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Key to the determination of taxa within the family of *Lemnaceae*

by

Elias LANDOLT

The family of *Lemnaceae* (duckweeds) consists of minute, free-floating water plants that most frequently propagate vegetatively. Its distribution is worldwide, the center of origin being tropical and subtropical South America.

The duckweeds form a taxonomically isolated group. Only very few characters are suitable for delimitation of taxa; for this reason, it is sometimes difficult to distinguish between particular species without having observed living plants at various developmental stages. The determination within the groups of *Spirodela polyrrhiza*, *Lemna minor*, *L. perpusilla*, *Wolffiella oblonga* and *Wolffia arrhiza* frequently present great problems and the knowledge of species distribution is often helpful for identification purposes.

The key proposed below comprises two subfamilies, four genera and 35 species of the family.

1. Fronds with 1-20 roots and two lateral reproductive pouches; cristal cells present.

A. *Lemnoideae*

2. Fronds with 2-20 roots (rarely 1 root), with 5-16 nerves (rarely with 3 nerves); underneath with a small scalelike leaflet covering the base of the roots; pigment cells (small brownish points, visible only in dead fronds) and two kinds of cristal cells (raphids and druses) present.

I. *Spirodela* Schleiden

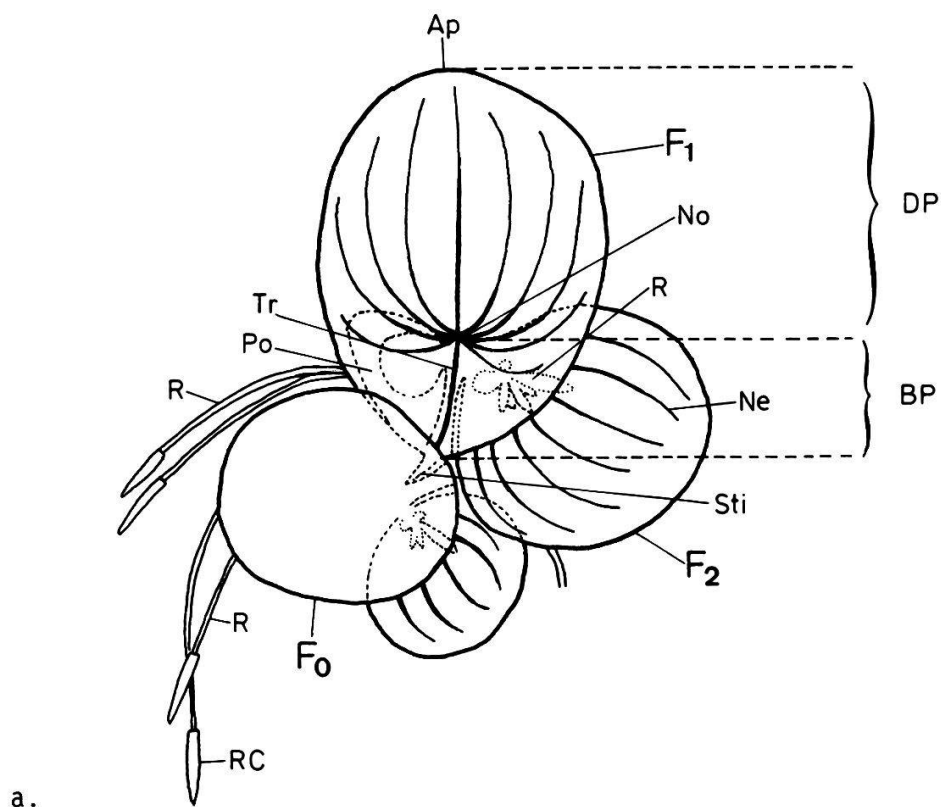
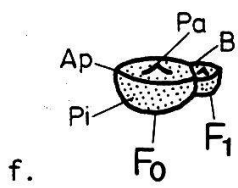
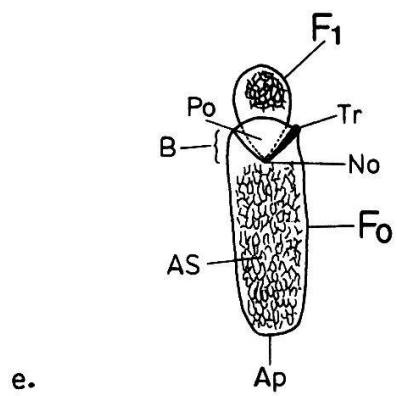
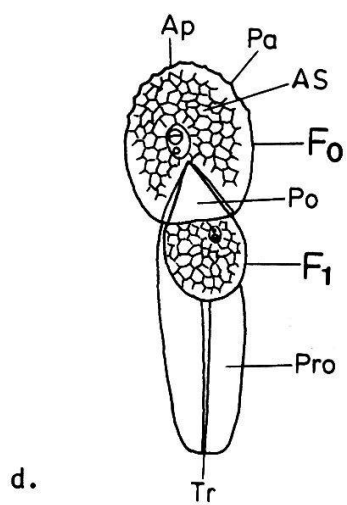
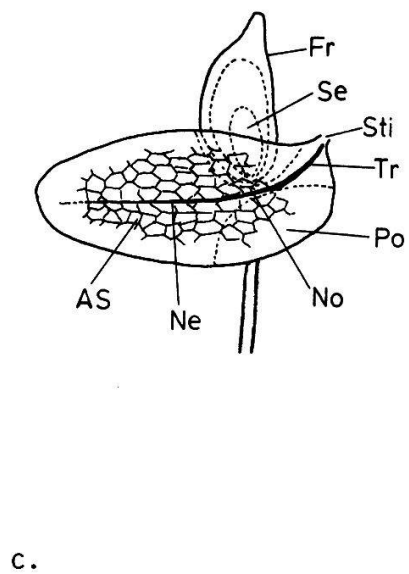
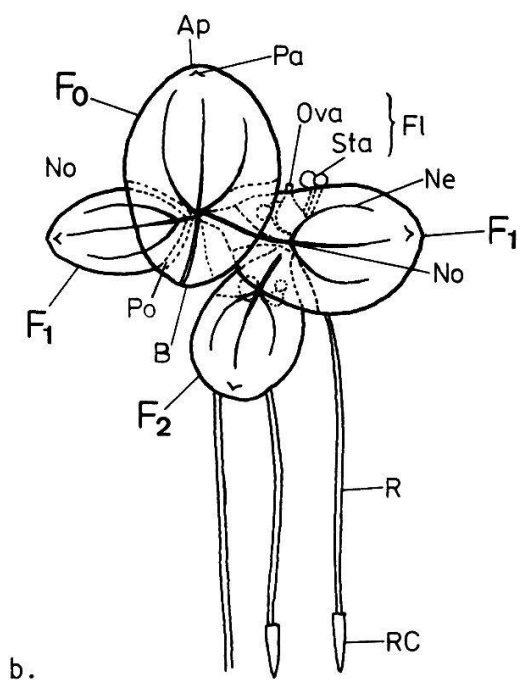


Fig. 1. Frond group of various *Lemnaceae* seen from above (after Hegelmaier 1868).

- | | |
|-------------------------------------|-------------------------------------|
| a. <i>Spirodela polyrrhiza</i> (x7) | b. <i>Lemna aequinoctialis</i> (x7) |
| c. <i>Lemna valdiviana</i> (x16) | d. <i>Wolffiella hyalina</i> (x7) |
| e. <i>Wolffiella oblonga</i> (x7) | f. <i>Wolffia brasiliensis</i> (x7) |

Ap	apex	Ne	nerve
AS	air space	No	node
B	base	Pa	papule
BP	basal part of the frond	Po	pouch
DP	distal part of the frond	Pro	prolongation
F ₀	mother frond	R	root
F ₁	daughter frond of the first generation	RC	root cap
F ₂	daughter frond of the second generation	Se	seed
F _l	flower	Sti	stipe connecting daughter frond and mother frond
Fr	fruit	Tr	track of elongated cells connecting stipe and node



