THE FAMILY OF LEMNACEAE IN VENEZUELA

La familia Lemnaceae en Venezuela

Elias LANDOLT[1] († 2013), Justiniano VELÁSQUEZ[2], Walter LÄMMLER[3] and Elizabeth GORDON[2]*

[1] Institut für Integrative Biologie, ETH Zürich Universitätsstr 16, CH-8092, Zürich
[2] Laboratorio de Ecología de Plantas Acuáticas, Centro de Ecología y Evolución, Instituto de Zoología y Ecología Tropical, Facultad de Ciencias, Universidad Central de Venezuela, Caracas 1041-A, A.P. 47058, Venezuela
elizabeth.gordon@ciens.ucv.ve; egordoncolon@gmail.com (Autor para correspondencia)*
[3] Landolt Duckweed Collection, Spiegelgasse 12, CH- 8001, Zürich

ABSTRACT

During a trip to the northern part of Venezuela in 2005 about 70 samples of Lemnaceae have been collected. Together with the results of herbaria studies it was possible to construct distribution maps of the respective Lemnaceae species in Venezuela. Fifteen species are recognized from which four have been recorded newly: *Landoltia punctata, Lemna obscura, Wolffiella neotropica, Wolffia globosa.* Out of these species, *W. neotropica* is endemic in the northeastern part of South America. The other three species are probably introduced. Three species of the resting 11 are only known from neighbouring countries in South America, but have not been recorded from Venezuela. For each species a morphological characteristic with key for determination is given and geographical and ecological distribution is shown. Phytosociological relevés have been recorded. Four associations are recognized.

Key words: distribution, free floating plants, Lemnaceae, morphology, Venezuela

RESUMEN

Durante el viaje que se hizo en el 2005 al norte de Venezuela fueron recolectadas alrededor de 70 muestras de Lemnaceae, las cuales junto con los resultados de los estudios de herbario permitió elaborar mapas de distribución de las especies de Lemnaceae en Venezuela. Se identificaron 15 especies, de las cuales cuatro fueron registradas como nuevas para Venezuela: *Landoltia punctata, Lemna obscura, Wolffiella neotropica, Wolffia globosa.* De éstas, *W. neotropica* es endémica del noreste de Sur América. Las otras tres especies posiblemente han sido introducidas en el país. Tres especies de las 11 restantes son conocidas solamente en los países vecinos, pero que no habían sido registradas en Venezuela. Para cada especie se presentan las características morfológicas junto con una clave para su determinación, así como su distribución geográfica y aspectos relacionados con la ecología. De acuerdo a los relevés fitosociológicos fueron reconocidas cuatro asociaciones.

Palabras clave: distribución, Lemnaceae, morfología, plantas flotantes libres, Venezuela

ISSN 0084-5906
Depósito Legal 196902DF68
Depósito Legal (Internet) ppi 201402DC4561

Recibido: 09/01/2015
Aceptado: 30/11/2015

INTRODUCTION

Lemnaceae is a small well defined family of five genera and 37 species occurring around the world except Arctic and Antarctic regions. The species are strict specialists as free-floating small water plants (pleustophytes). The centres of distribution are subtropical and tropical region.

Recent investigations by molecular biological methods show that the members of the family have a monophyletic origin within the Araceae. Therefore, many authors integrate the Lemnaceae within this family as a separate subfamily Lemnoideae (Cabrera *et al.* 2008). However, in this paper keep the distinction of a separate family of Lemnaceae on the following reasons:

– The Lemnaceae are a group of plants being very well separated from all the rest of the Araceae. There is not a single characteristic in common between Araceae and Lemnaceae which cannot be found in other families of Monocots.

– There are no species showing transitional morphological characteristics between Lemnaceae and Araceae. *Pistia*, an Araceae living on the surface of the water, was believed to be a link between the two families long time ago. But, there are many reasons why this species has no close morphological relations to the Lemnaceae (Landolt 1986). Also molecular investigations do not confirm a close relationship.

– The separation of the Lemnaceae from the Araceae must have taken place during the Cretaceous (Cabrera *et al.* 2008), at least 60-100 million years ago, i.e. very early in the evolution of the Araceae. Therefore, the authors of this research propose to keep the early separation of Lemnaceae and a few other genera as separate families within a monophyletic order Arales.

Since the species of Lemnaceae are rarely larger than a few millimetres and the differentiating morphological characteristics are difficult to recognize, the knowledge of the species of this family is rather rudimental in many countries. The authors have been investigating Lemnaceae worldwide since many years. Venezuela is situated in a zone of enhanced biodiversity of Lemnaceae due to the location in the tropics and the big variation of climates. The Lemnaceae in Venezuela were described by Velásquez (1994), however, until now has not been revised their taxonomy; more recent works have been made in Zulia State basically referred to the composition of species in the family (Zambrano *et al.* 2007b, c), and micro morphology of reproductive structures (Zambrano *et al.* 2007a). Recently, the interest in Lemnaceae was much enhanced in Venezuela due to explosive growth of a *Lemna* (*L. obscura*) in Lake Maracaibo which has been observed since 2004, as a result of the

process of eutrophication of the lake. Therefore, it seemed worthwhile to look closer at Lemnaceae occurrences in the nature, what is the purpose of this work, where in addition to a key, it also describes the morphological characteristics of the species, the geographical distribution and provide some of the aspects related to the ecology.

MATERIALS AND METHODS

To get an idea of distribution of the Lemnaceae in Venezuela a trip was performed by the first author in February 2005 during four weeks, together with the third and fourth authors. It was restricted to the northern and central part of the country, and included the Anzoátegui, Aragua, Distrito Capital, Guárico, Nueva Esparta, Trujillo, and Zulia States (Fig. 1, Table 1). The last part throughout the state of Nueva Esparta was guided by the second author.

From each station herbarium material was collected for further studies at home. From those material half was deposited in the Herbarium VEN in Caracas and the other half was sent to the Herbarium ETH (ZT) in Zürich. Many herbaria of the world were consulted for Venezuelan material. In the following herbaria Venezuelan material of Lemnaceae was found: A, ANS, BM, BR, G, L, LL, M, NY PAC, PH, STU, U, US, W, WIS, ZT (abbreviations according to Holmgren *et al.* 1990). From Venezuela it was consulted the following herbaria: VEN, MY, PORT. Species distribution maps were made based on those reported by Velásquez (1994). The photos of the species were done on fresh material collected during the trip and deposited in Landolt Duckweed Collection (Spiegelgasse 12, CH- 8001, Zürich).

On the trip the pH and the conductivity of the water was measured on each of 70 investigated places and a phytosociological relevé of the floating vegetation was taken. At each stand of Lemnaceae a phytosociological relevé according to the methods of Braun-Blanquet was taken (Mueller-Dombois & Ellenberg 1974). Relevés of three and less species were not considered. The frequency of occurrence of the species at a locality was noted by the following scale:

+ only present with very few individuals
1 covering 1-5% of the water surface
2 covering 5-25% of the water surface
3 covering 25-50% of the water surface
4 covering 50-75% of the water surface
5 covering 75<100% of the water surface

Table 1. Names and numbers of collection sites of Lemnaceae.

State	No.	Locality
Zulia	1-2	South of Maracaibo, Potrerito
	3	Maracaibo, road to Barranquillas
	4	Hacienda Alto Viento, Experimental Station of the Facultad de Agronomía, LUZ
	5	2 km south-west of Hacienda Alto Viento, near Río Palmar
	6	4 km south-west Hacienda Alto Viento, Experimental Station of the Facultad de Agronomía, LUZ
	7	Road to La Represa, 3 km before turning to Villa del Rosario
	8-13	Río Limón, 2.5 km S of Guardia Nat. Station, near Puerto Mara
	14	Near Puerto Concha
	15-19	Sector La Chamita, Parque Nacional Ciénagas de Juan Manuel de Aguas Blancas y de Aguas Negras
	20	Bobures
	24	Los Olivitos
Trujillo	22	Buena Vista
Distrito Capital	27	Embalse La Mariposa
	28	Círculo Militar, Caracas,
	76	Botanical Garden, Caracas
Aragua	29	Laguna Taiguaiguay
	42	Above Embalse de Camatagua
	43	South-east edge of the Embalse de Camatagua
Guárico	30-31	2 km south of Calabozo
	32	Corozo Pando, north of San Fernando
	33	Camaguán
	34-35	South of Las Mercedes
	36-37	South-east of Valle de la Pascua
	38	Potrerito, Represa Mata Redonda
	39	El Palito
	40	North of El Socorro, Caro Herrado

