

## 204. LEMNACEAE Gray

### • Duckweed Family

Elias Landolt

**Herbs**, mostly perennial (*Lemna aequinoctialis* and *L. perpusilla* also annual), aquatic, floating or submersed, reduced to small green bodies called fronds corresponding partly to leaf and partly to stem. **Roots** 0 or 1–21; **root** hairs absent. **Stems**: distinct stems absent. **Cataphylls** absent. **Fronds** 1 or 2–20 or more, not differentiated into petiole and blade (thin white stipe or green stalk attaching new fronds to mother frond), coherent at base, flattened or globular, fronds smaller than 1.5 cm, venation from node, outer veins sometimes branching distally from inner ones, or veins absent; new fronds (daughter fronds) arising successively in 1–2 pouches or in cavity at base of mother frond; turions present in some species. **Inflorescences** usually solitary (mostly 2 per frond for *L. perpusilla*). **Flowers** mostly bisexual, 1(–2) per frond (rare in many species); sepals absent; petals absent; stamens 1–2; ovaries 1, bottle-shaped, 1-locular, tapering into short styles; stigmas funnel-shaped. **Fruits** follicles; pericarp membranous, opening by bursting. **Seeds** 1–5, nearly as long as fruit.

Genera 4, species 37 (4 genera, 19 species in the flora); nearly worldwide, very rare in regions with high or very low precipitation; not in Greenland or Aleutian Islands.

In this treatment the terms upper/lower and above/below are always used in relation to the position of the frond in the water. The positions toward the base and the apex of the frond are called proximal and distal, respectively.

The “leaf” in the Lemnaceae does not correspond to the leaf of higher plants. It is supposed to consist of a stem in the proximal part (from base to node) and a leaf in the distal part (from node to apex). In Lemnaceae literature it is called a frond. Some authors hold that the flower of the Lemnaceae corresponds to an inflorescence consisting of 1 to 2 male flowers (anthers) and 1 female flower (ovary).

With respect to chromosome number, hundreds of Lemnaceae clones were counted, and three levels of cytological variations were identified: (1) intra-individual variation (aneusomy and/or mixoploidy), (2) intra-populational variation (aneuploidy or polyploidy), and (3) “racial” differentiation (K. Urbanska-Worytkiewicz 1980). Therefore, many chromosome numbers within a species were counted even if only North American plants are listed.

Lemnaceae are the smallest and most reduced flowering plants. Therefore, closely related species have but few distinguishing characteristics that are easy to recognize. In addition, most of these features are strongly modifiable and overlap considerably. Occasionally Lemnaceae have small, 1–5-celled papillae on the upper surface of the frond. Some species have turions (compact fronds reduced in size and structure, filled with starch grains, forming under unfavorable conditions). Turions remain for several days with the mother frond before they sink to the bottom.

Because of the rarity of flowering and fruiting, only vegetative characteristics are available in most cases. *Lemna gibba*, *L. aequinoctialis*, and *L. perpusilla* are the only American species fruiting rather frequently. The smallness of the plants requires good magnification and some technical preparations for identification. To analyze anatomic structures (e.g., number of veins or extension of air spaces), transparent slides are necessary. Fronds preserved in 70% ethanol become transparent. Dried fronds must be boiled first in 70% ethanol and treated afterwards with 10% NaOCl to clear them. Preserving them in ethanol, however, removes pigments that are sometimes important for determination. Under optimal growth conditions the typical anthocyanin pattern of some species does not develop. Therefore, one should observe the species in another season or cultivate it under different conditions. Another difficulty of determination occurs because several (up to 10) Lemnaceae species very often grow together in nature. Therefore, many collection samples contain more than one species, some of which may not be recognized as different at first glance.

Lemnaceae are easily distributed by birds over short distances. In many places, they live only so long as conditions are favorable. Afterwards they disappear. A species of a southern area might suddenly occur farther north and remain there for one or several years. If the species is exposed to water fed by a warm spring, it might persist far beyond expectations. The distribution maps of the Lemnaceae show the area where the species once was collected and do not represent the actual distribution area, which might be considerably smaller and change within a few years. Generally, most Lemnaceae species have expanded during the last years because of the warming of the climate and eutrophication of the waters.

Lemnaceae have a high productivity (some species can double in number within 24 hours) and a very high percentage of amino acids (up to 45% of dry weight). They are used in many regions as food for poultry, pigs, and cows. *Wolffia* fronds are eaten as a vegetable in south-eastern Asia; *Lemna gibba* is cultivated in Israel for use as a vegetable and salad. Lemnaceae are also used for waste-water purification and as test and indicator plants.

SELECTED REFERENCES Daubs, E. H. 1965. A monograph of Lemnaceae. Illinois Biol. Monogr. 34. Hegelmaier, C. F. 1868. Die Lemnaceen. Eine monographische Untersuchung. . . . Leipzig. Landolt, E. 1986. The family of Lemnaceae—A monographic study, vol. 1. Veröff. Geobot. Inst. E. T. H. Stiftung Rübel Zürich 71. Landolt, E. and R. Kandeler. 1987. The family of Lemnaceae—A monographic study, vol. 2. Veröff. Geobot. Inst. E. T. H. Stiftung Rübel Zürich 95. Urbanska-Worytkiewicz, K. 1980. Cytological variation within the family of Lemnaceae. Veröff. Geobot. Inst. E. T. H. Stiftung Rübel Zürich 70: 30–101.

