hollow and containing a central strand that could represent the true style) (Holttum, 1946, 1956).

From such work, it became apparent that a cluster of genera around Melocanna Trinianus and Schizostachyum Nees, which also included Neohouzeaua, was exclusive in sharing a number of characteristics, including relatively compact synflorescences at the apex of leafy branches, pseudospikelets as the basic inflorescence units, and hollow rigid ‘styles’. It was also emphasized that in this alliance the midculm branch complement consists of many slender subequal branches developing from a single branch bud, and there is a conspicuous white-waxy ring just below each culm node (Wong, 1995a). This alliance is now well recognized as the subtribe Melocanninae (Yang et al., 2008; Sungkaew et al., 2009; BPG, 2012; Goh et al., 2013; Chokhaweenpanich, 2014; Kellogg, 2015; Soreng et al., 2015; 2017; Vorontsova et al., 2016; Wong et al., 2016).

On the basis of pseudospikelet and floral features, Holttum (1958) and Xia (1993) included Neohouzeaua within Schizostachyum, but Holttum acknowledged that the group of species that could be segregated as Neohouzeaua appeared to be a distinct group that differed from other Schizostachyum members in having a filament tube (instead of free filaments) and a lack of lodicules (most other Schizostachyum have three well-developed lodicules). There are also other distinctive vegetative characteristics among most of the taxa that can, by floral characters, be grouped with N. mekongensis; these include a medium-brown hairy culm sheath with very slender reflexed blades and a sheath apex with hardly developed auricles and conspicuous erect oral setae on both sides of the blade base, as found in the Malayan Schizostachyum jaculans Holttum (Holttum, 1958; Wong, 1995a). Such characters would have led Dransfield et al. (2003) to continue to recognize Neohouzeaua, although one of the two new species they described, N. fimbriata Dransfield, Pattanavibool & Sungkaew, which is now treated under Schizostachyum (Goh et al., 2020), has large, deflexed and long-bristly culm sheath auricles. These authors also mentioned an additional character, namely the style apex being level on one side and dipping on the other which is filled with minute hairs; we have been unable to verify this fine characteristic.

The field survey

Although the trip was planned in November at the transition to the dry season with the hope of obtaining both representative vegetative and flowering material, we were unable to find the latter (see Table 1). Only one taxon of the Melocanninae, recognizable by their midculm branch complement (many subequal branches developing from a solitary primary branch bud at each node) and the presence of a white-waxy band just below each culm node, was found along the Mekong River from Mueang Ubon Ratchathani to Khemmarat. Although not flowering during our survey, the vegetative features corresponded well with those described for eastern Thai material identified as N. mekongensis by Dransfield (1998). Therefore, this taxon was identified as N. mekongensis.

Table 1. summarizes the results of our survey. Of the 23 sites with bamboos surveyed, six sites with cultivated clumps of this N. mekongensis were found adjacent to village houses and often within private compounds, and two sites (recorded as ‘natural’ populations) occurred some distance from any dwelling or private compound.

The natural populations had at least three recognizable seed cohorts (<1 m, 2–3 m, 3–5 m or taller) that were apparently established from different years of flowering/seeding, possibly in the dry season during November to April. One cultivated clump also had obvious seed regeneration separated from the presumed mother clump. A villager from Talong Village showed us how culm splits were mainly used to craft containers for steaming food as well as other ad hoc household items, and explained that in times of shortage (such as when the bamboo flowered gregariously locally and fresh culms were then not available for a prolonged period), supplies have had to be sought from across the Mekong in Laos from non-flowering populations.
Natural history aspects

What we could surmise from the nature of the existing specimen material, observations during our survey, and information from villagers, provided valuable insights into the natural history of the bamboos. The young clumps take several years to reach maturity, during which they do not produce flowers, and finally in a flowering year would flower and seed during the dry season (November to April) as they lose all or most of their leaves, and then die down. Gregarious flowering would be frequent but not every clump will flower at the same season as not all the clumps are even-aged. New seedlings and saplings would eventually replace the mother clumps. Regeneration was seen for both wild clumps we encountered, but not for the cultivated clumps.

Such one-off flowering of mature clumps during a dry season, when vegetative production of new shoots ceases and the foliage senesces, could explain why the type and most other collections had only inflorescences, and why during our 2017 survey we were not able to obtain reproductive material during a time when culm shoots were still actively produced.