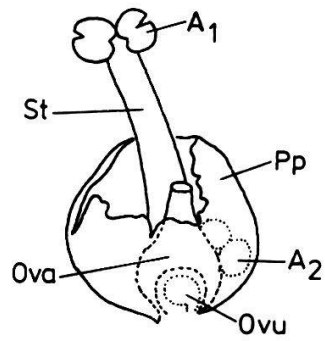


Fig. 2. Flower of *Lemna trisulca* (after Hegelmaier 1868) (x 18)

A ₁	anthers of the first stamen	Ova	ovarium
A ₂	anthers of the second stamen	Ovu	ovule
		Pp	prophyllum

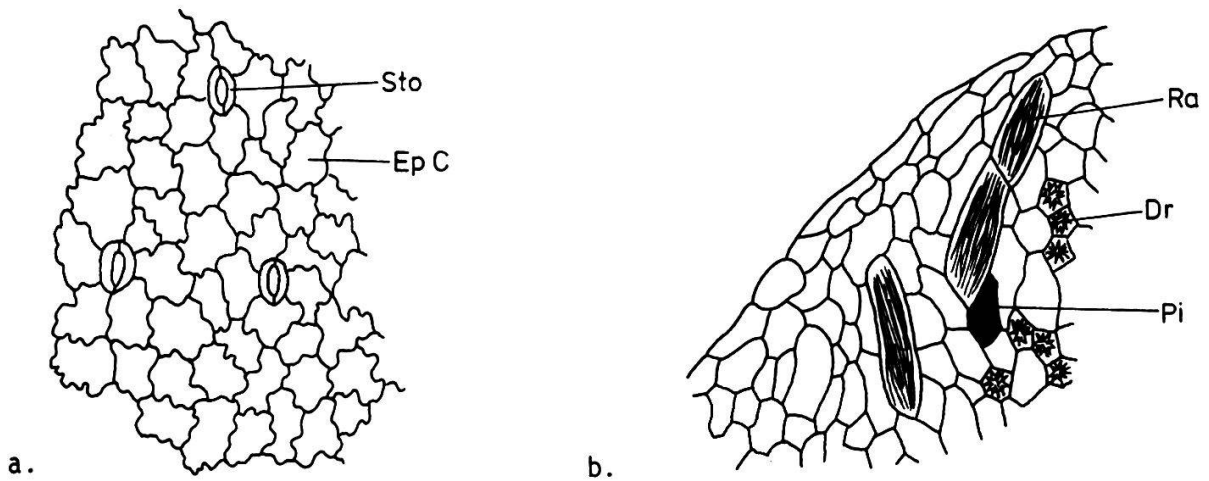


Fig. 3. Tissues of *Lemnaceae* (after Hegelmaier 1868) (x 180)

a. *Lemna aequinoctialis*: upper epidermis
 b. *Spirodela punctata* : leaf tissue

Dr	druses	Ra	raphids
Ep C	epidermis cells	Sto	stomata
Pi	pigment cells		

3. Fronds with 7-20 roots (rarely less in small specimens), with 7-16 nerves, 1 - 1½ times as long as wide; 1-5 roots perforating the scalelike leaflet (never all roots perforating).

Group of *S. polyrrhiza* (No. 1, 2, 3)

4. 2-5 roots perforating the scalelike leaflet; no turions present; never a red spot on surface of the frond above the node.
5. Fronds with mostly 11-20 roots; 3-5 roots perforating the scalelike leaflet; fronds mostly rounded at apex, 1 - 1⅓ times as long as wide, underneath often gibbous. South America.

1. *S. intermedia* W. Koch

- 5*. Fronds with mostly 7-11 roots; 2-3 roots perforating the scalelike leaflet; fronds mostly pointed at apex, 1⅓ - 1 2/3 as long as wide; never gibbous. Middle and South America.

