

Integrated Water Resources Management in Myanmar
**Aquatic macrophytes in lakes in
Myanmar 2014-2020**
Field survey and identification



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Summary This report is performed by NIVA, as part of the project Integrated Water Resources Management – Institutional Building and Training. The purpose of this report is to assist experts undertaking biological field surveys in Myanmar. The purpose of the report is to assist the Myanmar experts responsible for the aquatic macrophyte field surveys. In addition to a suggested field method for aquatic macrophyte survey in lakes in Myanmar, the report contains factsheets with short descriptions and photos of 40 hydrophyte species in Myanmar. These factsheets can be used as a supplement to other identifications keys and floras from the Asian region and serve as a “first identification step”.
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in Myanmar

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Field survey and identification

Preface

This report is performed by the Norwegian Institute for Water Research (NIVA), as part of the project Integrated Water Resources Management – Institutional Building and Training, a cooperation project between Department of Forest, Ministry of Natural Resources and Environmental Conservation (MONREC) and NIVA during the period 2014-2020. The project which is part of the Norwegian – Myanmar Bilateral Environment Programme, 2015-2023 has been funded by the Norwegian embassy in Yangon.

Marit Mjelde (NIVA), Thida Swe (Forest Research Institute; FRI) and Andreas Ballot (NIVA) carried out all the macrophyte collections. Most of the photos are taken by Andreas Ballot, and some by Thida Swe and Marit Mjelde. The identifications were made by Marit Mjelde.

We are very grateful for all help and assistance during the field surveys. Thin Thin Yu, Park Warden at Moeyingyi WS, participated in the field survey in Moeyingyi, while Ye Thist (FFI), Khin Maung Lwin, Saw Htoo Min, Thant Zin Oo and Tin Naing Win, from Indawgyi Wildlife Sanctuary, and Bente Wathne (NIVA) participated in the field survey in Indawgyi Lake. May Phoo, Htay Kywae, Nay Ni Kyaw, Toe Toe Aung, Phyo Thet and Swuam Pyaye Aye Aung assisted in the lake surveys in the Mandalay region.

We also want to thank all the fishermen and other local people for boat use and transport, and for local information about lakes and freshwater plants.

Thanks to all for the good and very fruitful cooperation!

Oslo 24.05.2023

Marit Mjelde

Table of contents

1	Introduction	6
2	Visited water bodies	7
3	Methods.....	9
3.1	Aquatic macrophyte – definition	9
3.2	Sampling method.....	9
3.3	Preparations of specimens for deposit as herbarium vouchers	10
3.4	Flora and identification keys.....	11
3.5	Previous work on aquatic macrophytes in Myanmar	11
3.6	Some words about the factsheets	11
4	Factsheets	14
5	References	55

Summary

This report is performed by the Norwegian Institute for Water Research (NIVA), as part of the project Integrated Water Resources Management – Institutional Building and Training (IWRM), a cooperation between Department of Forest, Ministry of Natural Resources and Environmental Conservation (MONREC) and NIVA during the period 2014-2020. The project which is part of the Norwegian – Myanmar Bilateral Environment Programme, 2015-2023 has been funded by the Norwegian embassy in Yangon.

The purpose of the report is to assist experts undertaking aquatic macrophyte field surveys in Myanmar. In addition to a suggested field method for aquatic macrophytes, the report contains factsheets with short descriptions and photos of 40 aquatic macrophyte species in Myanmar, recorded in the period 2014-2020. These factsheets can be used as a supplement to other identifications keys and floras from the Asian region and serve as a “first identification step”. Hopefully, they will support more accurate and consistent species identification amongst field surveyors.

Sammendrag

Denne reporten er utarbeidet som en del av IWRM-prosjektet i Myanmar, et samarbeidsprosjekt mellom MONREC og NIVA i perioden 2014-2020, finansiert av den norske ambassaden i Myanmar.

Rapporten inneholder forslag til feltmetodikk for vannplanteundersøkelser i innsjøer og reservoarer i Myanmar. I tillegg er det utarbeidet faktaark med fotografier og korte artsbeskrivelser for 40 vannplanter som er registrert i Myanmar i perioden 2014-2020. Faktaarkene er tenkt brukt som et supplement til andre identifiseringsnøkler og floraer fra Asia tjene som et første steg i identifiseringen. Forhåpentligvis vil faktaarkene gjøre artsidentifiseringen noe lettere.

Tittel: Vannplanter i innsjøer i Myanmar 2014-2020. Feltmetodikk og artsbestemmelse.

År: 2023

Forfatter(e): Marit Mjelde, Andreas Ballot, Thida Swe

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1 Introduction

Within the project Integrated Water Resources Management – Institutional Building and Training (IWRM) (2014-2020), Myanmar and Norway have collaborated on a broad range of issues. The collaboration includes input to the development of a National Water Framework Directive and to a classification system for the ecological status of lakes in Myanmar, similar to that implemented in the European Water Framework Directive (EU 2000). An important element in the directive is to assess the ecological status of lakes and rivers. The assessments of lakes include the status of aquatic macrophytes, which requires knowledge of monitoring methods and species identification.

The knowledge of species diversity in freshwater, including aquatic macrophytes, is poorly surveyed and documented in Myanmar as well as in the whole Indo-Burma region (Allen et al. 2012). In addition, some aquatic macrophyte genera are highly variable without satisfactory taxonomic determination. Several genera, e.g., the *Nymphaea* species, have been cultivated for a long time, which has resulted in several hybrid species, which may complicate their taxonomic identification.

The purpose of this field and species identification manual for aquatic macrophytes is to assist experts undertaking biological field surveys in Myanmar. The manual includes descriptions and photographs of species we recorded in lakes in Myanmar. As the project collaboration with Myanmar authorities was ended in 2021 due to the military coup, the planned investigations in lakes could not be fully completed.

Therefore, the diversity of macrophytes is certainly much higher than the number we recorded, but still, we hope these factsheets will make species identification a little easier for surveyors and more consistent between survey teams. They should be used as a “a first identification step”. The species identities should be certified by other identifications keys and floras for the Asian region.

Results from our surveys of aquatic macrophytes in lakes in Myanmar are included in different reports and articles, see appendix 1.

2 Visited water bodies

Altogether 17 lakes and reservoirs were selected and visited once or multiple times at one or several sampling points in the lake in the period 2014 -2020 (Table 1). The lakes represent different regions and different lake types in Myanmar. However, given the geological and climatic diversity in Myanmar, we believe that they include only a small part of the country's aquatic macrophyte community.

Aquatic macrophyte field surveys were carried out in all lakes. The investigations also comprised physical-chemical and phytoplankton sampling, see Ballot et al. 2023.

Table 1. Visited lakes and reservoirs in Myanmar in 2014-2020

Lake	State/Region/ Division	Latitude	Longitude	Altitude m	¹ Lake area km ²	Lake type
Inlay Lake	Shan State	20,563046	96,918640	884	116 ²	Natural
Sakar Inn	Shan State	20,169411	96,932716	884	3	Reservoir
Pekon Lake	Shan State	19,879100	97,032623	884	134	Reservoir
Indawgyi Lake	Kachin State	25,116667	96,316667	170	123	Natural
Meiktila Lake, North	Mandalay Region	20,886560	95,852966	230	4,8	Reservoir
Meiktila Lake, South	Mandalay Region	20,863464	95,854511	230	4,3	Reservoir
Yezin dam	Mandalay Region	19,855852	96,276798	128	6,4	Reservoir
Nga Laik Dam	Mandalay Region	19,861665	96,005058	163	5,5	Reservoir
Moeyingyi Reservoir	Bago Region	17,570721	96,596947	10	15	Reservoir
Taung Thaman Lake, North	Mandalay Region	21,900833	96,060556	61	3	Reservoir
Kantawgyi lake, South	Mandalay Region	21,936389	96,065833	66	1,8	Reservoir
Pyu Kan Lake	Mandalay Region	21,768056	95,891111	102	2	Reservoir
Khu Le Inn	Mandalay Region	22,592222	95,980000	76	2,5	Reservoir
Sunye In Tank	Mandalay Region	21,679722	96,230000	91	4	Reservoir
Pauk In	Mandalay Region	21,326944	95,048056	55	0,15	Reservoir
Kyet Mauk Taung Dam	Mandalay Region	20,812222	95,250833	279	4,5	Reservoir
Wethtigan lake	Magwe Division	20,575833	94,641111	66	1,7	Natural

1: Lake area can vary between wet and dry season. Lake areas measurements are based on Google Earth where satellite photo dates can vary from region to region, **2:** Inlay Lake area is reduced, and open water was in 2014 measured to 46 km².



Figure 1. Aquatic macrophytes surveys were conducted in 17 water bodies in Myanmar, indicated with violet dots. The overview-map from www.albatros-travel.no

3 Methods

3.1 Aquatic macrophyte – definition

A simple definition of macrophytes is vascular plants and macroalgae growing in or close to the water. They can be divided into semi-aquatic plants (emergent plants, helophytes) and aquatic macrophytes (hydrophytes), i.e., submerged plants or plants with floating leaves. The division of macrophytes into helophytes and hydrophytes is not straightforward and may vary between countries.