1. Roots 1–21 per frond; fronds with 1–21 veins; daughter fronds and flowers from 2 lateral pouches at frond base; flowers surrounded by small utricular, membranous scale; stamens 2, 4-locular; seeds longitudinally ribbed.
2. Roots (1–)2–21 per frond; fronds with (3–)5–16(–21) veins, surrounded at base by small scale covering point of attachment of roots; pigment cells present (visible in dead fronds as brown dots). . . . . 1. *Spirodela*, p. 145
2. Roots 1 per frond; fronds with 1–5(–7) veins, without scale at base; pigment cells absent (red pigmentation present in some species). . . . . 2. *Lemna*, p. 146
1. Roots absent; fronds without veins; daughter fronds from single terminal pouch or cavity

at frond base; flower(s) in cavity of upper frond surface; flower(s) not surrounded by utricular scale; stamens 1, 2-locular; seeds nearly smooth.

3. Fronds flat (linear, ribbon-, sabre-, or tongue-shaped, or ovate), with air spaces; daughter fronds from terminal flat pouch at mother-frond base; flower(s) in cavity at side of median line of upper frond surface. . . . . 3. *Wolffiella*, p. 150
3. Fronds 3-dimensional (globular, ovoid, or boat-shaped), without air spaces; daughter fronds from terminal conic pouch or cavity at mother-frond base; flower in cavity on median line of upper frond surface. . . . . 4. *Wolffia*, p. 151

1. SPIRODELA Schleiden, *Linnaea* 13: 391. 1839 • Duck-meal [Greek *speira*, winding, and *delos*, distinct] 

Roots (1-)2-21 per frond, abaxial surface at node. Fronds floating (only turions sink to bottom), 2-10, coherent in groups, each obovate-circular, flat or gibbous, 1.5-10 mm, margins entire; air spaces in tissue; reproductive pouches 2, lateral, at base from which daughter fronds and flowers originate, triangular; veins (3-)5-16(-21), from point in proximal part of frond (node); small 2-cleft membranous scale (interpreted as prophyllum) enveloping base of frond, covering point of attachment of roots; anthocyanins present (especially on abaxial surface); pigment cells present (visible in dead fronds as brown dots); turions present or absent, brownish olive, circular-reniform, smaller than growing frond. Flowers 1(-2) per frond, surrounded by small utricular, membranous scale; stamens 2, 4-locular. Seeds 1-3, longitudinally ribbed.  $x = 10, 18, 23$ .

Species 3 (2 in the flora): nearly worldwide.

1. Fronds 1-1.5 times as long as wide, with 7-16(-21) veins and 7-21 roots, 1 or 2 perforating scale. . . . . 1. *Spirodela polyrrhiza*
1. Fronds 1.5-2 times as long as wide, with (3-)5-7 veins and (1-)2-7(-12) roots, all perforating scale. . . . . 2. *Spirodela punctata*

1. *Spirodela polyrrhiza* (Linnaeus) Schleiden, *Linnaea* 13: 392. 1839 • Spirodèle polyrrhize  

*Lemna polyrrhiza* Linnaeus, Sp. Pl. 2: 970. 1753 (as *polyrrhiza*)



Roots 7-21, to 3 cm, 1 or 2 perforating scale. Fronds obovate to circular, flat or rarely gibbous, 2-10 mm, 1-1.5 times as long as wide, apex rounded or pointed, upper surface sometimes with red spot in center; veins 7-16(-21);

turions sometimes present, rootless, brownish olive, circular-reniform, 1-2 mm diam. Flowers: ovaries 1-2-ovulate. Fruits 1-1.5 mm, laterally winged to apex. Seeds with 12-20 distinct ribs.  $2n = 30, 38, 40, 50, 80$ .

Flowering (very rare) early summer-early fall. Eutrophic, quiet waters, in temperate to tropical regions; 0-2500 m; Alta., B.C., Man., N.B., N.S., Ont., P.E.I., Que., Sask.; Ala., Ariz., Ark., Calif., Colo., Conn., Del., D.C., Fla., Ga., Idaho, Ill., Ind., Iowa, Kans., Ky., La.,

Maine, Md., Mass., Mich., Minn., Miss., Mo., Mont., Nebr., Nev., N.H., N.J., N.Mex., N.Y., N.C., N.Dak., Ohio, Okla., Oreg., Pa., R.I., S.C., S.Dak., Tenn., Tex., Utah, Vt., Va., Wash., W.Va., Wis., Wyo.; nearly worldwide.

2. *Spirodela punctata* (G. Meyer) C. H. Thompson, Rep. (Annual) Missouri Bot. Gard. 9: 28. 1898   

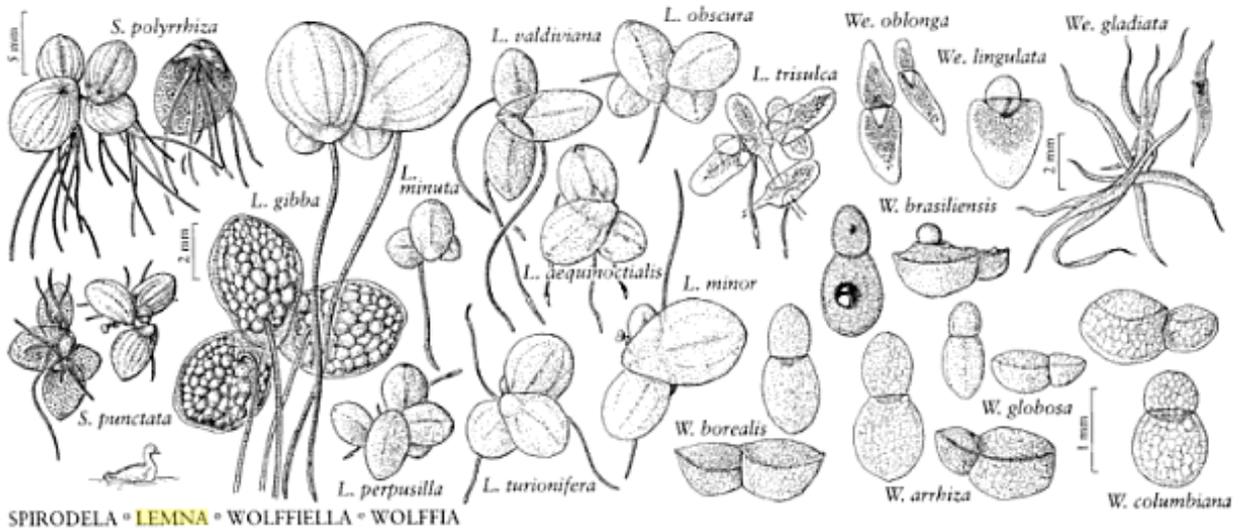
*Lemna punctata* G. Meyer, Prim. Fl. Esseq., 262. 1818; *Spirodela oligorrhiza* (Kurz) Hegelmaier