Table 1. Continuation

State	No.	Locality
Guárico	41	Fundo El Ríos
	44	Quebrada Valle de la Pascua, east of Valle de la Pascua,
	45-46	Finca Santo Domingo, between El Socorro and Santa Maria de Ipire,
Anzoátegui	47-48	Morichal between El Tigrito and San Tomé
	73-74	South of Barcelona, Potreros and front of La Cruz
	75	West of Aragua de Barcelona
Monagas	49	Sector Cachapera, south of Caripito
Sucre	50	Tabaquillos, Campo Libre
	51	Sector La Pica, el Mayar, vía Carúpano, Laguna de Cariaco
	52-53	Platanillo, Bajos de Guayana
	54	Tunapuy, vía Catuaro
	55	Río Seco I, vía Yaguaraparo
	56	Los Palmares, vía Yaguaraparo
	57-58	Río Chiquito Abajo, Irapa
	60	Laguna de Bohordal, vía Tunapuy – Yaguaraparo
	61	Río Grande Arriba, Finca of Mr. Subero
	62	Vuelta Larga, Guaraunos
	63	Salida de Playa Grande
	64-65	Laguna de Cariaco, al lado del Peaje
Nueva Esparta (Margarita Island)	66	El Palito, Pedegrales, Juan Griego
	67	Las Cabreras
	68-69	Los Millanes (Los Caraballos)
	70	Laguna El Macho, Vergel
	71	Embalse de San Juan (Valle Hondo)
	72	Sillero, via la Isleta

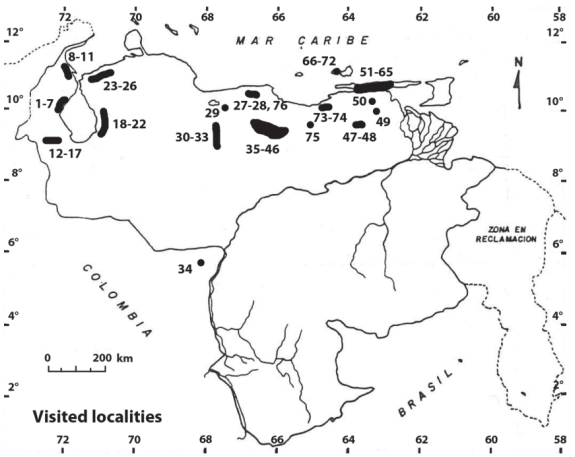

Fig. 1. Localities visited during the stay in Venezuela 2005. Numbers show collection sites of Lemnaceae.

The frequency of occurrence of a species in the relevés of a region is recorded by the number of relevés containing a species:

I present in 0-20% of all relevés
II present in 20-40% of all relevés
III present in 40-60% of all relevés
IV present in 60-80% of all relevés
V present in 80-100% of all relevés

The composition of different species determines the classification of the different communities. They are hierarchically structured. The most important community level is the association. The Latin name of it ends in –etum.

RESULTS AND DISCUSSION

Family description

Lemnaceae are characterized by a strongly reduced morphology and by extensive adaptation to the free-floating life on the surface of the water or submerged in the water. Plants are generally very small and not organized in shoot, leaves and roots like most of other flowering plants. The green photosynthesizing organ is called a frond. It is mostly interpreted as homologous to an integrated shoot and leave. The size of the frond is rarely larger than 10 mm and sometimes not bigger than 0.5 mm. New fronds originate from two pockets (*Spirodela*, *Landoltia*, *Lemna*), one pocket (*Wolffiella*) or a cavity (*Wolffia*) at the base of the frond. These so-called daughter fronds can cohere with the mother frond and form small groups, clusters or chains in the water.

Flowering organs, taken for flowers or reduced flower stands according to the interpretation of the expert are very reduced and consist of one pistil and 1-2 stamens (Hegelmaier 1868). In the following the flowering organs are called flowers independent of the disputed status. Flowering is mostly rare except in some tropic species. Roots are simple, adventitious, 1-21, all originating from one point at the lower side of the front, or missing. They are stabilizing organs and do not have root hairs. More about morphology and anatomy of Lemnaceae can be seen in Landolt (1986, 1998a, b), Landolt & Schmidt-Mumm (2009).

Key to genera and species

1a. Fronds with 1-21 roots and 1-21 veins; two lateral pockets with daughter fronds at the base of the fronds; 1-2 flowers per frond situated in the pocket; flower enclosed in an membranous utricular leaflet; 1-2 stamina and one pistil present; seeds with longitudinal ribs.....2

1b. Fronds without roots and veins; only one pocket or one cavity with daughter fronds at the base of the frond; 1-2 flowers developing in a cavity each on the upper surface of the frond, not surrounded by an utricular leaflet; one 2 locular stamen and one pistil present; seed nearly smooth on the surface 10

2a. Fronds with 2-21 roots and 5-21 veins, with a membranous prophyllum at the base of the frond (use a binocular!).....3

2b. Fronds with one root and 1-5 veins; no membranous prophyllum at the base of the frond.....5

3a. Fronds 1-11/2 times as long as roots, with 7-21 veins and 7-21 roots from which 1-5, but not all perforate the covering scale (*Spirodela*).....4

3b. Fronds 11/2-3 times as long as roots, with 5-7 veins and 2-7 roots from which all perforate the scale (*Landoltia*).....*L. punctata*

4a. 2-5 roots perforating the scale; no turion present, no red spot on the frond surface.....*S. intermedia*

4b. One root (rarely two roots) perforating the scale; turions sometimes present; the frond surface often with a red spot above the node....*S. polyrhiza*

5a. Fronds thick, often gibbous below; the lower surface sometimes reddish; roots often longer than 3 cm.....6

5b. Fronds not gibbous below, not with reddish colour; roots not longer than 3.5 cm.....7

6a. Longest airspaces mostly longer than 0.3 mm; if the lower front side is reddish the colour extends to the edge of the frond.....*L. gibba*

6b. Longest airspaces mostly smaller than 0.3 cm; if lower frond side is reddish, the colour leaves a small light stripe along the margin of the frond.....*L. obscura*
7a. Fronds with three veins, root sheath with lateral wings...*L. aequinoctialis*
7b. Fronds with one vein; root sheath not winged.....8
8a. Vein normally prominent, longer than the area of the airspaces or at least ¾ as long as the distance between node and frond tip.....9
8b. Vein normally shorter than the area of the airspaces, rarely longer than 2/3 of the distance between node and front tip.....*L. minuta*
9a. Fronds rarely longer than 3.5 mm, thin, often transparent, growing in water, very rarely on rocks .....*L. valdiviana*
9b. Fronds 3-6 mm long, not transparent, growing on steep wet rock walls.....*L. yungensis*
10a. Fronds flat; with aerenchymatic tissue throughout the frond or restricted to the base; one flat pocket at the base; flowers developing in a cavity on the upper surface of the frond which is situated laterally of the median frond line near the base (*Wolffiella*).....11
10b. Fronds rounded below, orbicular to ovoid; without aerenchymatic tissue; one cavity at the base; flowers originate in a cavity which is mostly situated on the upper frond surface in the median line near the base of the frond (*Wolffia*).....15
11a. Fronds with 20-35 stomata; the aerenchymatic tissue not very distinct; only one flower per frond.....*Wolffiella neotropica*
11b. Fronds with 0-8 stomata; the aerenchymatic tissue distinct; 1-2 flowers per frond 12
12a. Tract of elongated cells on the lower wall of the pocket following exactly the median line; 2 flowers per frond.....*Wolffiella welwitschii*
12b. Tract of elongated cells on the lower wall of the pocket following slightly to strongly on the side of the median line.....13
13a. Pocket more or less symmetrical; distal end of the frond nearly as wide as long or gradually attenuated into the tip.....14
13b. Pocket distinctly asymmetrical; distal end of the frond suddenly attenuated into a narrowly prolongated tip.....*Wolffiella caudata*
14a. Angle of the pocket 70-120°; the track of elongated cells on the lower wall of the pocket following somewhere between the median line and the lateral order of the pocket; aerenchymatic tissue reaches not more than to half of the distance towards the tip of the frond.....*Wolffiella lingulata*

14b. Angle of the pocket 45-90°; the track of the elongated cells on the lower wall of the pocket following along the lateral limit of the pocket; aerenchymatic tissue often reaching ear to the tip of the frond..... .....*Wolffiella oblonga*

15a. Fronds nut-shaped, with brown pigment cells in the vegetative tissue (visible only in dead cells); mostly with a prominent papule in the centre of the upper surface, with 50-100 stomata on the upper surface.. .....*Wolffia brasiliensis*

15b. Fronds cylindrical, globular or ovoid, without pigment cells in the vegetative tissue; without a prominent papule on the upper surface; with 1-10 (rarely up to 30) stomata on the upper surface.....16

16a. Fronds mostly cylindrical, 2-4 times as long as wide; the distal part of the daughter frond often submerged.....*Wolffia elongata*

16b. Fronds globular to ovoid, 1-2 times as long as wide; the distal part of the daughter frond not submerged.....17

17a. Fronds 1-11/3 times as long as wide, 0.4-1.2 mm wide..... .....*Wolffia columbiana*

17b. Fronds 11/3-2 times as long as wide, 0.3-0.7 mm wide..... .....*Wolffia globosa*

LANDOLTIA Les & D.J. Crawford, Novon 9: 532. 1999.