In this report, we have used a strict definition of hydrophytes; including only the species that belong to the following growth form groups (see Figure 2):

- (2) isoetids (submerged rosette-plants)
- (3) elodeids (submerged elongated plants)
- (4) nymphaeids (floating-leaved plants)
- (5) lemniids (free-floating plants).

In addition, we include the charophytes (macroalgae) (not shown in the Figure).

The helophytes (1) are not included in this report, nor are aquatic bryophytes and filamentous algae.

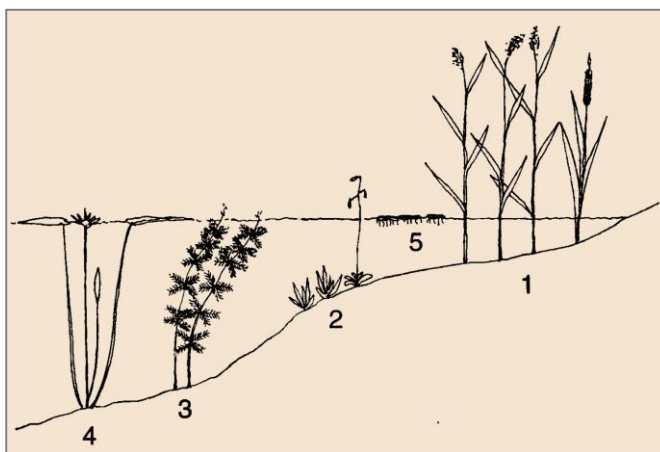


Figure 2. Growth forms of aquatic macrophytes.

The hydrophyte definition is the same approach as used in the EU Water Framework Directive, Intercalibration process in the Northern group of countries (Hellsten et al. 2014), including Norway (Mjelde and Dervo 2022).

3.2 Sampling method

The aquatic macrophyte sampling should take place during the period of maximum biomass, which in temperate areas means late summer. In the tropics with a growing period throughout the year, at least two macrophyte surveys per year are necessary; for instance, one after the dry period and one after the rainy period. At different localities/habitats in the lake (with different erosion conditions, outlet, inlet, shallow and deep areas, etc.) the plants should be recorded using an aqua scope and collected by dredging a rake from the boat (Figure 3). In large lakes, at least 20 localities should be visited, in small lakes fewer localities may be sufficient, however, the major habitats should be included in the survey.

The abundance of each species can be scored using different methods. We have used a semi-quantitative scale, where 1=rare, 2=scattered, 3=common, 4=locally dominant and 5=dominant.

In deeper lakes, maximum depth distribution for the most important species or growth form groups should be noted.



Figure 3. Aquascope and rake

3.3 Preparations of specimens for deposit as herbarium vouchers

For later identification and verification, all species should be sampled and pressed and dried in a plant press. The plant press consists of a wooden frame, blotter paper (to absorb moisture), and folded paper, typically a newspaper (to enclose the plant material). For keeping the morphological characteristics of the aquatic macrophytes, it may be necessary to drag a floating specimen on a blank sheet from a bowl with water. Each sheet with plant specimens should be placed within the newspaper sheet. The plant press with all the specimens is tightened using straps. The blotter papers should be replaced by dry sheets after 1-2 days. The objective of pressing plants is to extract moisture in the shortest period of time, while preserving the morphological integrity of the plant, for long-term storage. The voucher specimens should be deposited in a herbarium collection for future reference and to support research work

Each voucher should include information about the lake, locality, date, and suggested name of the species. In addition, the names of the collector and the one who identified the species should be included. The identification of unknown plant material can be based on keys in published floras; published plant descriptions, illustrations, and photographs; and comparison with properly identified herbarium specimens. A microscope is essential for the observation of many diagnostic features.

More information about preparation and identification of plant specimens can be found on different websites, e.g., <https://www.floridamuseum.ufl.edu/herbarium/voucher.htm>.

3.4 Flora and identification keys

All species included in this report are determined based on keys in standard floras for the region, primarily Cook (1996), in addition to updated or more specialized taxonomic work, e.g., Cook & Löönd (1982) Wiegleb (1990), Wiegleb & Kaplan (1998), Ito et al. (2014), Margua Raya et al. (2010), Triest (1988), La-Ongsri (2008), La-Ongsri et al. (2009), Yu et al. (2002). For the *Potamogeton*-species we have also used Preston (1995). The identification of the *Chara*-species is based on Wood & Imahori (1965), combined with DNA barcoding, see Mjelde et al. (2020). In the future, genetic analyses may be useful as an identification supplement also in Myanmar.

3.5 Previous work on aquatic macrophytes in Myanmar

The knowledge of species diversity in freshwaters of Myanmar, and the whole Indo-Burma region, is poorly documented and the region is relatively under-surveyed (Allen et al. 2012). However, some literature about aquatic macrophytes is available. An updated list of aquatic macrophytes in Myanmar was published by Ito and Barfod in 2014, while Tanaka et al. (2019) published a field guide for aquatic macrophytes in Myanmar. In addition, macrophyte notes from several lakes are included in Davies et al (2004). A comprehensive study of “Burmese Charophyta” was published in 1932 by B.P. Pal. However, see Mjelde et al (2020) for updated determinations and names. A macrophyte survey in Inlay Lake was included in the work of Nath (1960) and in Lansdown (2012).

3.6 Some words about the factsheets

All photos used in the factsheets are taken from aquatic macrophytes in the surveyed lakes in Myanmar, while the short species descriptions mainly are based on the descriptions in the above-mentioned floras and taxonomic works. For more complete description and keys, the taxonomic works mentioned in chapter 3.4 should be used. For several submerged species we have excluded the flower characteristics since flowers often are absent. In total, factsheets for 40 species are depicted (Table 2). We recommend using the factsheets as the first step in identification of aquatic macrophyte species.



Figure 4. Aquatic macrophyte registration in Inlay Lake.



Figure 5. The submerged species *Vallisneria spiralis* caught by the rake in Meiktila Lake.

Table 2. Aquatic macrophytes recorded in waterbodies in Myanmar in 2014-2020.

Latin names	Author	English names*
ELODEIDS		
<i>Ceratophyllum demersum</i>	L.	Common Hornwort, Coontail
<i>Hydrilla verticillata</i>	(L. f.) Royle	Hydrilla, Waterthyme
<i>Limnophila sessiliflora</i>	Vahl (Blume)	Asian marshweed
<i>Myriophyllum spicatum</i>	L.	Eurasian Watermilfoil
<i>Myriophyllum verticillatum</i>	L.	Whorl-Leaf Watermilfoil
<i>Myriophyllum tuberculatum</i>	Roxb.	Red Watermilfoil
<i>Najas indica</i>	(Willd.) Cham.	Pearlweed, Pearl Grass
<i>Najas minor</i>	All.	Brittle Waternymph
<i>Nechamandra alternifolia</i>	(Roxb. Ex Wight) Thwaites.	Indian oxygen-weed
<i>Ottelia cordata</i>	(Wall.) Dandy	
<i>Ottelia alismoides</i>	(L.) Pers.	Ducklettuce
<i>Potamogeton crispus</i>	L.	Curled Pondweed
<i>Potamogeton lucens</i>	L.	Shining Pondweed
<i>Potamogeton nodosus</i>	Poir.	Loddon Pondweed
<i>Potamogeton wrightii</i>	Morong	
<i>Stuckenia pectinata</i>	(L.) Börner	Sago pondweed
<i>Utricularia aurea</i>	Lour	Golden bladderwort
<i>Utricularia australis</i>	R. Br.	
<i>Utricularia gibba</i>	L.	Humped bladderwort
<i>Utricularia punctata</i>	Wall.	
<i>Vallisneria spiralis</i>	L.	Tape grass
NYMPHAEIDS		
<i>Euryale ferox</i>	Salisb.	Gorgon, prickly Water Lily
<i>Nelumbo nucifera</i>	Gaertn.	Indian lotus, Sacred lotus
<i>Nymphaea cyanea</i>	Roxb.	
<i>Nymphaea nouchali</i>	Burm. f.	Blue star water lily
<i>Nymphaea pubescens</i>	Willd.	
<i>Nymphaea rubra</i>	Roxb. ex Salisb.	
<i>Nymphoides indica</i>	(L.) Kuntze	Water Snowflake
<i>Nymphoides hydrophylla</i>	(Lour.) Kuntze	Crested Floating-heart
<i>Trapa natans</i>	L.	Water chestnut
LEMNIDS		
<i>Azolla pinnata</i>	R. Br.	Feathered mosquito fern
<i>Pontederia crassipes</i>	(Mart.) Solms	Common water hyacinth
<i>Hydrocharis dubia</i>	(Blume) Backer	
<i>Lemna minor</i>	L.	Common Duckweed
<i>Lemna trisulca</i>	L.	Ivy-Leaf Duckweed
<i>Pistia stratiotes</i>	L.	Nile-cabbage
<i>Salvinia cucullata</i>	Roxb. Ex Wall., 1829	
<i>Salvinia auriculata</i>	Aublet	Butterfly fern
<i>Spirodela polyrhiza</i>	(L.) Schleid.	Greater Duckweed
CHAROPHYTES		
<i>Chara zeylandica</i>	Klein ex Willdenow	
<i>Chara fibrosa</i>	Agardh ex Bruzelius	

*: English names are not found for all species

4 Factsheets

ELODEIDS (submerged, elongated plants)

Ceratophyllum demersum

Short description: *Ceratophyllum demersum* is a fully submerged plant. The stem can be several metres long and has submerged leaves in whorls of 7-11 which are divided 1-2 times. The leaf margin has spine-tipped teeth, particularly in the apical segments. It does not have roots however the base of the stem is often buried in sandy or silty substrates. It is often seen free-floating in the water column.