Roots (1-)2-7(-12), to 7 cm, all perforating scale. Fronds obovate, flat or gibbous, 1.5-8 mm, 1.5-2 times as long as wide, apex mostly pointed, upper surface without red spot; veins (3-)5-7;

distinct turions absent. Flowers: ovaries 1-2-ovulate. Fruits 0.8-1 mm, laterally winged to apex. Seeds with 10-15 distinct ribs.  $2n = 40, 46, 50$ .

Flowering (rare) summer-early fall. Eutrophic, quiet



SPIRODELA • LEMNA • WOLFFIELLA • WOLFFIA

waters, in warm-temperate to subtropical regions with mild winters; 0-900 m; introduced; Ala., Ariz., Ark., Calif., D.C., Fla., Ga., Ill., Ky., La., Miss., Mo., N.C.,

Okla., Oreg., Pa., S.C., Tenn., Tex., Va., Wash.; South America; Asia; Africa; Atlantic Islands; Pacific Islands; Australia.

2. **LEMNA** Linnaeus, Sp. Pl. 2: 970. 1753; Gen. Pl. ed. 5, 417. 1754 • Duckweed, lenticules [Greek name of a water plant] W

Roots 1 per frond. Fronds floating or submersed, 1 or 2-20 or more, coherent in groups or forming chains, lanceolate-ovate, flat or gibbous, 1-15 mm, margins entire or denticulate, upper surfaces sometimes with small conic papillae along veins (especially at node and near apex); air spaces in tissue; reproductive pouches 2, lateral, at base from which daughter fronds and flowers originate, triangular; veins 1-5(-7), originating from point in proximal part of frond (node) or if more than 3 veins present, outer ones sometimes branching distally from inner ones; scale at base of frond absent; anthocyanins sometimes present; pigment cells absent (red pigmentation present in some species); turions absent (sometimes present in *L. turionifera*). Flowers 1(-2) per frond, surrounded by small utricular, membranous scale; stamens 2, 4-locular. Seeds 1-5, longitudinally ribbed.  $x = 10, 21, 22$ .

Species 13 (9 in the flora): worldwide except arctic and antarctic regions.

In *Lemna* the connection to the mother frond is formed by a thin white stipe at the base that falls off or decays after the frond is grown (frond of *L. trisulca* is narrowed at base into a green stalk persisting on frond).

1. Fronds submersed (except when flowering or fruiting), margins denticulate distally, 2-3.5 times as long as wide, base suddenly narrowed into green stalk, 2-20 mm. . . . . 5. *Lemna trisulca*
1. Fronds floating, margins entire, 1-3 times as long as wide.
  2. Fronds with 1 vein.

- 3. Vein mostly prominent, longer than extension of air spaces, or running through at least 3/4 distance between node and apex. . . . . 8. *Lemna valdiviana*
- 3. Vein sometimes indistinct, very rarely longer than extension of air spaces, not longer than 2/3 distance between node and apex. . . . . 9. *Lemna minuta*
- 2. Fronds with 3–5(–7) veins.
  - 4. **Root** sheath winged at base; **root** tip usually sharp pointed; roots to 3(–3.5) **cm**; fronds without reddish color or spots of anthocyanin, mostly with 1 very distinct papilla near apex on upper surface.
    - 5. Seeds with 35–70 indistinct ribs (to count ribs remove membranous pericarp), staying within fruit wall after ripening; **root** sheath wing 2–3 times as **long** as wide. . . . . 6. *Lemna perpusilla*
    - 5. Seeds with 8–26 distinct ribs, falling out of fruit wall after ripening; **root** sheath wing 1–2.5 times as **long** as wide. . . . . 7. *Lemna aequinoctialis*
  - 4. **Root** sheath not winged; **root** tip mostly rounded; roots often longer than 3 **cm**; fronds often with reddish tinge or spots of anthocyanin, with or without distinct papilla near apex on upper surface.
    - 6. Plants forming small, olive to brown, rootless turions, which sink to bottom. . . . . 4. *Lemna turionifera* (in part)
    - 6. Plants usually without distinct turions.
      - 7. Largest air spaces longer than 0.3 mm; if red-colored on lower surface, coloring beginning from margin; ovary (1)–2–7-ovulate. . . . . 1. *Lemna gibba*
      - 7. Largest air spaces 0.3 mm or shorter; if pigmented on lower surface, red coloring beginning from attachment point of **root**; ovary 1-ovulate.
        - 8. Fronds not reddish on lower surface (or at least much less so than on upper); greatest distance between lateral veins near or proximal to middle. . . . . 3. *Lemna minor*
        - 8. Fronds often reddish on lower surface (more intensely so than on upper); greatest distance between lateral veins near or distal to middle.
          - 9. Fronds flat, with mostly distinct papillae on midline of upper surface; seeds with 30–60 indistinct ribs. . . . . 4. *Lemna turionifera* (in part)
          - 9. Fronds often gibbous, with very distinct papillae above node and near apex on upper surface but not between node and apex; seeds with 10–16 distinct ribs. . . . . 2. *Lemna obscura*