Fronds one to several cohering together, 1.5-8 mm long, 11/2-2 times as long as wide, surrounded at the base by a small scale-like leaflet (prophyllum); lower surface and margins of upper surface often red coloured; many layers of air spaces present between the upper and the lower surface, largest air spaces shorter than 0.3 mm; veins 3-7 with tracheids present, originating from the node and directed towards the tip; many small papules may occur above the veins on the frond surface present; two different crystal cells present: fascicle-like raphid crystals and morning star formed druse crystals; pigment cells missing. *Roots* 1-7, rarely up to 12, 0.5-120 mm long; root cap mostly acute. At the base of the frond two pockets present from where daughter fronds develop; tip of root cap rounded. *Flowers* enclosed in an utricular leaflet which is open on one side, with one pistil and two 4-locular stamens present. Ovary with 1-5 ovules; external locules of the anthers higher situated than the inner ones. *Seed* with longitudinal ribs. One species.

Landoltia punctata (G. Mey.) Les & D.J. Crawford, Novon 9: 532. 1999. (Fig. 2)

Lemna punctata G. Mey.
Spirodela punctata (G. Mey.) C.H. Thomps.
Spirodela oligorrhiza (Kurz) Hegelm.
See description under the genus. Rarely flowering.

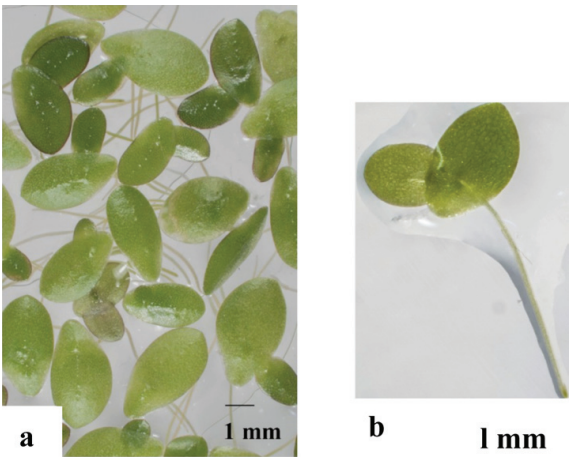

Fig. 2. *Landoltia punctata.* **a.** From above. **b.** From below.

Habitat: Warm temperate to tropic, moderately dry to moderately humid, suboceanic climate.

General distribution: Original distribution uncertain, probably south-east Asia and Australia; now is occurring in many continents: south-eastern and south-western Asia, southern Europe, Australia, North and South Africa, oceanic Islands, southern North America, coastal areas of warmer South America.

Distribution in Venezuela: Aragua, Distrito Capital, Nueva Esparta and Sucre (Fig. 3).

Examined material: **Aragua:** above Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 42/05* (VEN, ZT); SE edge of the Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 43/05* (VEN, ZT). **Distrito Capital**: La Mariposa, 11/02/2005, *E. Landolt & W. Lämmler 27/05* (VEN, ZT); Caracas, Botanical Garden, 25/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 76/05* (VEN, ZT). **Nueva Esparta**: Margarita Island, Laguna El Macho, Vergel, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 70/05* (VEN, ZT); Margarita Island, Sillero, vía la Isleta, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 72/05* (VEN, ZT). **Sucre:** Tunapuy, vía Catuaro, 20/02/2005, *E. Landolt*, *W. Lämmler & S.*

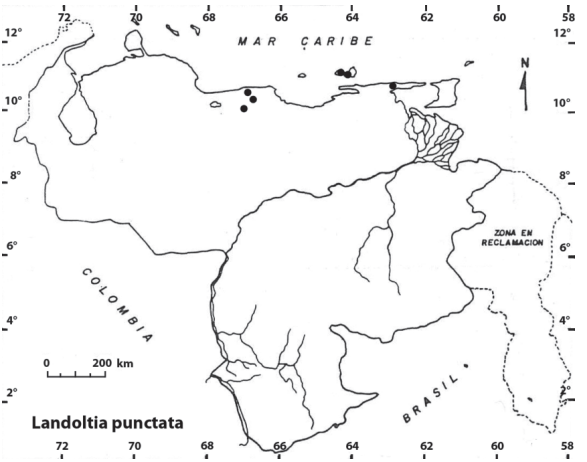

Fig. 3. Distribution of *Landoltia punctata.*

Pacheco 54/05 (VEN, ZT); río Seco 1, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 55/05* (VEN, ZT); río Chiquito Abajo, Irapa, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 57-58/05* (VEN, ZT); Bohordal, vía Tunapuy-Yaguaraparo, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 60/05* (VEN, ZT); Vuelta Larga Guaraunos, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 62/05* (VEN, ZT).

Remarks: Introduced in Venezuela. First voucher specimen: 2005.

LEMNA L., Sp. Pl. 2: 970. 1753.

Fronds one to several cohering together, 1-15 mm long, 1-4 times as long as wide, not surrounded at the base by a small scale-like leaflet; lower and upper surface often red coloured or without anthocyanins; air spaces present between the upper and the lower surface; veins 1-5 with or without tracheids present originating from the node and directed towards the tip; prominent papules above the veins on the frond surface present or missing; crystal cells present: only raphid crystals, but no druses. *Root* one, up to 15 cm long. At the base of the frond two pockets present from where daughter fronds develop. *Flowers* enclosed in an utricular leaflet which is open on one side, with one pistil and two 4-locular stamens present. Ovary with 1-7 ovules; external locules of the anthers higher situated than the inner ones. *Seed* with longitudinal ribs. 13 species.

Lemna aequinoctialis Welw., Ann. Cons. Ultramar. 1: 578. 1858 [1859] (Fig. 4).

Lemna angolensis Hegelm.
Lemna perpusilla auct. non Torr.
Lemna paucicostata Hegelm.
Lemna minor auct. plur. non L.

Fronds 1-6 mm long, 1-3 times as long as wide; greatest width in the medium, never gibbous, three veins present, very distinct papule near the tip and above the node, never with red colour; several layers of air spaces present,

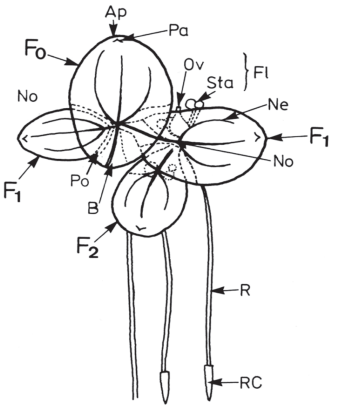

Fig. 4. *Lemna aequinoctialis.* Group of fronds with flowers (after Hegelmaier 1868) (x 7). **Ap** = apex; **B** = base; **BP** = basal part of the frond; **F_0** = mother frond; **F1** = daughter frond of the first generation; **F2** = daughter frond of the second generation; **Fl** = Flower; **Ne** = vein; **No** = node; **Ov** =ovary; **Pa** = papule; **Po** = pocket; **R** = root; **RC** = root cap; **Sta** = stamen; After Landolt (1980).

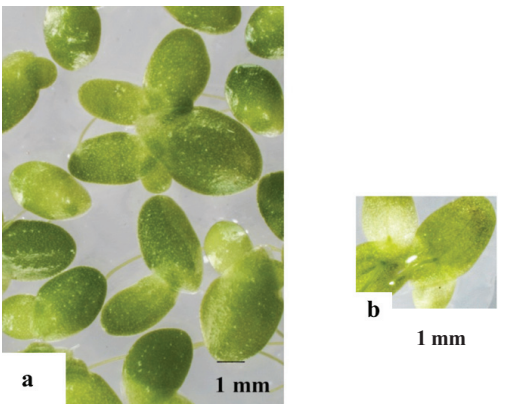

Fig. 4.2. *Lemna aequinoctialis*. **a.** From above. **b.** below.

largest air spaces shorter than 0.3 mm; veins three present with tracheids only at the base of the middle one. *Root* length up to 3 cm; root sheath with two wings at the base; tip of root cap acute. Ovary with one ovule. Often flowering.

Habitat: Subtropical to warm tropical, moderately humid to moderately dry climate.

General distribution: Warm regions of the whole world.

Distribution in Venezuela: Anzoátegui, Apure, Aragua, Barinas, Delta Amacuro, Distrito Capital, Falcón, Guárico, Lara, Miranda, Portuguesa, Sucre, Trujillo, Zulia (Fig. 5).

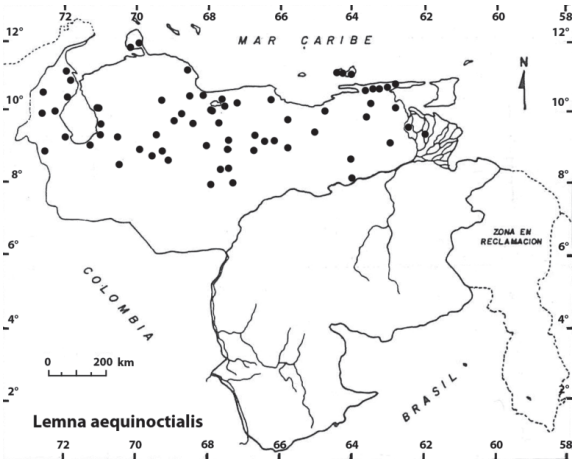

Fig. 5. Distribution of *Lemna aequinoctialis*.