Our observations: Inlay Lake, Pekon Lake, Indawgyi Lake, Ku Le Inn, Sunye In Tank, Wethtigan Lake



Similar species: can be separated from *C. submersum* by the leaf division (the leaves in *C. submersum* are divided 3-4 times).

Hydrilla verticillata

Short description: *Hydrilla verticillata* is a submerged species with only submerged leaves. The leaves appear in whorls around the stem, with 3-8 (up to 12) leaves per whorl. The midrib of the leaf is often reddish when fresh. The leaf edges have teeth, and *Hydrilla* feels scratchy when drawn through the hands. Turions are compact and can appear along the leafy stems. Presence of tubers is characteristic for this species and are underground potato- or pea-like structures at the end of the roots.

Our observations: Inlay Lake, Indawgyi Lake, Meiktila Lakes (north and south), Yezin Dam, Nga Laik Dam, Moeyingyi Reservoir, Ku Le Inn, Sunye In Tank, Kyetmauk Taung Dam

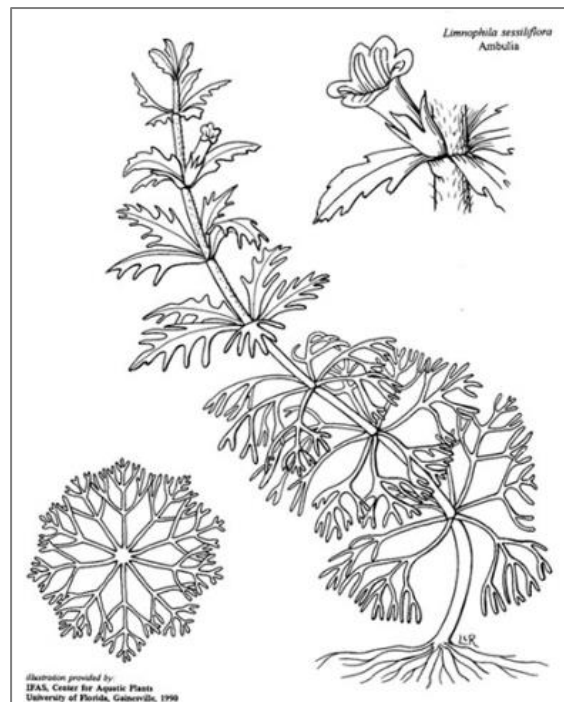


Similar species: Leaf number, stem elongation and leaf shape are highly variable, and the species can be difficult to distinguish from *Egeria* and *Elodea* species. *Egeria* usually has four leaves per whorl, while *Elodea* has three per whorl. *Egeria* is also a large plant with leaves at least 2 cm long, while the *Elodea* leaf is usually less than 1 cm long. Only *Hydrilla* produces tubers.

Limnophila sessiflora

Short description: Amphibious plant, which is extremely variable depending on the habitat. It has both emergent and submerged leaves. The aerial leaves are elliptic-lanceolate and appear in whorls of 3-8. The submerged leaves are in whorls of 5-12, with flattened segments. The flowers are sessile or rarely with a pedicel, solitary in axils of submerged and aerial leaves. It is found in permanent and temporary water.

Our observations: Sakar Inn



The drawing from:
<https://plants.ifas.ufl.edu/wp-content/uploads/images/limses/limses2.jpg>

Similar species: The submerged form of the species is difficult to separate from the very similar *L. indica* (the two species also hybridise; Cook 1966).

Myriophyllum spicatum

Short description: *Myriophyllum spicatum* is a submerged species and has only submerged leaves. The stem is often branched. The species can have a woody rootstock with traces of previous years' growth. The stem is usually reddish, sometime greenish, and the inflorescence branches are usually conspicuously swollen. The leaves are arranged in whorls of 4 (rarely 5) around the stem at each node, widely spaced, i.e., the leaves are often shorter than the internode section, but more crowded near growing shoot apices. Leaves are dark green, with (8)-12-24 pairs of narrowly spaced segments in a single plane and of even length, making leaves feather-like. The species does not form turions.

Myriophyllum spicatum prefers base-rich water systems and is tolerant to eutrophication. The species can be a serious weed, especially in North America.

Our observations: Inlay Lake (*M. cf. spicatum*)



Similar species: *Myriophyllum spicatum* is very similar to *M. verticillatum*, which can be separated by the appearance of turions, and the shorter length of the internodes compared to the leaves.

Myriophyllum verticillatum

Short description: *Myriophyllum verticillatum* is a submerged species, with only submerged leaves. The stem is branched or unbranched, and the internodes are often shorter than the leaves. Submerged leaves are 4-6-whorled and pectinate, with 8-16 pairs of filiform pinnae. The inflorescence is an erect spike, and the bracts are pinnate or pectinate. Clavate turions are formed along the stem during late summer.

M. verticillatum is widespread in the temperate regions in the northern hemisphere. It typically grows in clear or slightly turbid, still, or slow-flowing calcareous water.

Our observations: Inlay Lake, Pekon Lake



Similar species: The species may be confused with other *Myriophyllum* species, for instance *M. tuberculatum* and *M. spicatum*, however none of these produce turions. According to Yu et al. (2002), some authors think that the best field characters for identifying *M. verticillatum* are the floral bracts that are always divided, and the clavate winter turions along the stem.

Myriophyllum tuberculatum

Short description: *Myriophyllum tuberculatum* is a submerged species, with both submerged and emergent leaves. Submerged leaves are 4 or 5 whorled and pinnately divided, with 8-25 pairs of filiform lobes. Emergent leaves in lower part are similar to the submerged ones but smaller, the upper leaves are alternate, with less and shorter lobes, while the uppermost leaves are entire. No turions are formed.

Our observations: Pekon Lake (*M. cf. tuberculatum*)

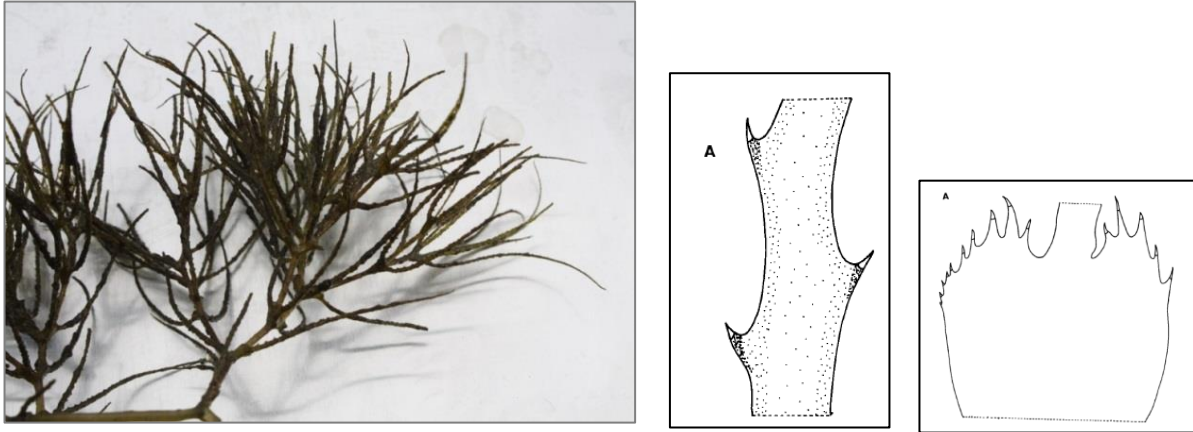


Similar species: *M. verticillatum*, *M. tetrandrum*

Najas indica

Short description: *Najas indica* is a submerged species. The stem is unarmed (i.e., without claws, thorns, scales etc.). The submerged leaves are 10-26 mm long, flat, acute, linear-lanceolate. The margin on each side is serrulate with 8-20 conspicuous spiny teeth. The midrib is generally without spines. The leaf sheath is slightly truncate to shortly auricled, with 4-10 spine cells on each side.

Our observations: Inlay Lake, Pekon Lake, Indawgyi Lake, Nga Laik Dam, Pyu Kan Lake, Ku Le Inn, Sunye In Tank, Kyetmauk Taung Dam



The illustration of the teeth on the submerged leaf (left) and the shape of the leaf sheath (right) (from Triest 1988).