1. *Lemna gibba* Linnaeus, Sp. Pl. 2: 970. 1753



Roots to 15 **cm**, tip mostly rounded; sheath not winged. Stipes white, thin, often decaying. Fronds floating, 1 or 2–5 or more, coherent in groups, obovate, often gibbous, 1–8 mm, 1–1.5 times as **long** as wide, margins entire; veins (3)–4–5(–7) (all originating from node), greatest

distance between lateral veins near or distal to middle; papillae often indistinct; lower surface sometimes red colored, coloring beginning from margin, upper surface occasionally with distinct red spots beginning from margins near apex; largest air spaces longer than 0.3 mm; distinct turions absent. Flowers: ovaries (1)–2–7-ovulate, utricular scale with narrow opening at apex. Fruits 0.6–1 mm, laterally winged. Seeds with 8–16 dis-

tinct ribs, falling out of fruit wall after ripening.  $2n = 40, 42, 44, 50$ .

Flowering (rather frequent) spring–fall. Eutrophic, quiet waters in temperate regions with mild winters; 0–1900 m; Ariz., Calif., Ill., Nebr., Nev., N.Mex., Tex., Wyo.; n Mexico; South America; Eurasia; Africa; Atlantic Islands.

2. *Lemna obscura* (Austin) Daubs, Illinois Biol. Monogr. 34: 20. 1965



*Lemna minor* Linnaeus var. *obscura* Austin in A. Gray, Manual ed. 5, 479. 1867

Roots to 15 **cm**, tip mostly rounded; sheath not winged. Stipes white, small, often decaying. Fronds floating, 1 or 2–5 or more, coherent in groups, obovate, flat or gibbous, 1–3.5 mm,

1–1.5 times as long as wide, margins entire; veins 3, greatest distance between lateral veins near middle; very distinct papillae near apex, some smaller indistinct ones on midline of upper surface; lower surface very often red colored (more intensely than on upper), coloring beginning at attachment point of root, upper surface sometimes with red spots; air spaces shorter than 0.3 mm; distinct turions absent. Flowers: ovaries 1-ovulate, utricular scale with narrow opening at apex. Fruits 0.5–0.7 mm, not winged. Seeds with 10–16 distinct ribs, staying within fruit wall after ripening.  $2n = 40, 42, 50$ .

Flowering (occasional) spring–fall. Mesotrophic to eutrophic, quiet waters, in temperate to subtropical regions with mild winters; 0–800 m; Ala., Ark., Del., D.C., Fla., Ga., Ill., Ind., Iowa, Kans., Ky., La., Md., Minn., Miss., Mo., Nebr., N.J., N.Y., N.C., Ohio, Okla., Pa., S.C., S.Dak., Tenn., Tex., Va., Wis.; c Mexico; South America (Colombia, Ecuador); Hawaii.

3. *Lemna minor* Linnaeus, Sp. Pl. 2: 970. 1753

• Lenticule mineure [F] [W]



Roots to 15 cm, tip mostly rounded; sheath not winged. Stipes white, small, often decaying. Fronds floating, 1 or 2–5 or more, coherent in groups, ovate, scarcely gibbous, flat, 1–8 mm, 1.3–2 times as long as wide, margins entire; veins 3(–5) (if more than 3, outer ones branching

from inner ones), greatest distance between lateral veins near or proximal to middle; papillae not always distinct (one near apex usually larger); lower surface very seldom slightly reddish (much less than on upper), coloring beginning from attachment point of root, upper surface occasionally diffusely reddish; air spaces 0.3 mm or shorter; distinct turions absent. Flowers: ovaries 1-ovulate, utricular scale with narrow opening at apex. Fruits 0.8–1 mm, laterally winged toward apex. Seeds with 8–15 distinct ribs, staying within fruit wall after ripening.  $2n = 40, 42, 50, 63, 126$ .

Flowering (rare) late spring–early fall. Mesotrophic to eutrophic, quiet waters, in suboceanic, cool-temperate regions with relatively mild winters; 0–2000 m; B.C., Ont., Que., Sask.; Ala., Ariz., Ark., Calif., Conn., Del., D.C., Fla., Idaho, Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Mass., Mich., Minn., Mo., Mont., Nebr., N.H., N.J., N.Mex., N.Y., N.C., N.Dak., Ohio, Okla., Oreg., Pa., R.I., S.Dak., Tenn., Utah, Vt., Va., Wash., W.Va., Wis.; w Eurasia; Africa; Atlantic Islands; introduced, Australia; introduced, New Zealand.

Indication of this species in Newfoundland (H. J.

Scoggan 1978–1979) probably refers to *Lemna turionifera*.

A specimen in the Gray Herbarium from St. Pierre and Miquelon may represent *Lemna minor* or *L. turionifera*; its determination is questionable.