Examined material: **Anzoátegui:** La Soledad, 8/1953, *H. Ginés 3893* (US); Morichal between El Tigrito and San Tomé, 19/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 47/05* (VEN, ZT); S of Barcelona, Potreros and frente a La Cruz, 24/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 73-74/05* (VEN, ZT); W of Aragua de Barcelona, 24/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 75/05* (VEN, ZT). **Apure**: distrito Rómulo Gallegos, Laguna de Término, Hato San Felipe, 8/03/1979, *G. Davidse & A.C. González 16193* (VEN). **Aragua:** Lake Valencia near Maracay Airport, 26/12/1938, *A.H.G. Alston 5682* (BM); Maracay, Instituto Botánico, 7/04/1970, *L. Cárdenas 1216* (MY, ZT); Maracay, INCE, 14/08/1968, *L. Cárdenas de Guevara 526* (MY); autopista Maracay-La Victoria, 9/8/1972, *B. Trujillo 13359a* (MY); Santa Cruz, Embalse de Taiguaiguay, 6/06/1972, *B. Trujillo 11151* (MY); Laguna Taiguaiguay, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 29/05* (VEN, ZT); above Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 42/05* (VEN, ZT); SE edge of the Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 43/05* (VEN, ZT). **Barinas:** between Bruzual and Dolores, near río Apure, 17/04/1986, *E. Zuber* (ZT); cerca de Barinas, 17/04/1986, *E. Zuber* (ZT). **Cojedes**: El Baúl,

entre El Montoso y el río Cojedes, 7/09/1980, *B. Trujillo*, *M. Ponce & A. Ridell 16603* (MY); distrito Ricaurte, El Amparo, 18/12/1979, *F. Delascio 8577* (VEN). **Delta Amacuro**: Capure, Caño Mánamo, 05/1996, *G. Colonnello 3252* (ZT); between Tucupita and Cocuina, 12/10/1977, *J.A. Steyermark*, *R. Liesner & F. Delascio 114544* (VEN). **Distrito Capital:** Caracas, río Caroata, *A. Ernst 1869* (STU); Caracas, 24/01/1865, *A. Ernst* (STU); La Mariposa, 11/02/2005, *E. Landolt & W. Lämmler 27/05* (VEN, ZT). **Falcón**: Parque Nacional Morrocoy, between Tucacas and Sanare, SW of Cerro Chichiriviche, 5/09/1982, *J.A. Steyermark & I. Narbeiza 126547* (VEN); Paraguaná, Pueblo Nuevo, Monte Cano, 16/08/1988, *J. Castillo & V. Marcano 102* (VEN); Paraguaná, Adícora, 1938, *F. Tamayo 18422* (BR). **Guárico**: entre Los Cruceros, La Guamita y Barbacoas, 9/08/1972, *B. Trujillo* (MY); 20 km S of Chaguaramas, Roblecito, 19/11/1973, *G. Davidse 4246* (VEN); 2 km S of Calabozo, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 31/05* (VEN, ZT); N of San Fernando, Corozo Pando, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 32/05* (VEN, ZT); Camaguán, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 33/05* (VEN, ZT); SE of Valle de La Pascua, 15/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 36-37/05* (VEN, ZT); E of Valle de La Pascua, quebrada del Valle de La Pascua, 18/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 44/05* (VEN, ZT); between El Socorro and Santa María de Ipire, Finca Santo Domingo, 18/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 45/05* (VEN, ZT); N of El Socorro, Caro Herrado, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 40/05* (VEN, ZT); Fundo El Ríos, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 41/05* (VEN, ZT). **Lara:** Crespo, Carrizal, 30 km N of Barquisimeto, 22/07/1970, *S.S. Tillett 707-49* (ZT); Crespo, El Paso, 25 km N of Barquisimeto, 22/07/1970, *S.S. Tillett 707-50* (ZT). **Miranda**: Cua, río Tuy, 23/03/1869, *A. Ernst* (STU). **Monagas:** río Morichal Largo, between Temblador and El Silencio, 27/10/2005, *J.A. Steyermark*, *R. Liesner & F. Delascio* (VEN); San Agustín, NW of Caripe, 5/04/1945, *J.A. Steyermark 61797* (VEN); río Amana, NE of Santa Bárbara, 13/04/1967, *R.A. Pursell et al. 8729* (NY, PAC); sector Cachapera, S of Caripito, 19/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 49/05* (VEN, ZT). **Nueva Esparta**: Margarita Island, Las Cabreras, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 67/05* (VEN, ZT); Margarita Island, El Palito Pedegrales, Juan Griego, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 66/05* (VEN, ZT); Margarita Island, Los Millanes (Los Caraballos), 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 68-69/05* (VEN, ZT); Margarita Island, Laguna El Macho, Vergel, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 70/05*

(VEN, ZT); Margarita Island, Embalse de San Juan (Valle Hondo), 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 71/05* (VEN, ZT); Margarita Island, Sillero, vía la Isleta, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 72/05* (VEN, ZT). **Portuguesa**: Píritu, 20 km S of Acarigua, 12/07/1970, *S.S. Tillett 707-48* (ZT); río Tucupido, Las Panelas-Agua Sucia, 27/04/1986, *B. Stergios 9286* (PORT); Guanare, between Guanare and río Portuguesa, 24/06/1985, *B. Stergios & G. Aymard 8523* (PORT); orilla del Caño, 6/06/1983, *B. Stergios & E. Reyes 6863* (PORT); Guanare-Guanarito, 27/07/1980, *B. Stergios 2045* (PORT); Guanare-La Morita, 8/01/1986, *B. Stergios 8822-8824* (PORT); Riego Las Majaguas, río Guanare, 10/10/1975, *B. Trujillo 11299* (MY); Páez, carretera Sombrerito-Payara, 25/08/1984, *B. Stergios & N. Grimán 7026* (PORT). **Sucre:** Lago de Guanoco, 08/1955, *T. Lasser & V. Vareschi 3732* (VEN); Lagunas Litorales de Cumaná, 9/01/1974, *L.J. Cumana & W. Lampe 0515* (US, VEN); Cariaco-Campoma, Laguna de Campoma, 28/10/1972, *B. Trujillo 11925* (MY); Tabaquillos, Campo Libre, 20/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 50/05* (VEN, ZT); sector La Pica El Mayar, vía Carúpano, Laguna de Cariaco, 20/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 51/05* (VEN, ZT); Platanillo, Bajos de Guayana, 20/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 52-53/05* (VEN, ZT); Tunapuy, vía Catuaro, 20/2/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 54/05* (VEN, ZT); río Seco 1, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 55/05* (VEN, ZT); Los Palmares, vía Yaguaraparo, 21/02/2005, *E. Landolt*, *W. Lämmler* & *S. Pacheco 56/05* (VEN, ZT); río Grande Arriba, Finca of Mr. Subero, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 60/05* (VEN, ZT); salida de Playa Grande, 22/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 63/05* (VEN, ZT); Laguna Cariaco, lado del Peaje, 22/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 64-65/05* (VEN, ZT). **Trujillo**: Valera, plateau of the Cordillera, 11/1890, *Goebel* (STU); Buena Vista, 6/02/2005, *E. Landolt & W. Lämmler 22/05* (VEN, ZT). **Zulia**: Bulevar, entre Lara-Zulia y El Zamuro, 27/11/1979, *G.S. Bunting 8300* (VEN); río El Palmar, 11/2004, *A. Fernández*, *G. Colonnello & E. Guzmán* (VEN); La Maroma, cerca de Santa Bárbara, 21/11/1972, *B. Trujillo 12134* (MY); laguna cerca del río Apón, 10/01/1948, *T. Lasser 2426* (VEN); Colón, intersection of río Catatumbo and the Fría -Maracaibo Hwy., 29/06/1980, *G. Davidse*, *A.C. González & R.A. León 18811* (VEN); Perijá, near Maracaibo, 11/1867, *A. Karsten* (JE, MO, STU, U); Santa Bárbara, caño La Maroma, 21/11/1972, *B. Trujillo 12135* (MY); río El Palmar sur Maracaibo, 11/2004, *G. Colonnello*, *A. Fernández & E. Guzmán 20786* (ZT); S of Maracaibo, Potrerito, 2/02/2005, *E. Landolt & W. Lämmler 1/05* (VEN, ZT); Maracaibo,

road to Barranquitas, 2/02/2005, *E. Landolt & W. Lämmler 3/05* (VEN, ZT); Hacienda Alto Viento, near río Palma, 2/02/2005, *E. Landolt & W. Lämmler 5/05* (VEN, ZT); 4 km SW Hacienda Alto Viento, Experimental Station of the Facultad de Agronomía, *E. Landolt & W. Lämmler 6/05* (VEN, ZT); río Limón, 2.5 km S of Guardia Nat. Station, near Puerto Mara, 3/02/2005, *E. Landolt & W. Lämmler 8/05, 9/05, 12/5, 13/05* (VEN, ZT); near Puerto Concha, 5/02/2005, *E. Landolt & W. Lämmler 14/05* (VEN, ZT); Parque Nacional Ciénagas de Juan Manuel, sector La Chamita, 5/02/2005, *E. Landolt & W. Lämmler 15-19/05* (VEN, ZT); Bobures, 6/2/2005, *E. Landolt & W. Lämmler 20/05, 21/05* (VEN, ZT); Los Olivitos, 7/02/2005, *E. Landolt & W. Lämmler 23-24/05* (VEN, ZT); El Níspero, 7/02/2005, *E. Landolt & W. Lämmler 25/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1865.