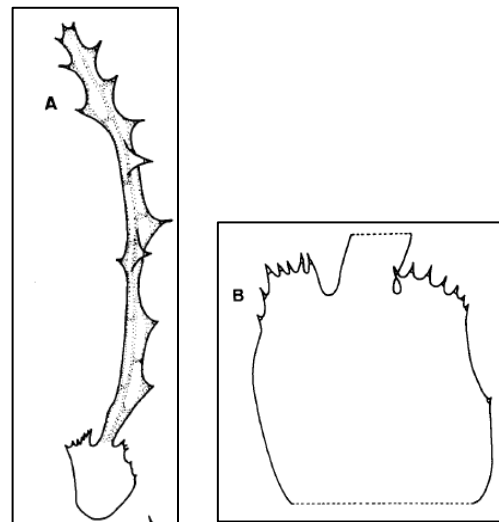


Similar species: *N. indica* can be separated from *N. tenuis* because of the leaves with large teeth and on the leaf sheath (*N. tenuis*: leaf sheath rounded or sloping). *N. indica* can also be confused with *N. graminea*.

Najas minor

Short description: *Najas minor* is a submerged species. The stem is unarmed (i.e., without claws, thorns, scales etc.) and less than 0.5 mm in diameter. The species has a bushy appearance because of the curved and closely packed leaves. The margin of the leaves is serrulate with conspicuous spiny teeth on small or broad triangular excrescences, also the midrib occasionally has spiny teeth. The leaf sheath is truncate/auriculate, with (3)8-13 spine cells on each side but none on the inner edge.

Our observations: Indawgyi Lake, Meiktila Lakes (north and south), Moeyingyi Reservoir, Pyu Kan Lake



The Illustration of the teeth on the submerged leaf (A) and the shape of the leaf sheath (B) (from Triest 1988).

Similar species: *Najas indica*, *N. tenuis*

Nechamandra alternifolia

Short description: Stem greatly elongated, irregularly branched, with long internodes. Leaves are alternate and sheathed at base. The leaf blade is elongate with parallel veins and without a prominent midrib, the margins minutely serrated. Flowers unisexual and axillary. Female flowers are borne on elongate pedicel-like stalks and opening at the water surface. Male flowers are very small and numerous, abscising from small spathes and opening on the water surface. The stem and leaves feel “slippery”.

Our observations: Inlay Lake, Pekon Lake



Similar species: none

Ottelia alismoides

Short description: *Ottelia alismoides* was found only with submerged leaves and flowering above the water. We have included the species among the elongated submerged species, however that can be debated, it may also belong to the isoetids since the leaves form a rosette on the bottom. It may also appear with (partly) floating leaves. The leaves are usually lanceolate to widely ovate with a distinct midrib and 2-10 longitudinal veins. The flower has an elongate peduncle, and the fruit is surrounded by a distinct membranous spathe with 3 or more wings.

Our observations: Inlay Lake, Pekon Lake, Moeyingyi Reservoir



Similar species: *Ottelia cordata*. Also similar to *O. ovalifolia*, however, this is a native species in New Zealand and Australia and has not been recorded in Myanmar/SE Asia.

Ottelia cordata

Short description: Similar to *Ottelia alismoides*, *Ottelia cordata* is here included among the elongated submerged species, however that can be debated, it may also belong to the isoetids since the leaves form a rosette on the bottom or considered a floating-leaved species. The species appears with both submerged and floating leaves in Myanmar. The submerged leaves (juvenile leaves) are linear, up to 70 cm or more long and up to 5 cm wide. The floating leaves (mature leaves) are cordate, thick and leathery. The species has both female and male flowers. The female flower has a very hard and thick spathe, usually covered by warts and/or spines. The male spathes are softer and thinner, and wider. Male flowers are numerous in each spathe, while only one flower appears in the female spathe.

Our observations: Meiktila Lakes (north and south), Khu Le inn

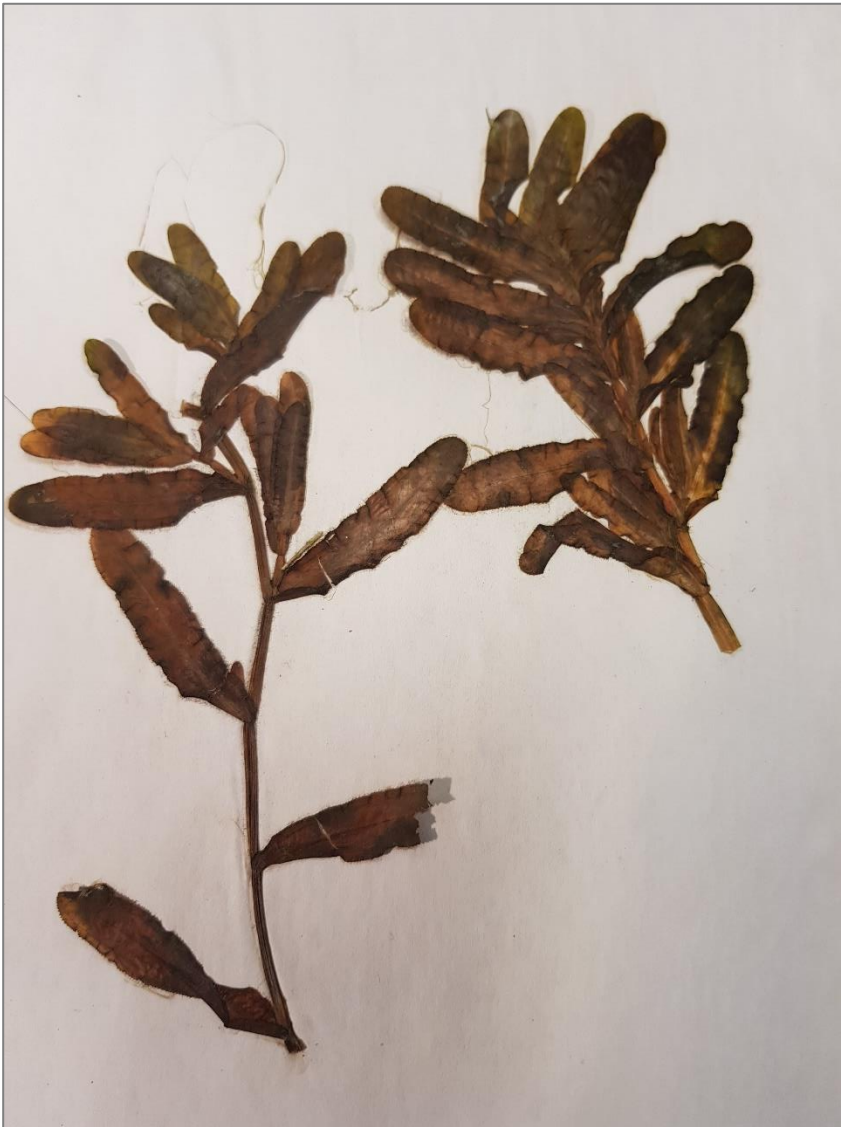


Similar species: *Ottelia alismoides*.

Potamogeton crispus

Short description: *Potamogeton crispus* is a submerged species, and has only submerged leaves, floating leaves are absent. The stems can be up to 1.5 m long, often unbranched and compressed. Stiff axillary turions can appear. Submerged leaves are sessile, 5-9(13) times as long as wide, with bright green, olive green or brownish green colour, often with a reddish tinge especially along the midrib. The apex is obtuse or acute. The margins are serrated and especially the upper leaves are strongly undulate.

Our observations: Inlay Lake, Khu Le Inn



Similar species: other broad-leaved *Potamogeton*-species

Potamogeton lucens

Short description: *Potamogeton lucens* is a submerged species, and has only submerged leaves, floating leaves are absent. The stems are robust and can be several metres long. The submerged leaves are 3-6 times as long as wide, usually rather glossy green colour, gradually or rather abruptly narrowed to the petiole. The apex of the leaves is rounded to acuminate, and always at least mucronate. The petiole is short, 1-12 mm long. The leaves are denticulate and minutely undulate at the margins. The midrib is prominent and leaves in the lower part of the stem can be reduced or partially reduced to phyllodes (i.e., reduced to the midrib). The stipules are open and translucent, very persistent, with 2 of the veins forming conspicuous green partly winged ribs. Turions are absent. The peduncles are very robust and broader than the stem.

Our observations: Inlay Lake, Pekon lake



Similar species:

P. lucens can be confused with other broad-leaved *Potamogeton*-species, e.g., *P. nododus* and *P. wrightii*. They can be separated based on submerged leaves and stipules. *P. lucens* does not have floating leaves, which the other two have.

Potamogeton nodosus

Short description: *Potamogeton nodosus* is a submerged species, with both submerged and floating leaves. The stem is usually simple or occasionally sparsely branched. The submerged leaves are 5-9 times as long as wide, with 11-21 veins, and have narrow to broad rows of lacunae bordering the midrib. They are minutely denticulate at margins, narrowly cuneate at base and acute at apex. The petiole is 0.2-1.5 the length of the leaf. Floating leaves are present, rarely absent, 2.0-4.5 times long as wide, narrowly cuneate to rounded at base, obtuse to broadly acute at apex.

Our observations: Inlay Lake, Sakar Inn, Indawgyi Lake, Meiktila lakes (north and south), Nga Laik Dam, Kyetmauk Dam



Similar species: *P. nodosus* is one of the most polymorphic *Potamogeton*-species, showing several distinct morphotypes as well as an extreme phenotypic plasticity throughout its range. It is especially difficult to separate from *P. distinctus* (which has an E. Asian distribution) and *P. wrightii*. Because transitional plants between *P. nodosus* and *P. distinctus* are sometimes found, they may, in the future, be regarded as geographical sub-species (Wiegleb 1990).