4. *Lemna turionifera* Landolt, Aquatic. Bot. 1: 355, fig. 4g–h. 1975 • Lenticulare turionifère [F] [W]



Roots shorter than 15 cm, tip mostly rounded; sheath not winged. Stipes white, small, often decaying. Fronds floating, 1 or 2–few, coherent in groups, obovate, scarcely gibbous, flat, 1–4 mm, 1–1.5 times as long as wide, margins entire; veins 3, greatest distance between lateral veins near

or distal to middle; papillae distinct on midline of upper surface (apical papilla scarcely larger than others); lower surface often red (more intensely so than on upper), coloring beginning at attachment point of root, upper surface (especially near apex) sometimes with red spots; air spaces to 0.3 mm; turions sometimes present, rootless, olive to brown, 0.8–1.6 mm diam., sinking to bottom. Flowers: ovaries 1-ovulate, utricular scale with narrow opening at apex. Fruits 0.5–0.6 mm, not winged. Seeds with 30–60 indistinct ribs, staying within fruit wall after ripening.  $2n = 40, 42, 50, 80$ .

Flowering (occasional) summer. Mesotrophic to eutrophic, quiet waters, in continental, temperate regions; 0–3700 m; Alta., B.C., Man., N.B., N.W.T., N.S., Ont., P.E.I., Que., Sask., Yukon; Ala., Alaska, Ariz., Calif., Colo., Conn., Idaho, Ill., Ind., Iowa, Kans., Mass., Mich., Minn., Mo., Mont., Nebr., Nev., N.Mex., N.Y., N.Dak., Ohio, Okla., Oreg., Pa., R.I., S.Dak., Tex., Utah, Vt., Wash., W.Va., Wis., Wyo.; Mexico (Baja California); Eurasia.

I know of no specimens of *Lemna turionifera* from St. Pierre and Miquelon or from New Jersey, but the species is to be expected there.

5. *Lemna trisulca* Linnaeus, Sp. Pl. 2: 970. 1753

• Lenticule trisulquée [F] [W]



Roots to 2.5 cm (sometimes not developed), tip pointed; sheath not winged. Green stalks 2–20 mm. Fronds submersed (except when flowering or fruiting), 3–50, coherent and very often forming branched chains, narrowly ovate, flat, thin, 3–15 mm (excluding stalk), 2–3.5 times as

long as wide, base suddenly narrowed into green stalk, margins denticulate distally; veins (1 or) 3, lateral veins

only in proximal part of frond; papillae absent; anthocyanin often present; air spaces shorter than 0.3 mm; turions absent. **Flowers:** ovaries 1-ovulate, utricular scale with narrow opening at apex. **Fruits** 0.6–0.9 mm, laterally winged toward apex. **Seeds** with 12–18 distinct ribs, staying within fruit wall after ripening.  $2n = 40, 42, 44, 60, 63, 80$ .

Flowering (rare) late spring–summer. Mesotrophic, quiet waters rich in calcium, in cool-temperate regions; 0–3000 m; Alta., B.C., Man., N.B., N.W.T., N.S., Nunavut, Ont., P.E.I., Que., Sask., Yukon; Alaska, Ariz., Ark., Calif., Colo., Conn., Idaho, Ill., Ind., Iowa, Kans., Maine, Md., Mass., Mich., Minn., Mo., Mont., Nebr., Nev., N.H., N.J., N.Mex., N.Y., N.Dak., Ohio, Oreg., Pa., R.I., S.Dak., Tenn., Utah, Vt., Va., Wash., W.Va., Wis., Wyo.; nearly worldwide, except arctic and antarctic regions and South America; in warm regions only in mountains.

The report of *Lemna trisulca* in Florida is dubious because the climate is too warm. The species may be temporarily introduced there by birds.

6. *Lemna perpusilla* Torrey, Fl. New York 2: 245. 1843  
• Lenticule très petite [E] [F] [W]



Roots to 3.5 cm, tip usually sharp pointed; sheath narrowly winged at base (wing 2–3 times as long as wide). Stipes white, small, often decaying. Fronds floating, 1 or 2–few, coherent in groups, ovate-obovate, flat, 1–4 mm, 1–1.7 times as long as wide, margins entire; veins 3, greatest

distance between lateral veins near or distal to middle; 1 distinct papilla near apex on upper surface, 2–3 very distinct papillae above node; anthocyanin absent, no reddish color; air spaces much shorter than 0.3 mm; distinct turions absent. **Flowers:** ovaries 1-ovulate, utricular scale open on 1 side. **Fruits** 0.7–1 mm, not winged. **Seeds** with 35–70 indistinct ribs, staying within fruit wall after ripening.  $2n = 40, 42$ .

Flowering (frequent) late spring–fall. Mesotrophic to eutrophic, quiet waters in temperate regions with relatively mild winters; 0–600 m; Que.; Ark., Del., D.C., Ill., Ind., Iowa, Kans., Ky., Maine, Md., Mass., Minn., Mo., Nebr., N.J., N.Y., N.C., Ohio, Okla., Pa., R.I., Tenn., Tex., Vt., Va., W.Va., Wis.

I know of no specimens of *Lemna perpusilla* from Connecticut.

7. *Lemna aequinoctialis* Welwitsch, Bol. Ann. Cons. Ultramar. (Portugal) 55: 578. 1859 [F] [W]



*Lemna paucicostata* Hegelmaier

Roots to 3 cm; tip usually sharp pointed; sheath winged at base (wing 1–2.5 times as long as wide). Stipes small, white, often decaying. Fronds floating, 1 or 2–few, coherent in groups, ovate-lanceolate, flat, 1–6 mm, 1–3 times as long as wide, margins

entire; veins 3, greatest distance between lateral veins near or proximal to middle; 1 often very distinct papilla near apex on upper surface and 1 above node; anthocyanin absent, no reddish color; largest air spaces much shorter than 0.3 mm; distinct turions absent. **Flowers:** ovaries 1-ovulate, utricular scale open on 1 side. **Fruits** 0.5–0.8 mm, not winged. **Seeds** with 8–26 distinct ribs, falling out of fruit wall after ripening.  $2n = 40, 42, 50, 60, 80, 84$ .