Lemna gibba L., Sp. Pl. 2: 970. 1753. (Fig. 6).

Fronds 2-7 cm long, 1-11/2 times as long as wide; greatest width in the medium or in the upper third of the frond, often gibbous; rarely prominent papules present; often red spots on the upper surface and reddish on the lower surface up to the margin, the pigmentation beginning from the margins of the frond; many layers of air spaces present; largest air spaces longer than 0.3 mm; *veins* 3-5 present. *Root* length up to 15cm; root sheath without wings at the base; tip of root cap rounded. Ovary with 2-7 ovules. Often flowering.

Habitat: Temperate to subtropical, suboceanic, rather dry, often Mediterranean climate; climbing up to more than 4000 m asl in warm climatic zones. Water rich in nutrients, especially nitrogen, calcium and magnesium.

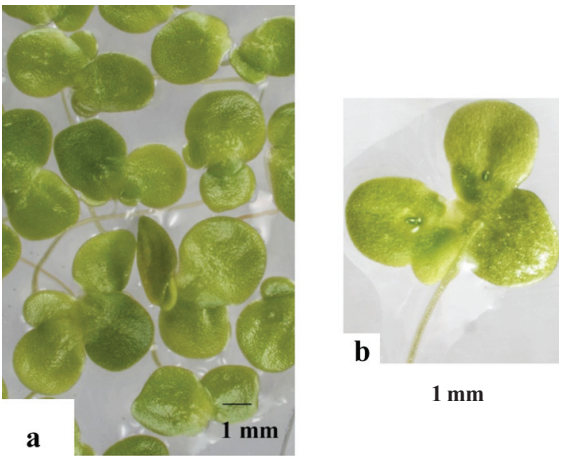

Fig. 6. *Lemna gibba*. **a.** From above. **b.** From below.

General distribution: Western North America, western and southern South America; western and southern Europe; southwestern Asia; northern and southern Africa; introduced in Japan.

Distribution in Venezuela: Cojedes (Fig. 7).

Examined material*:* **Cojedes**: distrito Anzoátegui, vía Lagunita, 1/06/1981, *F. Delascio-Chitty & R. López 9756* (VEN).

Remarks: Indigenous, but restricted to the cordilleras. In Venezuela it is also to be expected in. First and single voucher specimen: 1981.

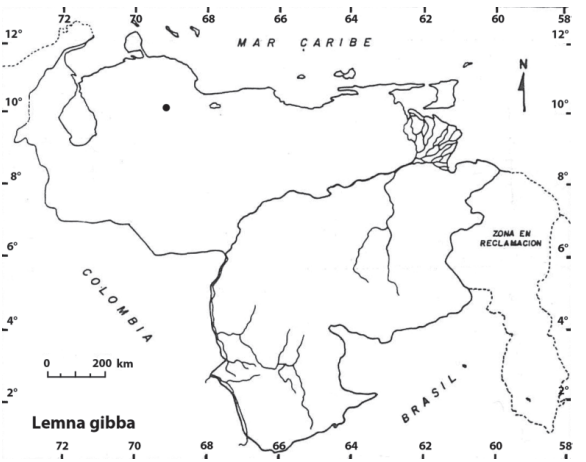

Fig. 7. Distribution of *Lemna gibba.*

Lemna minuta Kunth, Nov. Gen. Sp. ed. 4, 1: 372. 1816 (Fig. 8)
Lemna minima Phil. ex Hegelm.
Lemna minuscula Herter
Lemna valdiviana Phil. var. *abbreviata* Hegelm.

Fronds 1-3 mm long, 11/5-2 times as long as wide; greatest width in the medium, never gibbous; indistinct papules or no papules along the vein; 1-2 layers of air spaces present, largest air spaces shorter than 0.3 mm; *vein* one without tracheids present, mostly as long or shorter than the length of the area of air spaces. *Root* length up to 3 cm; *root* sheath without wings at the base; tip of root cap rounded to acute. Ovary with one ovule. Rarely flowering.

Habitat: Warm temperate, moderately dry to moderately humid, suboceanic climate, up to more than 4000 m asl.

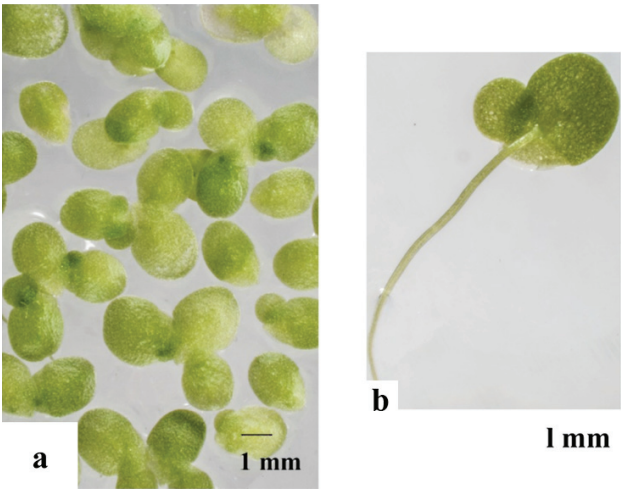

Fig. 8. *Lemna minuta.* **a.** From above. **b.** From below

General distribution: America without arctic and continental cool temperate regions; main distribution area in subtropical and mountain regions warm tropical regions; today introduced in most regions of the world with similar climate (e.g. Europe, eastern Asia).

Distribution in Venezuela: Carabobo, Distrito Capital, Mérida, Trujillo (Fig. 9).

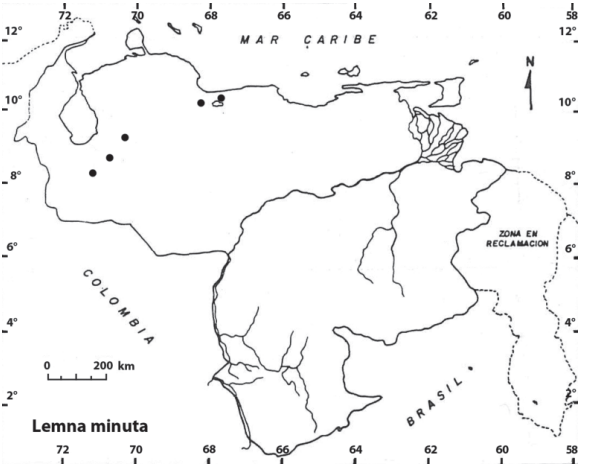

Fig. 9. Distribution of *Lemna minuta.*

Examined material: **Carabobo***:* Lake Valencia near Maracay Airport, 26/12/1938, *A.H.G. Alston 5680* (BM). **Distrito Capital**: Caracas, quebrada

Tenería, 6000 ft, 4/04/1869, *A. Ernst* (STU). **Mérida**: above La Carbonera, 2430 m, 22/04/1944, *J.A. Steyermark 56004* (VEN); Misinta above Mucuchíes, 6/02/1928, *H. Pittier 12918* (ANS, BR, G, M, US). **Trujillo**: Pico Teta de Niquitao, 3400 m asl, 04/1998, *G. Colonnello 3253* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1869.

Lemna obscura (Austin) Daubs, Illinois Biol. Monogr. 34: 20. 1965. (Fig. 10)
Lemna minor L. var *obscura* Austin
Lemna ecuadoriensis Landolt

Fronds 1-4 mm long, 11/5-12/3 times as long as wide; greatest width in the medium or in the upper third of the frond, sometimes gibbous; very distinct papule near the tip and several indistinct ones along the middle vein; sometimes with red spots on the upper surface, and often deep reddish on the lower surface, with a small light stripe near the margin; the pigmentation beginning from the node where the root arises; many layers of air spaces present; largest air spaces rarely longer than 0.3 mm; three veins with tracheids in the middle one present. *Root* length up to 15 cm; root sheath without wings at the base; tip of root cap acute. Ovary with one ovule. Rarely flowering.