2. *S. biperforata* W. Koch

- 4*. 1 root (very rarely 2 roots) perforating the scalelike leaflet; fronds forming under unfavourable conditions small circular to reniform, rootless, brownish turions; often with a red spot above the node. All Continents and many Islands.

3. *S. polyrrhiza* (L.) Schleid.

- 3*. Fronds with 2-7 roots (rarely 1 or 8-12 roots); with 3-7 nerves, 1½ - 2 times as long as wide; all roots perforating the scalelike leaflet. Milder regions of all Continents.

4. *S. punctata* (G.F.W. Meyer) Thompson
(*S. oligorrhiza* (Kurz) Hegelm., *S. pusilla* Hegelm.)

- 2*. Fronds with 1 root, with 1-5 (very rarely 7) nerves; the base of the root surrounded by a tubular sheath, not covered by a scalelike leaflet; no pigment cells (but often red coloured) and only one kind of crystal cells (raphids) present.

II. *Lemna* L.

6. Margin of fronds in the distal part denticulate; 3-50 fronds cohering together, often forming long and branched chains; fronds submerged (except when flowering or fruiting), narrowed to a green stalk at the base. Cool regions of North America, Eurasia, Africa and Australia.

5. *L. trisulca* L.

- 6*. Margin of fronds entire; fronds floating on the surface of the water or when submerged only 1-3 fronds cohering together, more or less rounded at the base, with a very small white joint often decaying; no green stalk present.

7. Fronds with 3-5 (rarely 7) nerves.

8. Fronds submerged (except when flowering or fruiting); sharply pointed or tapering in a long point at apex. Burma, Malaysia, Singapore.

6. *L. tenera* Kurz

- 8*. Fronds floating on the surface of the water, more or less rounded at apex.

9. Root sheath winged at the base; root tip sharply pointed; roots not longer than 3 cm; no anothocyanin present; ovule nearly orthotropous.

Group of *L. perpusilla* (No. 7, 8)

10. Seeds with 35-60 not very prominent ribs, whitish, not leaving fruit wall when ripening; fronds very often with 2-3 papules above the node. Eastern North America.

7. *L. perpusilla* Torrey

- 10*. Seeds with 8-22 prominent ribs, brownish, falling out of the fruit wall when ripening; fronds with only 1 prominent papule above the node. Warmer regions of the whole world.
8. *L. aequinoctialis* Welwitsch, (*L. angolensis* (Welwitsch) Hegelm., *L. paucicostata* Hegelm.)
- 9*. Root sheath not winged; root tip mostly rounded; roots often longer than 3 cm; fronds underneath often red coloured or with red spots on either side.
- Group of *L. minor* (No. 9, 10, 11, 12, 13, 14, 15)
11. Fronds with several papules of \pm equal size above the midline on the upper side; very often red coloured underneath; forming small obovate to circular, rootless, dark green to brown turions under unfavourable conditions which sink to the bottom of the water. Mostly continental climates of North America, Central and Eastern Asia.
9. *L. turionifera* Landolt
- 11*. Papules either missing or the one above the node and at apex bigger than the ones between; fronds rarely forming turions; if turion-like fronds are formed they have short roots and are slowly reproducing daughter fronds.
12. Fronds very often gibbous, with air spaces often larger than 0,3 mm, very often with 4-5 nerves; the nerves emerging from the same point at the node; if red underneath the redding beginning from the margin; ovules 1-6.
13. Fronds without prominent papule at apex (except for small fronds) wing of the fruit 0,1-0,2 mm wide. Mostly in regions of mediterranean climates: Europe, Western and Southern Asia, Africa, America.
10. *L. gibba* L.
- 13*. Fronds with a prominent papule at apex; wing of the fruit 0,05-0,1 mm wide. Southern Australia and New Zealand.
11. *L. disperma* Hegelm.
- 12*. Fronds flat, occasionally slightly gibbous; with air spaces smaller than 0,3 mm; rarely with more than 3 nerves; if with 4-5 nerves the outer nerves branching at the base of the inner ones; if red underneath the redding beginning from the node; only 1 ovule.
14. Papule at apex very prominent; fronds often red underneath.
15. Fronds $1\frac{1}{5}$ - $1\frac{2}{3}$ times as long as wide. Southeastern North America, Hawaii.
12. *L. obscura* (Austin) Daubs
- 15*. Fronds $1\frac{1}{2}$ - 2 times as long as wide. Ecuador.
13. *L. ecuadoriensis* Landolt
- 14*. Papule at apex not very prominent.
16. Fronds often red underneath, sometimes slightly gibbous. China, Korea, Japan.
14. *L. japonica* Landolt
- 16*. Fronds never red underneath, not gibbous. Cooler regions of Eurasia (except the East), Africa and North America; New Zealand; in Southern Australia probably introduced.
15. *L. minor* L.
- 7*. Fronds with 1 nerve.
- Group of *L. valdiviana* (No. 16, 17)