Flowering (frequent) spring–fall. Mesotrophic to eutrophic, quiet waters in warm-temperate to tropical regions; 0–1300 m; Ala., Ariz., Ark., Calif., Fla., Ga., Ill., Ind., Iowa, Kans., Ky., La., Miss., Mo., Nebr., N.Mex., N.C., Okla., S.C., Tenn., Tex., Va., Wis.; West Indies; Central America; South America; s Eurasia; Africa; Atlantic Islands; Indian Ocean Islands; Pacific Islands; Australia.

Some authors did not distinguish between *Lemna aequinoctialis* and *L. perpusilla* and used the latter name for both species.

8. *Lemna valdiviana* Philippi, Linnaea 33: 239. 1864  
[F] [W]



*Lemna cyclostasa* (Elliott) C. H. Thompson; *L. torreyi* Austin

Roots to 1.5 cm, tip rounded to pointed; sheath not winged. Stipes white, small, often decaying. Fronds floating or (rarely) submersed, 1 or 2–few, coherent in groups, ovate to lanceolate, flat, thin, 1–5 mm, 1.3–3 times as

long as wide, margins entire; veins 1, mostly prominent, longer than extension of air spaces, or running through at least 3/4 of distance between node and apex; with or without small papillae along midline of upper surface; anthocyanin absent; largest air spaces much shorter than 0.3 mm; turions absent. **Flowers:** ovaries 1-ovulate, utricular scale open on 1 side. **Fruits** 1–1.35 mm, not winged. **Seeds** with 15–29 distinct ribs.  $2n = 40, 42$ .

Flowering (very rare) spring–fall. Mesotrophic, quiet waters in temperate to tropical regions; 0–2000 m; Ala.,

Ariz., Ark., Calif., Conn., D.C., Fla., Ga., Ill., Ind., Kans., Ky., La., Md., Mass., Mich., Miss., Mo., Mont., Nebr., N.H., N.J., N.Mex., N.Y., N.C., Ohio, Okla., Pa., R.I., S.C., Tenn., Tex., Va., W.Va., Wyo.; Mexico; West Indies (Bermuda); Central America; South America.

I know of no specimens of *Lemna valdiviana* from Delaware, but the species is to be expected there.

9. *Lemna minuta* Kunth in A. von Humboldt et al., Nov. Gen. Sp. 1: 372. 1816 [F] [W]

*Lemna minima* Philippi; *L. minuscula* Herter



Roots to 1.5 cm, tip rounded to pointed; sheath not winged. Stipes white, small, often decaying. Fronds floating, 1 or 2-few, coherent in groups, obovate, flat to thickish (but not gibbous), 0.8–4 mm, 1–2 times as long as wide,

margins entire; veins 1, sometimes indistinct, very rarely longer than extension of air spaces, not longer than 2/3 of distance between node and apex; with or without small papillae along midline; anthocyanin absent; largest air spaces much shorter than 0.3 mm; turions absent. Flowers: ovaries 1-ovulate, utricular scale open on 1 side. Fruits 0.6–1 mm, not winged. Seeds with 12–15 distinct ribs.  $2n = 36, 40, 42$ .

Flowering (very rare) late spring–early fall. Mesotrophic to eutrophic, quiet waters in temperate to subtropical regions with relatively mild winters; 0–2600 m; Ala., Ariz., Ark., Calif., Colo., Fla., Ga., Ill., Ind., Kans., Ky., La., Mich., Mo., Nebr., Nev., N.Mex., Ohio, Okla., Oreg., Tenn., Tex., Utah, Wash., W.Va., Wyo.; Mexico; West Indies; Central America; South America; introduced, Eurasia.

I know of no specimens of *Lemna minuta* from Mississippi, but the species is to be expected there.

3. WOLFFIELLA (Hegelmaier) Hegelmaier, Bot. Jahrb. Syst. 21: 303. 1895 • [For Johann Friedrich Wolff, 1778–1806, German physician, and Latin *-ella*, diminutive] [W]  
*Wolffia* Horkel ex Schleiden subg. *Wolffiella* Hegelmaier, Lemnac., 131. 1868

Roots absent. Fronds submersed (except when flowering or fruiting), proximal part near surface, 1 or 2–20 or more, coherent, linear, ribbon-, sabre- or tongue-shaped, or ovate, flat, longer than 2 mm, margins entire; air spaces in tissue; pouch 1, terminal, at base from which daughter fronds (no flowers) originate, triangular, lower wall of pouch with tract of elongated cells forming connection between node and attachment to mother frond; veins 0; scale at base of frond absent; anthocyanins absent; pigment cells present (visible in dead fronds as brown dots); turions absent. Flowers 1(–2) per frond, originating in cavity at side of median line of upper frond surface, not surrounded by utricular scale; stamen 1, 2-locular. Seeds 1, nearly smooth.  $x = 10, 20, 21$ .

Species 10 (3 in the flora): North America, West Indies, Central America, South America, Africa.

1. Fronds (4–)6–15(–20) times as long as wide; angle of pouch 25°–50°. . . . . 3. *Wolffiella gladiata*  
 1. Fronds 1.5–8 times as long as wide; angle of pouch 45°–120°  
 2. Angle of pouch 70°–120°; tract of elongated cells running between median line and edge of lower wall of pouch; area of air spaces within frond rarely longer than wide. . . . . 1. *Wolffiella lingulata*  
 2. Angle of pouch 45°–90°; tract of elongated cells running along or close to edge of lower wall of pouch; area of air spaces within frond mostly longer than wide. . . . . 2. *Wolffiella oblonga*

1. *Wolffiella lingulata* (Hegelmaier) Hegelmaier, Bot. Jahrb. Syst. 21: 303. 1895 [F] [W]

*Wolffiella lingulata* Hegelmaier, Lemnac., 132. 1868



Fronde 1 or 2-4 coherent in small groups, wide tongue-shaped or ovate, 3-9 mm, 1.5-4 times as long as wide, rounded at tip; tract of elongated cells running between median line and edge of lower wall of pouch; area of air

spaces within frond rarely longer than wide; angle of pouch 70°-120°; flowering fronds narrower than most vegetative ones. Fruits 0.41-0.44 mm.  $2n = 40, 42$ .