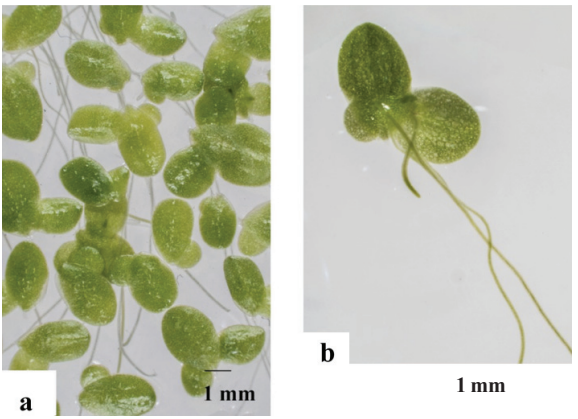

Fig. 10. *Lemna obscura.* **a.** From above. **b.** From below.

Habitat: Warm temperate to tropical suboceanic and moderately dry climate. Water rich in nutrient.

General distribution: Originally in southeastern USA and Highland of Mexico, introduced to Hawaii and coastal lowlands of northwestern South America (Ecuador, Colombia, Venezuela).

Distribution in Venezuela: Falcón, Zulia (Fig. 11)

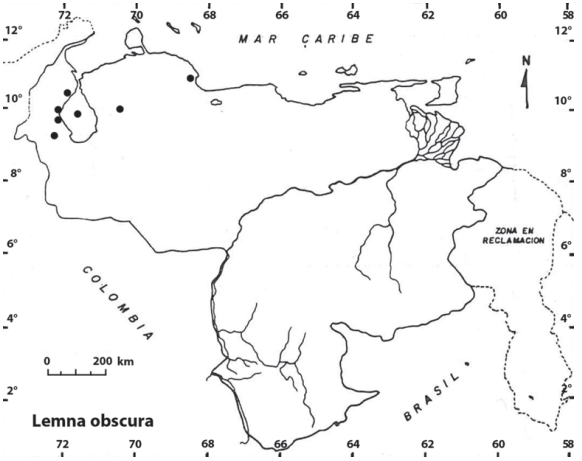

Fig. 11. Distribution of *Lemna obscura.*

Examined material: Falcón: Parque Nacional Morrocoy, Tibana, carretera de Tocuyo a Sanare, 11/10/1993, *E. Melgueiro & M. Ballesteros MB 232, 233* (VEN). **Zulia:** Colón, intersection of río Catatumbo and La Fría, Maracaibo, Hwy 6, 29/06/1980, *G. Davidse*, *A.C. González & R.A. León 18811* (VEN); Maracaibo, road to Barranquitas, 2/02/2005, *E. Landolt & W. Lämmler 3/05* (VEN, ZT); 4 km SW Hacienda Alto Viento, Experimental Station of the Facultad de Agronomía, 2/02/2005, *E. Landolt & W. Lämmler 7/05* (VEN, ZT).

Remarks: Probably introduced. First voucher specimen: 1980 (first voucher specimen from Ecuador: 1974).

Lemna valdiviana Phil., Linnaea 33: 329. 1864 (Fig. 12)
Lemna cyclostasa (Elliott) C.H. Thomps.
Lemna torreyi Austin

Fronds 1-4 mm long, 11/5-2 times as long as wide; greatest width in the medium, never gibbous; indistinct papules or no papules along the vein; one layer of air spaces present, largest air spaces shorter than 0.3 mm; *vein* one without tracheids present, mostly prominent and longer than the area of air spaces or at least ¾ of the distance between the node and the tip of the frond. *Root* length up to 1.5 cm; root sheath without wings at the base; tip of root cap rounded to acute. Ovary with one ovule. Rarely flowering.

Habitat: Warm temperate to tropical, moderately humid, suboceanic climate.

General distribution: Warm regions of America.

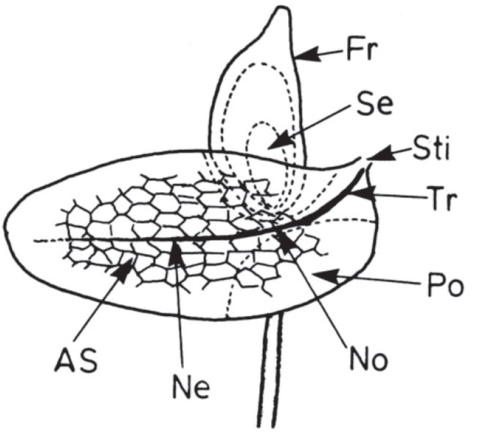

Fig. 12. *Lemna valdiviana*. Frond with fruit (after Hegelmaier 1868) (x 12).
AS = air spaces; **Fr** = fruit; **Ne** = vein; **No** = node; **Po** = pocket; **Se** = seed; **Sti** = stipe connecting daughter frond and mother frond; **Tr** = tract of elongated cells connecting stipe and node. After Landolt (1980).

Distribution in Venezuela: Aragua, Carabobo, Distrito Capital, Guárico, Monagas, Portuguesa, Sucre, Yaracuy, Zulia (Fig. 13)

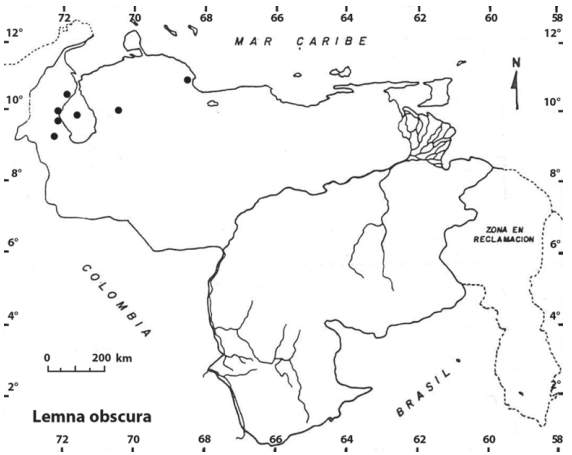

Fig. 13. Distribution of *Lemna valdiviana.*

Examined material: **Aragua:** Maracay, Palo Negro, 20/05/1972, *B. Trujillo 11117* (MY). **Carabobo:** 7 km E of Morón, 16/08/1970, *S.S. Tillett 708-52* (ZT). **Distrito Capital**: Silla de Caracas, 1870, *A. Ernst* (STU).

Guárico: Camaguán, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 33/05* (VEN, ZT). **Monagas:** río Morichal Largo between Temblador and El Silencio, 27/10/2005, *J.A. Steyermark*, *R. Liesner & F. Delascio 115374* (VEN). **Portuguesa:** Papelón, caño Maraca, 20/08/1984, *B. Stergios 8639* (PORT); Guanare-La Morita, 8/01/1986, *B. Stergios 8822-8824* (PORT). **Sucre:** Benítez, east of Pozotes between Guaraunos and Ajíes, 18/02/1980, *J.A. Steyermark*, *R. Liesner & Carreño 121281* (VEN); río Seco 1, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 55/05* (VEN, ZT); Vuelta Larga, Guaraunos, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 62/05* (VEN, ZT). **Yaracuy:** between Chivacoa and Morón, 12 km N of Marín, 6/12/1970, *S.S. Tillett 7012-57* (ZT). **Zulia:** La Maroma, cerca de Santa Bárbara, 21/11/1972, *B. Trujillo 12134, 12135* (MY); río Limón, 3/02/2005, *E. Landolt & W. Lämmler 12/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1870.

Lemna yungensis Landolt, Ber. Geobot. Inst. E.T.H., Stiftung Rübel Zürich 64: 16. 1998.

Fronds 3-5 mm long; mostly two layers of air spaces present. Otherwise like *L. valdiviana*. Rarely flowering.

Habitat: Moderately warm, humid tropical climate. Vertical wet rocks at altitudes of 1500-2800 m asl.

General distribution: Yunga of Bolivia.

Distribution in Venezuela: No locality.

Remarks: The species is probably restricted to Bolivia.

SPIRODELA Schleid., Linnaea 13: 391. 1831.

Fronds one to several cohering together, 5-12 mm long, 1-11/2 times as long as wide, surrounded at the base by a small scale-like leaflet (prophyllum); lower surface and margins of upper surface often red coloured; many layers of air spaces present between the upper and the lower surface, largest air spaces shorter than 0.3 mm; 7-16 (rarely up to 21); veins with tracheids present, originating from the node and directed towards the frond tip; no prominent papules above the veins on the frond surface; two different crystal cells present: fascicle-like raphid and morning star formed druse crystals; pigment cells present in the frond tissue (visible in dead fronds as brown dots). *Roots* 7-21, of which 1-5 perforate the covering lobe of the prophyllum, up to 4 cm long; root cap mostly acute. At the base of the frond two pockets present

from where daughter fronds develop. *Flowers* enclosed in an utricular leaflet with narrow opening at the top, with one pistil and two 4-loculed stamina present. Ovary with 1-5 ovules; external locules of the anthers situated at the same level than the inner ones. *Seed* with longitudinal ribs. Two species.