Potamogeton wrightii

Short description: *Potamogeton wrightii* is a submerged species, mainly with submerged leaves, however floating and intermediate leaves are sometimes present. Submerged leaves are 4-10 times as long as wide, bright green to yellow-green, 9-13 veined, with narrow rows of lacunae bordering the midrib, minutely denticulate at margins, mucronate at apex; the petioles are 0,1-1,0 times as long as the lamina. The lowest leaves are often reduced to phyllodes. The stipules are axillary, convolute, 25-85 mm long, translucent, and persistent. The peduncles are slightly thicker than the stem. Turions do not develop.

Our observations: Inlay Lake, Indawgyi Lake (all *P. cf. wrightii*)



Similar species:

P. wrightii can be confused with other broad-leaved *Potamogeton*-species, e.g., *P. lucens* and *P. nodosus*. They can be separated based on submerged leaves and stipules.

Stuckenia pectinata

Short description: *Stuckenia pectinata* is a submerged, thread-like plant. The plant is branched mainly in the upper part of the stem, creating fan-like aggregations of leaves. The leaves are 2-15 cm long and 1 mm wide with pointed tips and 1 vein (sometimes 3). Sheaths (stipules) are 2-5 cm long. The flowers appear in 2-7 whorls, which usually float horizontally just beneath the water. The species produces tubers from rhizome tips.

Our observations: Inlay Lake, Meiktila Lake north



Similar species: *Stuckenia filiformis* and *S. vaginata*, and *Ruppia cirrhosa* and *R. maritima*.

Utricularia aurea

Short description: *Utricularia aurea* (= *U. flexulosa*) is a free-floating submerged plant. The stolon (plant) can be up to 1 m long, branched, glabrous. Rhizoids are usually present at the base of the inflorescence stalk, either short and linear or elongated and inflated (as in the photos), bearing leaf-like branches. The plant has numerous leaves, divided into 3-5 primary filiform and forked segments. The inflorescence stalk is erect and emergent, and scales are absent. Corolla is yellow; with reddish-brown veins, upper lip ovate, obtuse to retuse at apex, lower lip more or less obovate, undulate at apex; spur more or less equal to lower lip in length.

Our observations: Inlay Lake, Pekon Lake, Indawgyi Lake, Moeyingyi Reservoir



Similar species: The genus *Utricularia* is taxonomically complex, and many taxa rarely flower. All species bear bladder-like animal traps, and the *Utricularia*-species can be separated from other species by these bladders. The determination of the *Utricularia*-species is however difficult, especially specimens without flowers. *U. aurea* can be confused with the other *Utricularia*-species, e.g., *U. australis* and *U. stellaris*.

Utricularia australis

Short description: *Utricularia australis* is a free-floating submerged plant. The stolon can be up to 2 m long, branched. Rhizoids are usually present, few, filiform, bearing sort, forked branches. The leaves are divided into ± 2 equal segments, forked. Inflorescence stalk weakly erect, emergent, at first straight later becoming flexuous. 1-3 scales present at the inflorescence stalk. Flowers 4-10, the axis initially short, becoming elongated and decurved in fruit. Petals yellow with the basal swollen part of the lower lip much darker and with reddish-brown lines and spots. Upper lip very broadly ovate, apex retuse, lower lip with a base with a very prominent swelling.

Our observations: Inlay Lake, Sakar Inn (*Utricularia* cf. *australis*), Sunye In Tank, Wethtigan Lake



Similar species: The genus *Utricularia* is taxonomically complex, and many taxa rarely flower. The *Utricularia*-species can be separated from other species by the bladders. The determination of the *Utricularia*-species is however difficult, especially specimens without flowers. *U. australis* can be confused with the other *Utricularia*-species, e.g., *U. aurea* and *U. stellaris*.

Utricularia gibba

Short description: *Utricularia gibba* is a free-floating submerged plant. Rhizoids absent or filiform, sometimes stolon-like. Stolons are usually numerous, much branched and often mat forming, up to 20 cm or longer. The leaves are numerous, with 2 primary segments, and sparsely forked. Inflorescence stalk is erect and emergent (or sometimes submerged with cleistogamous flowers), with 1-2 scales at or near the middle of the stalk. Usually 2-6 yellow flowers, often with reddish-brown veins. Upper lip is broadly ovate to almost circular, somewhat 3-lobed. The lower lip is smaller, circular to transversely elliptical with a prominent, rounded, 2-lobed swelling and rounded apex.

Our observations: Indawgyi Lake (*Utricularia cf gibba*)



Similar species: The genus *Utricularia* is taxonomically complex, and many taxa rarely flower. The *Utricularia*-species can be separated from other species by the bladders. The determination of the *Utricularia*-species is however difficult, especially the specimens without flowers.

Utricularia punctata

Short description: *Utricularia punctata* is a free-floating submerged plant. The stolon is filiform and branched with numerous leaves, which are divided from near base into 2 or 3 primary segments, and further divided into numerous segments. The inflorescence stalk is erect, with 5-10 flowers. The calyx lips are orbicular, lower lobe slightly smaller, and upper lip with rounded apex. Corolla is lilac, violet, or white, with a yellow blotch at base of lower lip, and base with a prominent 2-lobed swelling. Ellipsoid floats at the basis of the inflorescence's pedicel.

Our observations: Moeyingyi reservoir



Photo upper left: from <http://cpphotofinder.com/utricularia-punctata-730.html>.

Similar species: The genus *Utricularia* is taxonomically complex, and many taxa rarely flower. The *Utricularia*-species can be separated from other species by the bladders. The determination of the *Utricularia*-species is however difficult, especially specimens without flowers.

Vallisneria spiralis

Short description: *Vallisneria spiralis* is a submerged species, with only submerged leaves. The stems are elongated, mostly developing stolons or runners. The plant is rooted or anchored in sediment, and all leaves arise from a basal rosette at the sediment surface. The long strap-like leaves can vary in length and be more than 2 m long in deeper water. The margins of the leaves usually have unicellular spines. Inflorescence axillary. The male flowers are numerous and free-floating, while the female flowers have a spiral peduncle.

Our observations: Indawgyi Lake, Meiktila Lake south, Khu Le Inn



Similar species: none in freshwater but similar to *Zostera* spp. in marine areas.

NYMPHAEIDS (floating-leaved species)

Euryale ferox

Short description: *Euryale ferox* is a floating-leaved species with very large floating leaves, often more than 1 m in diameter. The petiole is densely prickly, and the mature leaves have spines on both surfaces. The flowers are submerged or at the surface. The petals are blue to violet or red, to inner white. The fruit is dark purple and densely prickly. The species is extensively cultivated.

Our observations: Indawgyi Lake



Similar species: No similar species.

Nelumbo nucifera

Short description: *Nelumbo nucifera* is a floating-leaved species with circulate floating leaves, 10-100 cm (or more) in diameter. When mature, the leaves are raised above the surface. The petiole has numerous spines. The flowers are 8-20 (4) cm in diameter, and the colour is white to pink or red. The fruit has a characteristic head of very hard-coated nutlets. The seedpod is very distinctive.

Our observations: Inlay Lake (pink coloured), Meiktila Lake North (white), Moeyingyi Reservoir (pink), Sunye Tank (pink), Wethtigan Lake (pink)



Similar species: *Nelumbo nucifera* can be confused with the similar species *N. lutea*, however the latter has yellow flowers and is native to North America. The distinctive seedpod easily separate *N. nucifera* from the *Nymphaea*-species.



Nymphaea cyanea

Short description: *Nymphaea cyanea* is a floating-leaved species. The leaves are elliptic to ovate, with rounded or retuse apex. The midrib is flat above and prominent below, reddish-purple with brown spots beneath; and the margin is crenate or repand. The petioles are terete, brown, and glabrous. Flowers are blue and borne well above the water surface. There are 4 ovate-lanceolate sepals, with obtuse or acute apex, green outside and glabrous or papillate above. The petals are 12–18, elliptic-lanceolate to lanceolate, pale, or deep blue, obtuse or subacute. The stamens are yellow with blue appendages.

Our observations: Meiktila Lake North, Moeyingyi Reservoir



See the different sepals in *N. pubescens* (left) and *N. cyanea* (right)

Similar species: other *Nymphaea*-species.

Nymphaea nouchali

Short description: *Nymphaea nouchali* (= *N. stellata*) is a floating-leaved species. The leaves are elliptic to ovate, with rounded or retuse apex. The midrib is flat above and prominent and angular below, above green, and sometimes blotched purple, below reddish purple, brown spotted, and the margin is repand to entire, irregularly sinuate with broad obtuse teeth. The petioles are terete, thick and glabrous. Flowers are borne above the water surface. There are 4 lanceolate to ovate-lanceolate sepals, with obtuse or acute apex, green with dark purplish streaks outside, glabrous or papillate. The petals are 8–12, elliptic-lanceolate to oblong-lanceolate, white, or bluish with white tinge. The stamens are yellow.