Bamboo flowering in South-East Asia has been documented as being gregarious in both seasonal and ever wet climates (Holttum, 1958; McClure, 1966; Janzen, 1976; Wong, 1995a, b) and also continuous for some Schizostachyum species in the ever wet Malay Peninsula (Holttum 1958, Wong 1995b). Clearly, in the case of *N. mekongensis*, it is seasonal and takes place during the dry season after maturity of a seed cohort, and at least regionally gregarious.

Quite a few bamboo taxa from the Asian seasonal tropics are similarly typified by flowering material with perhaps just a few leaves, such as in the genera *Bambusa* Schreber, *Dendrocalamus* Nees and *Gigantochloa* Kurz ex Munro. They typically flower in the dry season, when shoots and other characters, such as culm shoots and their sheath characteristics, are not produced. This hampers the identification of these bamboos, and when collections are poor and do not allow correlation between flowering and vegetative features, taxonomic progress is seriously impeded. In a number of cases, not only were the original material consisting only of flowering specimens, the descriptions of these bamboos mentioned not one, but several collections, so making way for possible mixtures and a degree of doubt regarding a specific reference.

**Taxonomy and the epitypification of *Neohouzeaua mekongensis***

The original material of *N. mekongensis* did not specify a type clearly and the requirement of lectotypification following the Article 9.3 of the Shenzhen Code (Turland et al., 2018). Luckily enough, lectotypification for the type species, *N. mekongensis*, has been carefully done by Goh et al. (2020), where
the most complete specimen P03652490 (M. le Dr Thorel s.n., 1866–1868, Expédition du Me-kong, Ubon, see Fig. 1) was designated as the lectotype. Other isolectotypes and a probable isolectotype were also provided. In addition, based on a molecular phylogenetic analysis, they treated Neohouzeaua A.Camus as a synonym of Schizostachyum Nees. As all of the original material, including the lectotype, comprised only flowering material without accompanying vegetative material that could aid in the identification of the bamboo in question, we here also propose an epitype in accordance with the Article 9.9 of the Shenzhen Code. We also provide a full description of N. mekongensis that is hitherto not available.

Neohouzeaua mekongensis A.Camus, Bull. Mus. Hist. Nat. Paris 28 (1922) 100.— Type: Thailand, Expédition du Me-kong, Ubon, M. le Dr Thorel s.n. (P, [03652490]), lectotype, designated by Goh et al. (2020: 117).— Supported by epitype: Thailand, Ubon Ratchathani, Khong Chiam District, Khong Chiam Subdistrict, Woen Buek Village, transition zone between mixed deciduous forest and dry evergreen forest, Sungkaew 1570 (epitype BKF, here designated, isoeotypes KUFF, SING; Herbarium, Thailand Natural History Museum, National Science Museum, Technopolis, Pathum Thani, Thailand). Figs. 1–2.