Spirodela intermedia W. Koch, Ber. Schweiz. Bot. Ges. 41: 114. 1932 (Fig. 14)

Spirodela biperforata W. Koch

Fronds obovate, suborbicular to pear-shaped, mostly rounded at the tip, often gibbous; without a red spot above the node. No brown to dark-green rootless *turions* present. *Roots* 2-5 perforate the prophyllum. Rarely flowering.

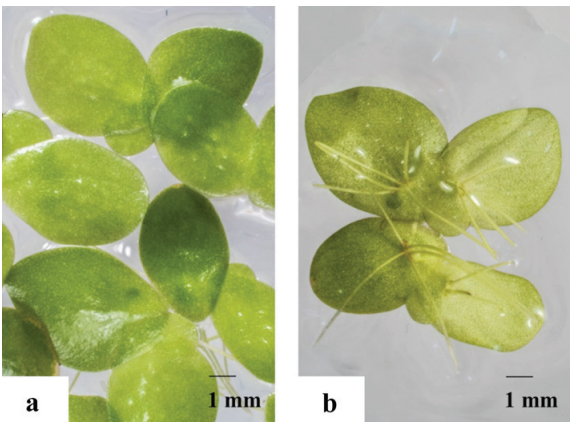

Fig. 14. *Spirodela intermedia*. **a.** From above. **b.** From below.

Habitat: Warm temperate to warm tropical, moderately dry to moderately humid climate.

General distribution: South and Central America.

Distribution in Venezuela: Aragua, Barinas, Bolívar, Delta Amacuro, Carabobo, Monagas, Portuguesa, Sucre, Zulia (Fig. 15).

Examined material: **Aragua**: Lake Valencia near Maracay Airport, 26/12/1938, *A.H.G. Alston 5680* (BM); Malariología, 26/05/1941, *Salazar 7* (US); Embalse de Taiguaiguay**,** 20/08/1962, *H. Cárdenas* (MY). **Barinas**: Arismendi, río Guanare Viejo, 6/04/1984, *B. Stergios*, *D. Taphor*, *L. Nico & C. Gilbert 6913* (PORT); Reserva Forestal Ticoporo, Socopo, 10/04/1983, *B. Stergios*, *D. Taphorn & C. Lilyestrom 5674* (PORT). **Bolivar**: distrito Roscio, río Venamo, confluencia con el río Cuyuní, 1/02/1980, *F. Delascio-Chitty & R. López 8837* (VEN). **Carabobo**: Lago de Valencia, *P.J.M. Maas 2175* (U).

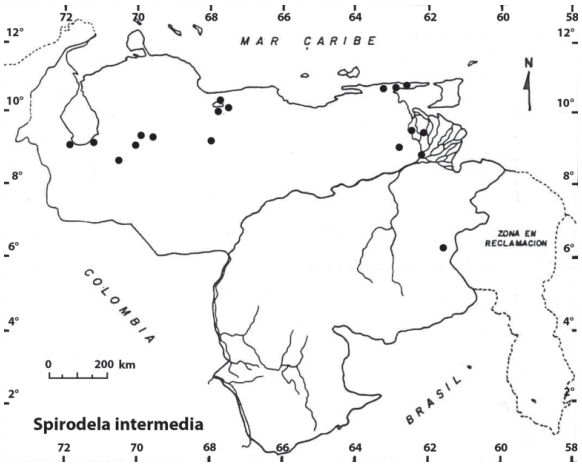

Fig. 15. Distribution of *Spirodela intermedia.*

Delta Amacuro: between Tucupita and La Horqueta, 12/10/1977, *J.A. Steyermark*, *R. Liesner & F. Delascio 114565* (VEN); laguna Las Clavellinas, 30/9/1993, *G. Colonnello 1501* (VEN); entre Tucupita y Los Guires, *G. Agostini & Th. Agostini 1623* (MY). **Guárico**: Calabozo, *H. Karsten 1867* (STU). **Monagas**: along río Morichal Largo between Temblador and El Silencio, 27/10/2005, *J.A. Steyermark*, *R. Liesner & F. Delascio 115374* (VEN). **Portuguesa**: Guanare, Papelón, lugar del caño Maraca, 6/06/1984, *B. Stergios & E. Reyes 6874* (PORT); Guanare, carretera Guanare-Papelón, Agripaca 27/07/1980, *B. Stergios 2064, 2065* (PORT). **Sucre**: río Seco 1, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 55/05* (VEN, ZT); río Chiquito Abajo, Irapa, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 58/05* (VEN, ZT); río Grande Arriba, finca of Mr. Subero, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 61/05* (VEN, ZT); Bohordal, vía Tunapuy - Yaguaraparo, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 60/05* (VEN, ZT). **Zulia**: Santa Bárbara, caño La Maroma, 21/11/1972, *B. Trujillo 12135* (MY); near Puerto Concha, 5/02/2005, *E. Landolt & W. Lämmler 14/05* (VEN, ZT); Parque Nacional Ciénagas de Juan Manuel, Sector La Chamita, 5/02/2005, *E. Landolt & W. Lämmler 17/05*, *18/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1867.

Spirodela polyrhiza (L.) Schleid., Linnaea 13: 392. 1839 (Fig. 16)
Lemna polyrhiza L.

Fronds obovate to orbicular, rounded or pointed at the tip, very rarely gibbous, often with a red spot above the node; forming brown to dark-green

rootless *turions* under unfavourable conditions. *Roots* one, rarely two roots perforate the prophyllum. Rarely flowering.

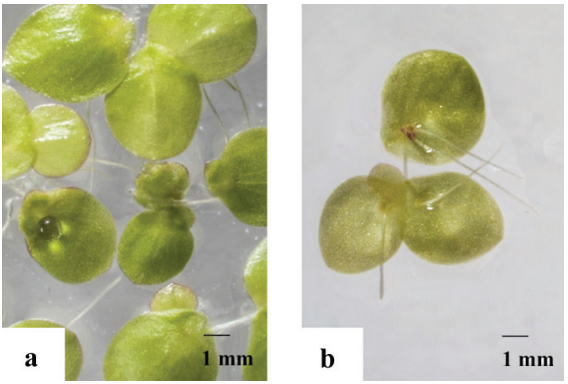

Fig. 16.1. *Spirodela polyrhiza*. **a.** From above. **b.** From below.

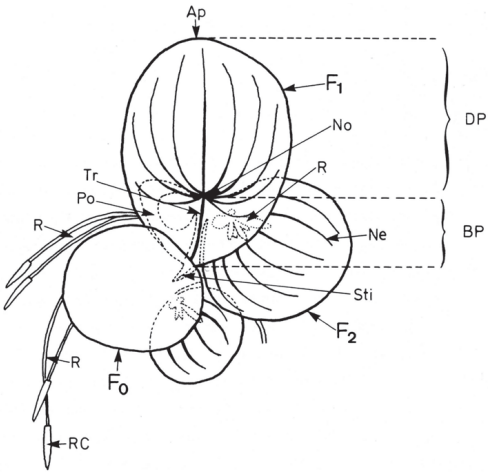

Fig. 16.2. *Spirodela polyrhiza*. Group of fronds after Hegelmaier (1868) (x 7). **Ap** = apex; **BP** = basal part of the frond; **DP** = distal part of the frond; $\mathbf{F_0}$ = mother frond; **F1** = daughter frond of the first generation; **F2** = daughter frond of the second generation; **Ne** = vein; **No** = node; **Po** = pocket; **R** = root; **RC** = root cap; **Sti** = stipe connecting daughter frond and mother frond; **Tr** = tract of elongated cells connecting stipe and node. After Landolt (1980).

Habitat: Cool temperate to warm tropical, moderately dry to moderately humid climate.

General distribution: Whole world, except eastern and southern South America.

Distribution in Venezuela: No locality. Next station in Santa Marta (Colombia), 150 km from the borderline.

Remarks: It seems possible to find also stations of the species on Venezuelan territory. It is not certain if the species is indigenous in South America. First voucher specimen from Colombia in 1922.

WOLFFIA Horkel ex Schleid., Beitr. Bot. 1: 233. 1844.

Fronds mostly 2 cohering together, 0.5-1.5 mm long, 1-3 times as long as wide, globoid, ovoid or cylindrical, not surrounded at the base by a small scale-like leaflet; no red colour; no air spaces present; no veins present; papules mostly missing; no crystal cells present. *Roots* no present. At the base of the frond one cavity present from where daughter fronds develop. *Flowers* in a cavity on the upper frond surface, without utricular leaflet, with one pistil and one 2 locular stamen present. Ovary with one ovule. *Seeds* globoid, nearly smooth. 11 species.

Wolffia brasiliensis Wedd., Ann. Sci. Nat. Bot., sér. 3, 12: 170. 1849 (Fig. 17).

Wolffia papulifera C.H. Thomps.
Wolffia punctata Griseb.