Our observations: Inlay Lake, Sakar Inn, Moeyingyi Reservoir, Sunye In Tank



Synonyms: *N. stellata* and *N. nouchali* are considered as synonyms (e.g., La-Ongsri et al. 2009, Cook 1996, Margua Raja et al 2010). However, in some literature and books they have been differentiated as two species.

Similar species: other *Nymphaea*-species.

Nymphaea pubescens

Short description: *Nymphaea pubescens* is a floating-leaved species. The leaves are broadly ovate to slightly orbicular, dark green above, purplish green with purple spots beneath, apex round, and with dentate and somewhat crispate margins. The petioles are terete, green, or reddish-brown, pubescent. Flowers are white and borne well above the water. There are 4 sepals, oblanceolate to ovate-lanceolate, obtuse, or subacute, green or portions tinged with purple toward outside, below with 5–9 prominent white veins, pubescent or glabrous. The 8–30 petals are oblanceolate, obtuse, or acute, white, the outer portion tinged with red. The stamens are yellow.

Our observations: Inlay Lake, Indawgyi Lake, Moeyingyi Reservoir, Sunye In Tank



Similar species: Other *Nymphaea*-species.

Nymphaea rubra

Short description: *Nymphaea rubra* is a floating-leaved species. The leaves are orbicular, dark-reddish both above and below, becoming greenish above with age, below pubescent. The margin is dentate and more or less wavy, with sharp teeth. The petioles are terete, green, or reddish-brown, pubescent. The flowers are deep red, laying on the water surface. There are 4 sepals, oblong to lanceolate, purplish red, with about 7 nerves. The 16-25 petals are elliptic to oblanceolate, deep red. The stamens are orange or cinnabar-red, becoming brownish.

Observed in: Moeyingyi Reservoir

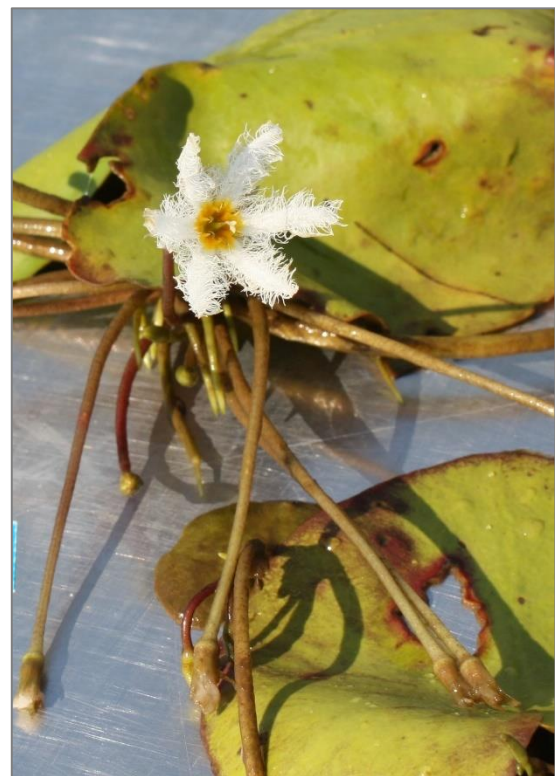
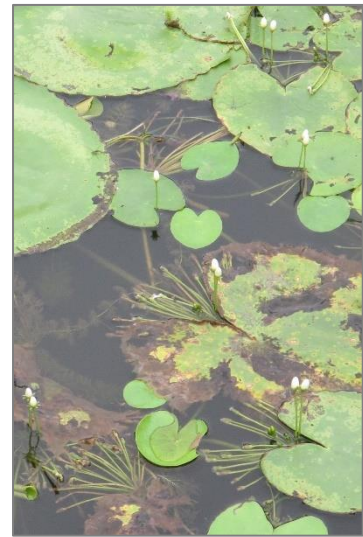


Similar species: Other *Nymphaea*-species.

Nymphoides indica

Short description: *Nymphoides indica* is a floating-leaved species. All leaves are floating and associated with inflorescence. The leaves are oval-orbicular to orbicular, glossy green above, pale and gland-dotted below, and rather thick and leathery. The flowering stem is single-noded (flowers arising from the end of the petiole). The flowers appear in umbellate clusters of 15-35, born below a floating leaf. The corolla is white with a yellow throat, densely covered with long, white hairs within. The petals are linear-lanceolate to oblong-lanceolate and up to 17 mm long.

Our observations: Inlay Lake, Indawgyi Lake, Moeyingyi Reservoir

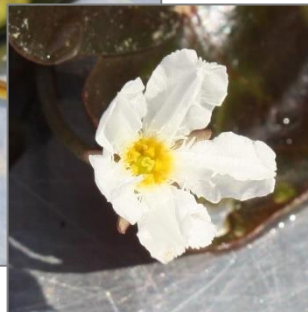
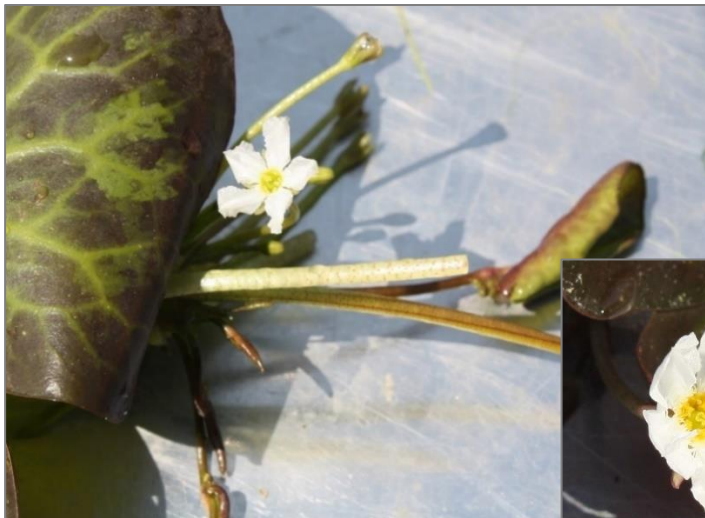
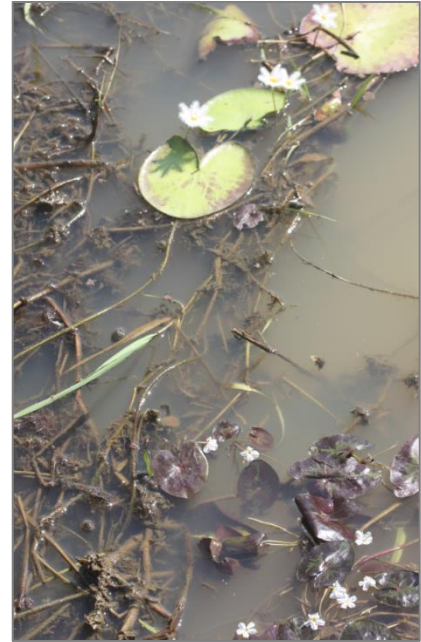


Similar species: other *Nymphoides*-species with white flowers.

Nymphoides hydrophylla

Short description: *Nymphoides hydrophylla* (= *N. cristata*) is a floating-leaved species. All leaves are floating and associated with the inflorescence. The leaves are oval-orbicular to orbicular, green sometimes with purplish blotches. The flowering stem is single-noded (flowers arising from the end of the petiole). The flowers appear in umbellate clusters of 10-20, or more, born below a floating leaf. The corolla is white with or without a yellow throat. The 5 (6) petals are oval-oblong, 7-10 mm long, pure white with a longitudinal crest along the centre of the inner surface and with crest-like undulate margins. The apex of the petal is obtuse. The petals are without hairs but with some hairy glands near the base.

Our observations: Sakar Inn, Pekon Lake, Indawgyi Lake, Moeyingyi Reservoir



Upper right picture shows the different size of *N. indica* (top) and *N. hydrophylla* (down)

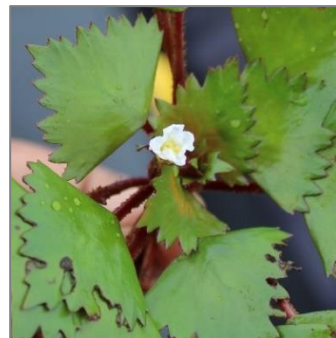
Similar species: other *Nymphoides*-species with white flowers, especially *N. cordata* which, however, is a North American species (see gbif.org)

Trapa natans

Short description: *Trapa natans* is a floating-leaved species, with both floating and submerged leaves. The submerged leaves are sessile, linear, pinnately branched, and fall off early. Adventive roots develop from the leaf scars. The floating leaves appear in terminal rosettes. The blades are rhombic with toothed margins. The petiole often has an ellipsoidal and spongy swelling. The flowers are small with 4 white petals. The fruit is large and woody or bony with 2 large and 2 small spines.

According to Hummel & Kiviat (2004), two varieties of *Trapa natans* are generally recognized; *T. natans* var. *natans*, which has a 4-horned fruit (in Eurasia, Africa, and the northeastern United States) and *T. natans* var. *bispinosa*, which produces fruit with 2 stout curved horns (in China, Japan, India, and Southeast Asia). The species is widely cultivated in Myanmar.