Arborescent, unarmed bamboo. Rhizomes pachymorph with short-necks, forming a clump usually with dense culms. Culms erect, 5–10 m tall, 1–4.5 cm in diameter, tips out-arching to drooping; internodes terete, 45–100 cm long, walls rather thin, dark to bluish green when young, covered with dense appressed white to pale hairs and white-waxy substance, margins of the culm-sheath proper drying off earlier towards the apex; culm-sheath blades narrowly linear, green, spreading to reflexed, ca ⅓ or as long as the culm-sheath proper, covered with dense pale hairs adaxially and scattered pale hairs abaxially; auricles inconspicuous or replaced by a low dark thickened rim to ca 1 mm high, with dense, relatively erect pale bristles (oral setae) in a tidy row, to ca 10 mm long; ligule ca 1 mm tall, margin irregular toothed or laciniate and fringed with pale bristles to 5 mm long. Foliage leaves 5–11 per branchlet; pseudo-petioles 0.2–0.8 cm long; leaf sheaths 5.5–14 cm long, back covered with scattered, appressed pale hairs to glabrous, margins ciliate to glabrous; auricles absent, replaced by low rims along both sides of sheath apex, fringed with dense, relatively erect to apically curved pale bristles (oral setae), to ca 5 mm long; ligules short, ca 0.5 mm tall, margin fringed with pale bristles to 1.5 mm long; margin of outer ligule ciliolate; leaf blades lanceolate-oblong, 10–38(–40) by 2–6.5(–9) cm, adaxially and abaxially scaberulous to glabrous, base obtuse to acute or cuneate, apex acuminate (vegetative components described primarily from Sungkaew 1570). Synflorescence fully bracteate, the subtending lanceolate sheaths/bracts usually glabrous, paniculate, 40–50 cm long, much branched and dense, glabrous, usually on leafless branches, inflorescence units iterucautant (indeterminate), composed of pseudospikelets. Pseudospikelets slender, oblong or fusiform, (1.9–)2.2–2.4 cm long, apices acute, glabrous, basal bracts several-nerved; empty glumes 3–4, ovate-lanceolate, unequal, 5–9 mm long, apices mucronate or sub-aristate, glabrous; fertile floret 1, rachilla extension beyond floret absent or much reduced and slender. Florets with lemmas ovate-lanceolate, 1.4–1.7 cm long, margins involute, apices mucronate, glabrous, several-nerved; paleas 1.7–1.9 cm long, margins involute, apices attenuate, or bi-cuspidate with the tips 2 mm long, without keels, glabrous; lodicules absent; stamens 6, filaments connate into a narrowly cylindrical tube, anthers ca 8 mm long, glabrous, apices obtuse; ovary oblong, glabrous, ending in a long rigid style ca 1.5 cm long; stigmas 3, plumeose. Caryopses not seen. (Floral components described primarily from the lectotype)
Figure 1. The lectotype of *Neohouzeaua mekongensis* A. Camus, designated by Goh et al. (2020). Photograph from https://science.mnhn.fr/institution/mnhn/collection/p/item/p03652490?fbclid=IwAR3dhX09Mj5M__TVbXOoMj-omx4AIXgOSHtHk_FgNz1GbSVuYzuoSkIA.
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Figure 2. Habit and vegetative characteristics of Neohouzeaua mekongensis A.Camus: A. Clump habit, showing erect caespitose culms, B. Arching over to drooping culm tips, C. & D. Mature culms (with no culm sheaths remaining on internodes) and young culms (with attached culm sheaths), E. Culm sheath, showing reflexed culm-sheath blade, the relatively erect pale bristles (oral setae) along the low dark thickened rims, and the appressed white hairs and a thin covering of white waxy substance on the back of the sheath proper, F. Portion of a young culm, showing a narrow band of white-waxiness just below the node and a copious covering of appressed white to pale hairs all over the internode (A from Sungkaew 1569, E & F from Sungkaew s.n., Talong Village, Huai Phai subdistrict, Khong Chiam District, Ubon Ratchathani (photographed by K.M. Wong), B from the same population, but different clump, where the Sungkaew 1573 was collected, C & D from Sungkaew s.n., Talong Village (photographed by S. Sungkaew)).
REFERENCES

BPG (Bamboo Phylogeny Group) (2012). An updated tribal and subtribal classification for the Bambusoideae (Poaceae). The Journal of the American Bamboo Society 25(1):1–10.

Camus, A. (1922). Un genre nouveau de Bambusee. Bulletin du Museum National d’ Histoire Naturelle 28: 100–102.

Chokthaweepanich, H. (2014). Phylogenetics and Evolution of the Paleotropical Woody Bamboos (Poaceae: Bambusoideae: Bambuseae). Graduate Theses & Dissertations. Paper 13778. Iowa State University, Ames, U.S.A., 212 pp.

Dransfield, S. (1998). Report on fieldwork collecting bamboos in Thailand, October-November 1997. Thai Forest Bulletin (Botany) 26: 35–39.

Dransfield, S., Pattanavibool, R. & Sungkaew, S. (2003). Two new species of *Neohouzeoua* [sic!] from Thailand and Myanmar. Thai Forest Bulletin (Botany) 31: 27–33.

Gamble, J.S. (1896). The Bambuseae of British India. Annals of the Royal Botanic Garden, Calcutta 7: 102–103, plates 90.

________. (1923). *Neohouzeoua*, a new genus of bamboos. Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew) 1923(2): 89–93.

Goh, W.L., Chandran, S., Franklin, D.C., Isagi, Y, Koshy, K.C., Sungkaew, S., Yang, H.Q., Xia, N.H. & Wong, K.M. (2013). Multi-gene region phylogenetic analyses suggest reticulate evolution and a clade of Australian origin among paleotropical woody bamboos (Poaceae: Bambusoideae: Bambuseae). Plant Systematics and Evolution 299: 239–257.