17. Nerve longer than the aërenchymatic part of the front, reaching at least $\frac{3}{4}$ of the distance from node to apex; fronds very asymmetrical at the base, $\frac{1}{3}$ - 3 times as long as wide. Mostly oceanic climates with high rainfall; America.

16. *L. valdiviana* Phil. (*L. Torreyi* Austin)

- 17*. Nerve as long or shorter than the aërenchymatic part of the frond, reaching at most $\frac{2}{3}$ of the distance from node to apex; fronds nearly symmetrical at the base, 1 - $1\frac{2}{3}$ times as long as wide. Mostly mediterranean climates. America; in Europe introduced.

17. *L. minuscula* Herter (*L. minima* Phil. nec Thuill.)

- 1*. Fronds rootless with a terminal reproductive pouch; no cristal cells present.

B. *Wolffioideae*

18. Fronds more or less flat; pouch flat; flowers situated laterally on the upper side of the frond.

III. *Wolffiella* Hegelm.

19. Lower wall of the pouch prolonged backwards; prolongation 1-8 mm long, vertically crooked downwards; fronds with a papule above the node at apex.

Group of *W. hyalina* (No. 18, 19)

20. Air spaces distinct, filling $\frac{1}{2}$ - $\frac{4}{5}$ of the distal part of the frond; prolongation at the lower wall of the pouch 0,6-1,8 mm wide; $\frac{1}{2}$ - $\frac{4}{5}$ as wide as the frond. Africa.

18. *W. hyalina* (Delile) Monod

- 20*. Air spaces indistinct; prolongation of the lower wall of the pouch 0,2-0,5 mm wide, $\frac{1}{4}$ - $\frac{1}{2}$ as wide as the frond. Southwestern Africa.

19. *W. repanda* (Hegelm.) Monod

- 19*. Lower wall of the pouch not prolonged; fronds without papules above the node and the apex.

21. Fronds with more than 20 stomata; air spaces indistinct.

22. Fronds with more than 100 stomata, ovate to circular, without pigment cells. Zimbabwe.

20. *W. rotunda* Landolt

- 22*. Fronds with 20-35 stomata, oval to tongue shaped, with brown pigment cells (visible only in dead fronds). Tropical South America.

21. *W. neotropica* Landolt

- 21*. Fronds with 0-8 stomata; with very distinct air spaces at least around the node.

23. Track of longer cells situated in the middle of the lower wall of the pouch; 2 flowers on the upper side of the frond. Tropical regions of Middle and South America and Africa.

22. *W. Welwitschii* (Hegelm.) Monod

- 23*. Track of longer cells situated laterally on the lower wall or at the edge of the wall of the pouch; 1 flower on the upper side of the frond.