Our observations: Indawgyi Lake, Moeyingyi Reservoir, Khu Le Inn



Similar species: none

LEMNIDS (free-floating species)

Azolla pinnata

Short description: *Azolla pinnata* is a fern, i.e., reproduces by spores instead of seeds. It is a small free-floating species. The stem is alternately branched, the branches are arranged pinnately or bipinnately, and the whole plant appearing deltoid or trapezoid in outline. The plant is up to 4 cm long but usually less. The leaves alternate, often overlapping towards the tips of the branches. Each leaf is divided into 2 lobes. The upper lobe is thick, green, and usually somewhat reddish, borne above the water. The *Azolla* species form a symbiotic relationship with the cyanobacterium *Anabaena azollae*, which fixes nitrogen and grows in a cavity in the dorsal lobe of the fern's leaves.

Our observations: Indawgyi Lake, Moeyingyi Reservoir, Sunye In Tank



Similar species: other *Azolla*-species, however none are known to the authors in this region.

Pontederia crassipes

Short description: *Pontederia crassipes* (old name: *Eichorinia crassipes*) is a free-floating species. The stems are floating, stoloniferous or creeping. The leaves of adult plants are emergent, and have an up to 30 cm long petiole, which often has a bulbous swelling below the blade. The leaves are thick, waxy, rounded, and glossy, and rise well above the water surface on stalks. The inflorescence is erect, carrying 8-15 flowers. The flowers have 6 petals and are purplish blue or lavender to pinkish. The species may form dense floating mats and is one of the world's worst invasive weeds. It is invasive in Myanmar.

Our observations: Inlay Lake, Sakar Inn, Indawgyi Lake, Moeyingyi Reservoir, Thaug Taman Lake (north), Kantawgyi Lake (south), Sunye In Tank, Pauk In, Wethtigan Lake



Similar species: none

Hydrocharis dubia

Short description: *Hydrocharis dubia* is a free-floating species. The small floating leaves are cordate or orbicular, with a rounded apex. The abaxial surface (below) of the leaves usually has a pad of honeycomb-like aerenchymatous tissue with numerous stomata. The species has both female and male flowers. The male flowers are small with yellow petals, while female flowers are larger with 3 white petals, yellow at the base. The fruits are berrylike. The leaves are small and without flowers the species may be difficult to discover among other free-floating and floating-leaved species. *H. dubia* is distributed in southeast and east Asia, Indonesia, and northern Australia. Our record in Indawgyi Lake seems to be the same locality shown in Cook & Lüönd (1982).

Our observations: Indawgyi Lake



Similar species: *Hydrocharis morsus-ranae* (distributed in Europe, Canada, and scattered in Western Asia).

Lemna minor

Short description: *Lemna minor* is a free-floating species, and one of the smallest *Lemna*-species. The leaves are almost symmetrical, elliptical to ovate-obovate or oblong, and flat on both surfaces. They are usually green on both sides, solitary or several joined together by a hyaline stipe. Only one root from each leaf.

Our observations: Indawgyi Lake, Meiktila Lake south, Taung Taman Lake (north), Kantawgyi Lake (south), Wethtigan Lake



Similar species: *Spirodela polyrrhiza*, *Wolffia* spp., *Landolva punctata*, other *Lemna* species.

Lemna trisulca

Short description: *Lemna trisulca* is a small, free-floating species. Unlike other *Lemna* spp, *L. trisulca* grows submerged beneath the water surface, except when flowering or fruiting. The leaves are narrowly ovate, with margins toothed towards the tip. The upper surface without papillae, green or reddish colour, with (1) 3 veins. The leaves often form branched chains.

Our observations: Inlay Lake



picture from: <http://pixgood.com/lemna-trisulca.html>

Similar species: *Spirodela polyrrhiza*, *Wolffia* spp., *Landolva punctata*, other *Lemna* species.

Pistia stratiotes

Short description: *Pistia stratiotes* is a free-floating species. The sub-sessile leaves (very short petiole) form rosettes with numerous roots. The leaves are obovate to ovate-cuneate, pale-green, and densely pubescent on both surfaces. The inflorescence is axillary and solitary. *P. stratiotes* reproduces by vegetative offshoots that are connected to the mother plant by stolons, as well as by the production of seeds.

Our observations: Inlay Lake, Indawgyi Lake, Meiktila Lake south, Moeyingyi Reservoir, Kantawgyi Lake (south), Sunye In Tank, Pauk In, Wethtigan Lake



Similar species: none

Salvinia cucullata

Short description: *Salvinia cucullata* is a fern, i.e., reproduces by spores instead of seeds. It is a free-floating species. The leaf sides are curved upwardly and inwardly to meet the edges. The upper surface of the floating leaves bears simple hairs, scattered, without any obvious pattern on the surface.

Our observations: Inlay Lake, Sakar Inn, Indawgyi Lake, Moeyingyi Reservoir



Similar species: other *Salvinia*-species.

Salvinia auriculata

Short description: *Salvinia auriculata* is a fern, i.e., reproduces by spores instead of seeds. It is a free-floating species. The floating leaves are light green to medium green, with brownish edges when mature and a distinctive fold in the centre. The leaf sides are slightly curved upwards. The hairs on the adaxial (upper) surface of the floating leaves are arranged in tufts of 3 or 4, the tufts are then clearly arranged in rows along the surface.

Observed in: Moeyingyi Reservoir

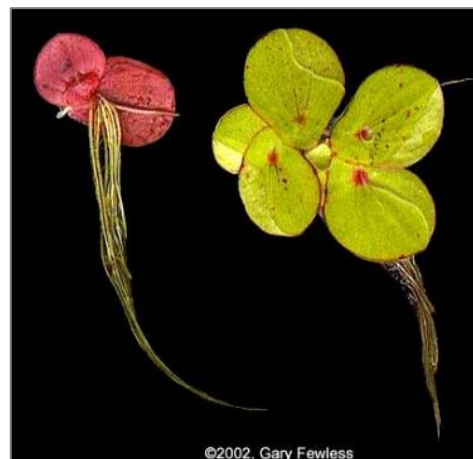
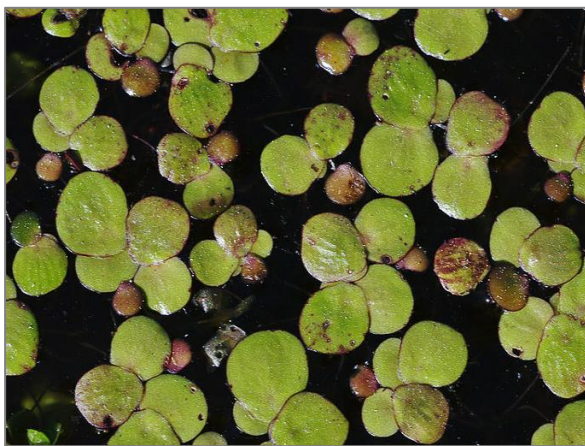


Similar species: other *Salvinia*-species, mainly *S. natans*

Spirodela polyrhiza

Short description: *Spirodela polyrhiza* is a free-floating species. Though very small, it is the largest of the duckweeds. The species has ovate to orbicular leaves, 1-1,5 times as long as wide, with rounded or sometimes pointed at the tip. 3-4 leaves are usually connected. The upper leaf surface usually has a red fleck above the node. The abaxial leaf surface (below) is dark red. Several roots grow from each leaf.

Our observations: Inlay Lake, Indawgyi Lake, Meiktila Lake south, Taung Taman Lake (north), Kantawgyi Lake (south), Khu Le Inn, Sunye In Tank



The lowest pictures from: <http://it.wikipedia.org> and <https://www.uwgb.edu/>

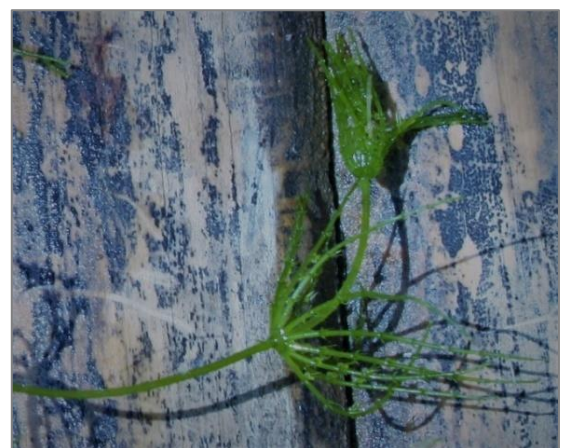
Similar species: *Wolffia* spp., *Landolfa punctata*, *Lemna* species.

CHAROPHYTES

Chara zeylandica and *Chara fibrosa*

Short description: The *Charophytes* are a group of freshwater green algae, however with a growth form like the elodeids. All Charophytes are completely submerged and can appear at several metres depth in lakes, depending on the light conditions. The species have a long central axis (stem) and short multicellular nodes where whorls of branchlets originate. The *Charophyte*-group consists of 6 genera (Wood and Imahori 1964), where *Chara* and *Nitella* are the far most species rich genera. All charophytes specimens we collected in the Myanmar lakes belong to *Chara zeylandica* (C.z.) and *C. fibrosa* (C.f.).

Our observations (species abbreviations in brackets): Inlay Lake (C.z.), Meiktila Lakes north and south (C.z.), Yezin Dam (C.f.), Nga Laik Dam (C.z.), Kyetmauk Taung Dam (C.z & C.f.), Wethtigan Lake (C.z. & C.f.)