Flowering (very rare) throughout year. Mesotrophic, quiet waters in subtropical to tropical regions with mild winters; 0-200 m; Calif., Fla., La., Tex.; Mexico; West Indies; Central America; South America.

2. *Wolffiella oblonga* (Philippi) Hegelmaier, Bot. Jahrb. Syst. 21: 303. 1895 [F] [W]

*Lemna oblonga* Philippi, Linnaea 29: 45. 1857



Fronde 1 or 2-8 coherent together in often starlike groups, narrowly tongue-shaped to ribbonlike, 1.2-7.5 mm, 3-8 times as long as wide, rounded at tip or pointed; tract of elongated cells running along or near edge of

lower wall of pouch; area of air spaces within frond much longer than wide, often spreading throughout most of frond; angle of pouch 45°-90°; flowering fronds similar to vegetative ones. Fruits 0.3-0.4 mm.  $2n = 40, 42$ .

Flowering (very rare) throughout year. Mesotrophic, quiet waters in warm-temperate to subtropical regions with mild winters; 0-400 m; Calif., Fla., La., Miss., Tex.; Mexico; West Indies; Central America; South America.

3. *Wolffiella gladiata* (Hegelmaier) Hegelmaier, Bot. Jahrb. Syst. 21: 304. 1895 [F] [W]

*Wolffiella gladiata* Hegelmaier, Lemnac., 133. 1868; *W. gladiata* var. *floridana* Donnell Smith; *Wolffiella floridana* (Donnell Smith) C. H. Thompson



Fronde 1 or 2-20 or more, coherent in starlike groups, narrowly sabre-shaped, 3-9 mm, (4-)6-15(-20) times as long as wide,

pointed at tip; tract of elongated cells running along edge of lower wall of pouch; area of air spaces much longer than wide, spreading throughout most of frond; angle of pouch 25°-50°; flowering fronds much wider at base than vegetative ones. Fruits 0.3-0.4 mm.  $2n = 40, 42$ .

Flowering (very rare) spring and fall. Mesotrophic, quiet waters in warm-temperate regions with relatively mild winters; 0-400 m; Ala., Ark., Del., D.C., Fla., Ga., Ill., Ind., Ky., La., Md., Mass., Miss., Mo., N.J., N.C., Ohio, Okla., Pa., S.C., Tenn., Tex., Va., Wash.; Mexico (Federal District).

The type collection of *Wolffiella gladiata*, from Mexico City, is taxonomically identical with plants from Florida called *W. gladiata* var. *floridana* by J. D. Smith. Some authors included narrow specimens of *W. oblonga* in *W. gladiata*, causing confusion.

4. WOLFFIA Horkel ex Schleiden, Beitr. Bot., 233. 1844 • Water-meal [for Johann Friedrich Wolff, 1778-1806, German physician] [W]

Roots absent. Fronde floating or submersed (only turions sink to bottom), 1 or 2, coherent, each frond globular, ovoid, or boat-shaped, 3-dimensional, smaller than 1.6 mm, margins entire; air spaces not in tissue; reproductive cavity terminal, at base from which daughter fronds (but no flowers) originate, conic, lower side of cavity with short tract of elongated cells along median line forming connection between node and attachment to mother frond; veins 0; scale at base of frond absent; anthocyanins absent; in some species pigment cells present (visible in dead fronds as brown dots); turions light green, globular, smaller than growing fronds. Flowers 1 per frond, originating in cavity on median line of upper frond surface, not surrounded by utricular scale; stamen 1, 2-locular. Seeds 1, nearly smooth.  $x = 10, 20, 21, 22, 23$ .

Species 11 (5 in the flora): nearly worldwide (except arctic and antarctic regions).

1. Fronds boat-shaped, 0.3–1 times as deep as wide, with pigment cells in vegetative tissue.
  2. Fronds 1–1.5 times as long as wide, rounded at apex, papilla usually prominent in center of upper surface. . . . . 1. *Wolffia brasiliensis*
  2. Fronds 1.3–2 times as long as wide, with point at apex bent upwards, papilla absent. . . . . 2. *Wolffia borealis*
1. Fronds globular to ovoid, 1–1.5 times as deep as wide, without pigment cells in the vegetative tissue.
  3. Fronds with 10–100 stomates, slightly pointed at apex, the upper surface intensely green (not transparent). . . . . 3. *Wolffia arrhiza*
  3. Fronds with 1–10(–30) stomates, rounded or slightly pointed at apex, upper surface transparently green.
    4. Fronds 1.3–2 times as long as wide, 0.3–0.5 mm wide. . . . . 4. *Wolffia globosa*
    4. Fronds 1–1.3 times as long as wide, 0.4–1.2 mm wide. . . . . 5. *Wolffia columbiana*

1. *Wolffia brasiliensis* Weddell, Ann. Sci. Nat., Bot., sér. 3, 12: 170. 1849 [F][W]

Mont., Nebr., N.H., N.Y., Ohio, Okla., Oreg., Pa., S.Dak., Tenn., Utah, Vt., Wash., Wis.