24. Fronds rounded or pointed at apex, not denticulate. America.

Group of *W. oblonga* (No. 23, 24, 25)

25. Fronds $1\frac{1}{2}$ - 6 times as long as wide; angle of the triangular pouch $45-120^\circ$.

26. Angle of the pouch 80-120°; track of longer cells situated laterally between the middle and the edge of the lower wall of the pouch; aërenchymatic part of the frond scarcely longer than wide. Subtropical and tropical America.
23. *W. lingulata* (Hegelm.) Hegelm.
- 26*. Angle of the pouch 45-85°; track of longer cells situated at the edge or nearly at the edge of the lower wall of the pouch; aërenchymatic part of the frond longer than wide. Mostly mediterranean type of climate; America.
24. *W. oblonga* (Phil.) Hegelm.
- 25*. Fronds 6-20 times as long as wide; angle of the pouch 25-50°. North America.
25. *W. gladiata* (Hegelm.) Hegelm. (*W. floridana* (J.D. Smith) Thompson)
- 24*. Fronds denticulate at apex, with 2-4 teeth, 6-15 times as long as wide. South Africa.
26. *W. denticulata* (Hegelm.) Hegelm.
- 18*. Fronds thick: globoid, cylindrical, nutshell- or boat-like or conical; pouch in form of a conical cavity; flowers situated in the middle of the upper side of the frond.
- IV. *Wolffia* Horkel ex Schleiden
27. Fronds with a flat polygonal upper side, downwards conically tapering into a cylindrical 0,4-3 mm long prolongation. India.
27. *W. microscopia* (Griff.) Kurz
- 27*. Fronds not with a cylindrical prolongation.
28. Fronds cylindrical, 2-4 times as long as thick with the distal part submerging; daughter fronds emerging from the pouch with an acute angle. Northern Columbia, Curaçao.
28. *W. elongata* Landolt
29. Fronds globoid to ovoid, boat- or nutshell-like; daughter fronds horizontally emerging from the pouch.
30. Fronds nutshell-like, 1/2 - 1 times as deep as wide, with brownish pigment cells (visible only on dead fronds).
- Group of *W. brasiliensis* (No. 29, 30)
31. Fronds 1 - 1 1/2 times as long as wide, rounded at apex, with a prominent papule in the middle of the upper side (small and flowering fronds without papule). America.
29. *W. brasiliensis* Weddell, (*W. papulifera* Thompson, *W. punctata* Griseb. nec auct. amer.)
- 31*. Fronds 1 1/3 - 2 times as long as wide, with a slightly convex upper side, ± pointed at apex with rising point; no papule in the middle of the upper side. Eastern and Western North America.
30. *W. borealis* (Engelm.) Landolt (*W. punctata* auct. amer. nec Griseb.)
- 30*. Fronds globoid to ovoid or boat-like, 1 - 3 times as deep as wide; no pigment cells present.
- Group of *W. arrhiza* (No. 31, 32, 33, 34, 35)
32. Fronds boat-like, 2 - 3 times as deep as wide, biggest width near the water surface. Australia, New Zealand.

33. Fronds 0,3-0,8 mm wide, $1 \frac{1}{3}$ - 2 times as long as wide, with 50-80 stomata on the upper side, intensely green on the upper side. South-eastern Australia, New Zealand.
31. *W. australiana* (Benth.) Hartog & Plas
- 33*. Fronds 0,2-0,5 mm wide, $1 \frac{2}{3}$ - $3\frac{1}{2}$ times as long as wide, with 8-25 stomata on the upper side; whitish green on the upper side with intensely green margin. Australia.
32. *W. angusta* Landolt
- 32*. Fronds globoid to ovoid, 1 - $1\frac{1}{2}$ times as deep as wide, biggest width below the water surface.
34. Fronds on the upper side intensely green, with 10-100 stomata. Europe, Southwestern Asia, Africa.
33. *W. arrhiza* L.
- 34*. Fronds on the upper side transparent green, with 1-15 (rarely to 30) stomata.
35. Fronds 1 - $1 \frac{1}{3}$ times as long as wide, 0,4-1,2 mm wide. America.
34. *W. columbiana* Karsten
- 35*. Fronds $1 \frac{1}{3}$ - 2 times as long as wide, 0,3-0,5 mm wide. Eastern and Southern Asia, Southern and Eastern Africa, California.
35. *W. globosa* (Roxb.) Hartog & Plas

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