Similar species: other *Chara* species, and *Nitella* species.

5 References

- Allen, D.J. 2014. *Potamogeton trichoides*. The IUCN Red List of Threatened Species 2014: e.T164357A43126268:
- Allen, D.J., Smith, K.G. and Darwall, W.R.T. (Compilers) 2012. The Status and Distribution of Freshwater Biodiversity in Indo-Burma. Cambridge, UK and Gland, Switzerland: IUCN. x+158pp+4pp cover.
- Ballot, A., Mjelde, M., Eriksen, T.E., Håll, J., Gundersen, C.B., Veiteberg Braaten, H.F. 2023. Integrated Water Resources Management in Myanmar Ecology of Rivers, Lakes, and Reservoirs. NIVA-report 7855-2023. ISBN 978-82-577-7591-9.
- Cook, C. D. K. 1996. Aquatic and Wetland Plants of India: A reference book and identification manual for the vascular plants found in permanent or seasonal fresh water in the subcontinent of India south of the Himalayas. Oxford University Press, Oxford.
- Cook, C.D.K. and Lüönd, R., 1982. A revision of the genus *Hydrocharis* (Hydrocharitaceae). *Aquat. Bot.*, 14: 177--204.
- Davies, J., Sebastian, A.C., Chan, S. 2004. A wetland inventory for Myanmar. Ministry of Environment Japan.
- EU 2000. Directive 2000/60/EC OF THE European Parliament and of the Council of 23 October 2000: Establishing a framework for Community action in the field of water policy. Official Journal of the European Communities L 327:1-72.
- Hellsten, S., Willby, N., Ecke, F., Mjelde, M., Phillips, G., Tierney, D. 2014. Northern Lake Macrophytes. Ecological assessment methods. Water Framework Directive, Intercalibration Technical Report. JRC. Report EUR 26513 EN. Ed. S. Poikane.
- Hummel, M & Kiviati, E. 2004. Review of World Literature on Water Chestnut with Implications for Management in North America. *J. Aquat. Plant Manage* 42: 17-28.
- Ito, Y., Barfod, A.S. 2014. An updated checklist of aquatic plants of Myanmar and Thailand. *Biodiversity Data Journal* 2: e1019. doi: 10.3897/BDJ.2.e1019.
- Ito, Y., Ohi-Toma, T., Tanaka, N., Tanaka, N., Murata, J. 2014. New and Noteworthy Plant Collections from Myanmar (8) *Lemna trisulca* (Araceae), *Blyxa aubertii* var. *echinosperma* and *Najas tenuis* (Hydrocharitaceae). *Acta Phytotax. Geobot.* 65(2): 89-97.
- Jonsell, B. & Karlsson, T. 2010. *Flora Nordica*. Vol 6: Thymelaeaceae to Apiaceae. The Swedish Museum of Natural History, Stockholm.
- Kress, W. J. et al. (eds.) 2003. A Checklist of the Trees, Shrubs, Herbs, and Climbers of Myanmar. Contributions from the United States National Herbarium. Volume 45: 1-590. (<http://botany.si.edu/myanmar/checklistNames.cfm>)

Lansdown, R.V. 2012. Box 7.4 Inlé Lake, Myanmar. In: Allen, D.J., Smith, K.G. and Darwall, W.R.T. (Compilers) 2012. The Status and Distribution of Freshwater Biodiversity in Indo-Burma. Cambridge, UK and Gland, Switzerland: IUCN. x+158pp+4pp cover.

La-Ongsri, W. 2008. Taxonomic revision and ethnobotany of the families Nelumbonaceae and Nymphaeaceae in Thailand. PhD. Thesis, Chiang Mai University, Thailand.

La-Ongsri, W., Trisonthi, C., Balslev, H. 2009. A synopsis of Thai Nymphaeacea. *Nordic Journal of Botany* 27: 97-114.

Margua Raja, M.K, Sethiva, N.K., Mishra, S.H. 2010. A comprehensive review on *Nymphaea stellata*: A traditionally used bitter. *J Adv Pharm Technol Res.* 2010 Jul-Sep; 1(3): 311–319. doi: [10.4103/0110-5558.72424](https://doi.org/10.4103/0110-5558.72424)

Mjelde, M., Swe, T., Langangen, A., Ballot, A. 2020. A contribution to the knowledge of Charophytes in Myanmar; morphological and genetic identification and ecology notes. *Botany Letters* DOI: 10.1080/23818107.2020.1847189.

Nath, D.M. 1960. Botanical Survey of the southern Shan States. University of Rangoon, Burma.

Pal, B. 1932. Burmese charophyta. *Bot J Linn Soc.* 49 (327):47–92.

Preston, C.D. 1995. Pondweeds of Great Britain and Ireland. BSBI Handbook No 8. Botanical Society of the British Isle, London.

Tanaka, N., Ito, Y., Aung, M.M, Tanaka, N. 2019. A field guide to aquatic plants of Myanmar. Natural history Publications (Borneo).

Triest, L. 1988. A revision of the genus *Najas* L. in the Old World. Koninklijke Academie voor Overzeese Wetenschappen. Verhandelingen in-8°, Nieuwe Reeks, Boek 22, afl. I, Brussel.

Wiegleb, G. 1990. A rescription of *Potamogeton distinctus* (Potamogetonaceae) including remarks on the taxonomic structure of the *P. nodus* group. *Pl. Syst. Evol.* 169: 245-259.

Wiegleb, G., Kaplan, Z. 1998. An account of the species *Potamogeton* L. (Potamogetonaceae). *Folia Geobotanica* 33. 241-316.

Wood R.D., & Imahori, K. 1965. A revision of the Characeae: Part-I. Monograph of the Characeae. New York, USA: Weinheim, Verlag Von, J. Cramer.

Yu, Dan, Wang Dong, Li Zhen-yu and A. M. Funston 2002. Taxonomic Revision of the Genus *Myriophyllum* (Haloragaceae) in China. *Rhodora* 104 (920): 396-421.

Yu, Ling-Fei; Yu, Dan 2009. Responses of the threatened aquatic plant *Ottelia alismoides* to water level fluctuations. *Fundamental and Applied Limnology/Archiv für Hydrobiologie* 174(4): 295-300.

Appendix A.

Results from our surveys of aquatic macrophytes in Myanmar are included in several reports and articles:

- Ballot, A., Mjelde, M., Eriksen, T.E., Håll, J., Gundersen, C.B., Veiteberg Braaten, H.F. 2023. Integrated Water Resources Management in Myanmar Ecology of Rivers, Lakes, and Reservoirs. NIVA-report 7855-2023. ISBN 978-82-577-7591-9.
- Ballot, A., Mjelde, M., Swe, T. 2018. Integrated Water Resources Management in Myanmar. Assessing ecological status in Inlay Lake. NIVA-report 7301-2018.
- Ballot, A., Swe, T., Mjelde, M., Cerasino, L., Hostyeva, V., Miles, C.O. 2020. Cylindrospermopsin- and deoxycylindrospermopsin-producing *Raphidiopsis raciborskii* and microcystin-producing *Microcystis* spp. in Meiktila Lake, Myanmar. *Toxins* 12(4), 232.
- Mjelde, M., Ballot, A. 2016. Moeyingyi Reservoir, Myanmar. Aquatic macrophytes, phytoplankton and water chemistry. November 2015. NIVA-report 6975-2016.
- Mjelde, M., Ballot, A., Swe, T. 2018a. Conservation of biodiversity and improved management of protected areas in Myanmar. Aquatic macrophytes and phytoplankton in Indawgyi Lake. NIVA-report 7253-2018.
- Mjelde, M., Ballot, A., Swe, T., Eriksen, T.E., Nesheim, I., Aung, T.T. 2017. Integrated Water Resources Management in Myanmar. Water usage and introduction to water quality criteria for lakes and rivers in Myanmar. NIVA-report 7163-2017.
- Mjelde, M., Swe, T., Langangen, A., Ballot, A. 2020. A contribution to the knowledge of Charophytes in Myanmar; morphological and genetic identification and ecology notes. *Botany Letters* DOI: 10.1080/23818107.2020.1847189.
- Mjelde, M., Wathne, B.M. 2015. Report from: Introductory Study in Moeyingyi reservoir and Indawgyi Lake. NIVA, 15. June 2015.
- Swe, T. 2023. The Ecology of Phytoplankton with focus on Cyanobacteria and Aquatic Macrophytes in selected Lakes and Reservoirs of Myanmar. Forest Research Institute, Myanmar and University of South-Eastern Norway, Norway. PhD thesis, South-East University, Bø, Norway. February 2023.
- Swe, T., Lombardo, P., Ballot, A., Thrane, J-E., Sample, J., Eriksen, T. E., Mjelde, M. 2021a. The importance of aquatic macrophytes in a eutrophic tropical shallow lake. *Limnologica* 90, 125910.
- Swe, T., Miles, C.O., Cerasino, L., Mjelde, M., Kleiven, S., Ballot, A. 2021b. Diversity of cyanobacteria and cyanotoxins in Yezin Dam, Myanmar. *Limnologica* 90, 125901.

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