*Wolffia papulifera* C. H. Thompson;  
*W. punctata* Grisebach

Fronds boat-shaped, 0.5–1.6 mm, 1–1.5 times as long as wide, 0.3–0.7 times as deep as wide, rounded at apex, papilla usually prominent in center of upper surface (tent-shaped); upper surface intensely green, with 50–100 stomates; pigment cells present in vegetative tissue (visible in dead fronds as brown dots).  $2n = 20, 40, 42, 50, 60, 80$ .

Flowering (rare) late spring–early fall. Mesotrophic to eutrophic, quiet waters in temperate to subtropical regions; 0–1000 m; Ala., Ark., Calif., Conn., Del., D.C., Fla., Ga., Ill., Ind., Kans., Ky., La., Md., Mass., Mich., Miss., Mo., N.J., N.Y., N.C., Ohio, Okla., Oreg., Pa., S.C., Tenn., Tex., Va., Wash., W.Va., Wis.; Mexico; West Indies; Central America; South America.

Flowering (rare) late spring–early fall. Mesotrophic to eutrophic, quiet waters in temperate to subtropical regions; 0–1000 m; Ala., Ark., Calif., Conn., Del., D.C., Fla., Ga., Ill., Ind., Kans., Ky., La., Md., Mass., Mich., Miss., Mo., N.J., N.Y., N.C., Ohio, Okla., Oreg., Pa., S.C., Tenn., Tex., Va., Wash., W.Va., Wis.; Mexico; West Indies; Central America; South America.

2. *Wolffia borealis* (Engelmann) Landolt, Ber. Geobot. Inst. E. T. H. Stiftung Rübel 44: 137. 1977 • *Wolffie boréale* [E][F][W]



*Wolffia brasiliensis* Weddell var.  
*borealis* Engelmann in C. F.  
Hegelmaier, Lemnac., 127. 1868

Fronds boat-shaped, 0.7–1.5 mm, 1.3–2 times as long as wide, 0.7–1 times as deep as wide, with point at apex bent upward; papilla absent; upper surface intensely green, with 50–100 stomates; pigment cells present in vegetative tissue (visible in dead fronds as brown dots).  $2n = 20, 22, 30, 40$ .

Flowering (very rare) summer–early fall. Mesotrophic to eutrophic, quiet waters in temperate regions; 0–1400 m; Alta., B.C., Ont., Que.; Calif., Colo., Idaho, Ill., Ind., Iowa, Kans., Ky., Mass., Mich., Minn., Mo.,

The name *Wolffia punctata* has been applied to this species in error.

3. *Wolffia arrhiza* (Linnaeus) Horkel ex Wimmer, Fl. Schles. ed. 3, 140. 1857 [F][I][W]



*Lemna arrhiza* Linnaeus, Mant. Pl. 2: 294. 1771

Fronds globular to ovoid, 0.5–1.5 mm, 1–1.3 times as long as wide, 1.2–1.5 times as deep as wide, slightly pointed at apex, papilla absent; upper surface intensely green (not transparent), with 10–100 stomates; pigment cells absent in vegetative tissue.  $2n = 30, 40, 42, 44–46, 50, 60, 62$  (Europe, Africa).

Flowering (very rare) late spring–summer. Mesotrophic to eutrophic, quiet waters in temperate to subtropical regions with relatively mild winters; 0–800 m; introduced; Calif.; South America (Brazil); w Eurasia; Africa.

*Wolffia arrhiza* was reported from Alberta because of the size of epidermal cells. The plants are within the variation shown by *W. columbiana*, however.

4. *Wolffia globosa* (Roxburgh) Hartog & Plas, Blumea 18: 367. 1970 [F][I][W]



*Lemna globosa* Roxburgh, Fl. Ind. ed. 1832, 3: 565. 1832

Fronds ovoid, 0.4–0.8 mm (× 0.3–0.5 mm), 1.3–2 times as long as wide, rounded or slightly pointed at apex, papilla absent; adaxial surface transparently green, with 1–10(–30) stomates; pigment cells absent in vegetative tissue.  $2n = 30, 60$ .

Flowering (very rare) late spring–fall. Mesotrophic to

eutrophic, quiet waters in warm-temperate to tropical regions with mild winters; 0–600 m; probably introduced; Calif., Fla.; South America (Colombia, Ecuador); e Asia; Pacific Islands (Hawaii).

5. *Wolffia columbiana* H. Karsten, Bot. Untersuch.

(Berlin) 1: 103, figs. 2g, 3g. 1865 • Wolffie de

Colombie  



Fronds nearly globular, 0.5–1.4 mm ( $\times$  0.4–1.2 mm), 1–1.3 times as long as wide, 1–1.3 times as deep as wide, rounded at apex, papilla absent; upper surface transparently green, with 1–10(–30) stomates; pigment cells absent in vegetative tissue.  $2n = 30, 40, 42, 50, 70, 80$ .

Flowering (very rare) summer–early fall. Mesotrophic to eutrophic, quiet waters in temperate to subtropical regions; 0–1100 m; Alta., Man., Ont., Que., Sask.; Ala., Ark., Calif., Colo., Conn., Del., D.C., Fla., Ga., Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Mass., Mich., Minn., Miss., Mo., Mont., Nebr., N.H., N.J., N.Y., N.C., N.Dak., Ohio, Okla., Oreg., Pa., S.C., S.Dak., Tenn., Tex., Vt., Va., W.Va., Wis.; Mexico; West Indies (Curaçao); Central America; South America.

I know of no specimens of *Wolffia columbiana* from Rhode Island.

[Note added in press: Recent research shows that *Spirodela punctata* should be treated in a distinctive genus as *Landoltia punctata* (G. Meyer) D. H. Les & D. J. Crawford (Novon 9: 530–533. 1999).—Ed.]