Goh, W.L., Sungkaew, S., Teerawatananan, A., Ohnrbenger, D., Widjaja, E.A., Sabu, K.K., Gopakumar, B., Koshy, K.C., Xia, N.H. & Wong, K.M. (2020). The phylogenetic position and taxonomic status of the Southeast and South Asian bamboo genera *Neohouzeoua* and *Ochlandra* (Poaceae: Bambusoideae). Phytotaxa 472 (2): 107–122.

Holtum, R.E. (1946). The classification of Malayan bamboos. Journal of the Arnold Arboretum 27: 340–346.

Holtum, R.E. (1956). The classification of bamboos. Phytomorphology 6: 73–90.

________. (1958). The bamboos of the Malay Peninsula. Gardens’ Bulletin Singapore 16: 1–135.

Janzen, D.H. (1976). Why bamboos wait so long to flower. Annual Review of Ecology and Systematics 7: 347–391.

Kellogg, E.A. (2015). Flowering plants, monocots, Poaceae. In: Kubitzki, K. (ed.) The Families and Genera of Vascular Plants, Vol. 13. Springer, Heidelberg, pp. 1–416.

McClure, F.A. (1957). Typification of the genera of the Bambusoideae. Taxon 6: 199–210.

________. (1966). The Bamboos: A Fresh Perspective. Harvard University Press, Cambridge, Massachusetts, 347 pp.

Soreng, R.J., Peterson, P.M., Romaschenko, K., Davidse, G., Zuloaga, F.O., Judziewicz, E.J., Filgueiras, T.S., Davis, J.J. & Morrone, O. (2015). A worldwide phylogenetic classification of the Poaceae (Gramineae). Journal of Systematics and Evolution 53(2): 117–137.

Soreng, R.J., Peterson, P.M., Romaschenko, K., Davidse, G., Teisher, J.K., Clark, L.G., Barbera, P., Gillespie, L.J. & Zuloaga, F.O. (2017). A worldwide phylogenetic classification of the Poaceae (Gramineae) II: An update and a comparison of two 2015 classifications. Journal of Systematics and Evolution 55(4): 259–290.

Sungkaew, S., Stapleton, C.M.A., Salamin, N. & Hodkinson, T.R. (2009). Non-monophyly of the woody bamboos (Bambuseae; Poaceae): a multi-gene region phylogenetic analysis of Bambusoideae s.s. Journal of Plant Research 122: 95–108.

Thiers, B. (2020, continuously updated). Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden’s Virtual Herbarium.

Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Kubler, W.-H., Li, D.-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F. (2018). International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Koeltz Botanical Books, Glashütten.
Vorontsova, M., Clark, L.G., Dransfield, J., Govaerts, R.H.A., Wilkinson, T. & Baker, W.J. (2016). World Atlas of Bamboos and Rattans. International Network of Bamboo and Rattan & the Board of Trustees of the Royal Botanic Gardens, Kew, 819 pp.

Wong, K.M. (1995a). The Bamboos of Peninsular Malaysia. Malayan Forest Records No. 41. Forest Research Institute Malaysia, Kuala Lumpur, 200 pp.

_____. (1995b). The Morphology, Anatomy, Biology and Classification of Peninsular Malaysian Bamboos. University of Malaya Botanical Monographs No. 1. University of Malaya, Kuala Lumpur, 189 pp.

Wong, K.M., Goh, W.L., Chokthaweepanich, H., Clark, L.G., Sungkaew, S., Widjaja, E.A. & Xia, N.H. (2016). A subtribal classification of Malesian and Southwest Pacific woody bamboos (Poaceae: Bambusoideae: Bambuseae) informed by morphological and molecular studies. Sandakania 22: 1–36.

Xia, N.H. (1993). Studies on the genus Schizostachyum and other bamboos from China. Journal of Tropical and Subtropical Botany 1: 1–10.

Yang, H.Q., Peng, S. & Li, D.Z. (2007). Generic delimitations of Schizostachyum and its allies (Gramineae: Bambusoideae) inferred from GBSSI and trnL-F sequence phylogenies. Taxon 56: 45–54.

Yang, H.Q., Yang, J.B., Peng, Z.H., Gao, J., Yang, Y.M., Peng, S. & Li, D.Z. (2008). A molecular phylogenetic and fruit evolutionary analysis of the major groups of the paleotropical woody bamboos (Gramineae: Bambusoideae) based on nuclear ITS, GBSSI gene and plastid trnL-F DNA sequences. Molecular Phylogenetics and Evolution 48: 809–824.