Fronds 0.6-1.5 mm long, 1-11/2 times as long as wide, suborbicular to broad ovate from above, with a prominent papule in the middle of the upper surface (in no other *Wolffia* species a distinct papule present!), with 50-100 stomata on the upper surface; pigment cells present (seen as dark brown dots

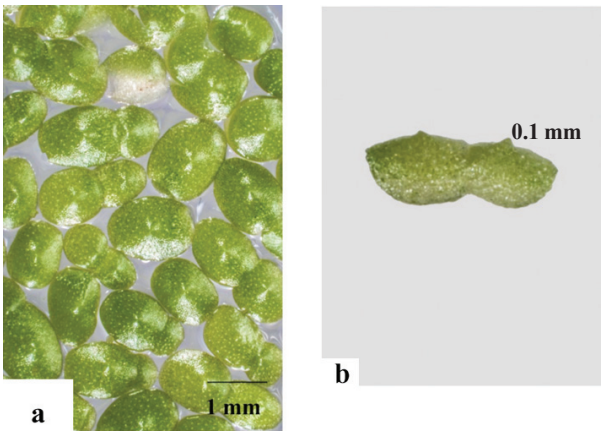

Fig. 17.1. *Wolffia brasiliensis*. **a.** From above. **b.** Group of two fronds from the side.

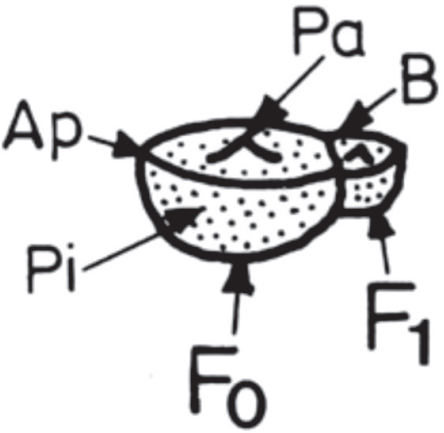

Fig. 17.2. *Wolffia brasiliensis*. Group of fronds (after Hegelmaier 1868) (x 7). **Ap** = apex; **B** = base; **F_0** = mother frond; **F1** = daughter frond of the first generation; **Pa** = papule; **Pi** = pigment cell. After Landolt (1980).

on dead fronds; only in this *Wolffia* species pigment cells present!). Rarely flowering.

Habitat: Warm temperate to warm tropical, moderately dry climate. Water often with high nitrogen content.

General distribution: Warm regions of America.

Distribution in Venezuela: Aragua, Barinas, Bolívar, Carabobo, Distrito Capital, Falcón, Guárico, Lara, Mérida, Nueva Esparta, Portuguesa, Sucre, Trujillo, Zulia (Fig. 18).

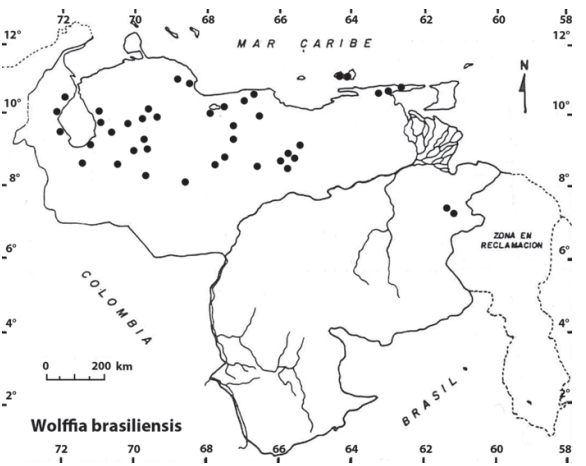

Fig. 18. Distribution of *Wolffia brasiliensis*.

Examined material: **Aragua:** Maracay, Jardín Botánico, 7/04/1970, *L. Cárdenas de Guevara* (ZT); above Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 42/05* (VEN, ZT). **Barinas:** between Bruzual and Dolores, near río Apure, 17/04/1986, *E. Zuber* (ZT); cerca de Barinas, 17/04/1986, *E. Zuber* (ZT). **Bolívar:** Roscio, Tumeremo, 9/09/1972, *B. Trujillo 11511* (MY); Tumeremo, entre Puesto Corumo y caño Matuco del río Negro, 18/05/1982, *B. Stergios*, *G. Aymard & O. Palacios 3640* (PORT). **Carabobo:** El Aislado, between Guacara and Lake Valencia, 26/12/1938, *A.H.G. Alston 5696* (BM, L, U, WIS). **Distrito Capital**: Amatica, laguna de Conejo Blanco, 23/01/1946, *T. Lasser 2004* (VEN); La Mariposa, 11/02/2005, E. *Landolt & W. Lämmler 27/05* (VEN, ZT); Caracas, Círculo Militar, 11/02/2005, *E. Landolt & W. Lämmler 28/05* (VEN, ZT). **Falcón:** distrito Petit, Ciénagas en El Caballo y vecindades, 13/02/1977, *J.A. Steyermark & A. Gonzalez 113782* (VEN); Parque Nacional Morrocoy, Tibana, carretera de Tocuyo a Sanare, 11/10/1993, *E. Melgueiro & M. Ballesteros MB 232, 233* (VEN). **Guárico:** Calabozo, 15/04/1986, *E. Zuber* (ZT); N of Calabozo, vía Calabozo, Préstamo, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 29/05* (VEN, ZT); N of San Fernando, Corozo Pando, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 32/05* (VEN, ZT); Camaguán, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 33/05* (VEN, ZT); S of Mercedes 14/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 34/05* (VEN, ZT); SE of Valle de La Pascua, 14/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 36/05* (VEN, ZT); between El Socorro and Santa María de Ipire, finca Santo Domingo, 18/02/2005, *E. Landolt*, *W. Lämmler & E. Gordon 45/05* (VEN, ZT); Potrerito, represa Mata Redonda, 15/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 38/05* (VEN, ZT); El Palito, 15/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 39/05* (VEN, ZT); N of El Socorro, Caro Herrado, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 40/05* (VEN, ZT). **Lara:** Jiménez, between Quíbor and Sanare, 24/07/1970, *S.S. Tillett 707-51* (ZT); Jiménez, 1 km S of Quíbor, 26/10/1970, *S.S. Tillett 7010-55* (ZT); Irribarren, Terepaima, 15/08/1971, *S.S. Tillett 718-64* (ZT); between Valera and Barquisimeto, 20/04/1986, *E. Zuber* (ZT). **Mérida:** Las Gonzales, between Mérida and La Azulita, 23/10/1971, *S.S. Tillett 7110-88* (ZT). **Nueva Esparta:** Margarita Island, laguna El Macho, Vergel, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 70/05* (VEN, ZT); Margarita Island, Embalse de San Juan (Valle Hondo), 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 71/05* (VEN, ZT); Margarita Island, Sillero, vía la Isleta, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 72/05* (VEN, ZT). **Portuguesa:** Guanare-La Morita, 8/01/1986, *B. Stergios 8822-8824* (PORT); 4 km W of Sipororo, 25-30 km W of Guanare, 12/01/1971, *S.S.*

Tillett 711-19 (ZT). **Sucre:** Platanillo, Bajos de Guayana, 20/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 53/05* (VEN, ZT); río Chiquito Abajo, Irapa, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 58/05* (VEN, ZT); Bohordal, vía Tunapuy-Yaguaraparo, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 61/05* (VEN, ZT); Vuelta Larga, Guaraunos, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 62/05* (VEN, ZT). **Trujillo:** near Valera, plateau of the cordilleras, 11/1890, *Goebel* (STU). **Zulia:** Bulevar, entre Lara-Zulia y El Zamuro, 27/11/1979, *G.S. Bunting 8300* (VEN); laguna cerca de río Apón, 10/01/1948, *T. Lasser 2462* (VEN); río El Palmar, sur Maracaibo, 11/2004, *G. Colonnello*, *A. Fernández & E. Guzmán 20786* (ZT); Maracaibo, road to Barranquitas, 2/02/2005, *E. Landolt & W. Lämmler 3/05* (VEN, ZT); Hacienda Alto Viento, Experimental station of the Facultad de Agronomía, 2/02/2005, *E. Landolt & W. Lämmler 4/05* (VEN, ZT); Hacienda Alto Viento, 4 km SW of the Experimental Station of the Facultad de Agronomía, 2/02/2005, *E. Landolt & W. Lämmler 6/05* (VEN, ZT); río Limón, 2.5 km S of Guardia Nat. Station, 3/02/2005, *E. Landolt & W. Lämmler 10/05, 11/05* (VEN, ZT); río Limón, 3/02/2005, *E. Landolt & W. Lämmler 12/05, 13/05* (VEN, ZT); Bobures, 6/02/2005, *E. Landolt & W. Lämmler 20/05* (VEN, ZT); Los Olivitos, 7/02/2005, *E. Landolt & W. Lämmler 24/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1890.

Wolffia columbiana H. Karst., Bot. Untersuch. (Berlin) 1: 103. 1865 (Fig. 19)

Fronds 0.6-1.5 mm long, 1-11/3 times as long as wide, suborbicular to broad ovate from above, with 0-10, rarely up to 30 stomata on the upper surface. Rarely lowering.

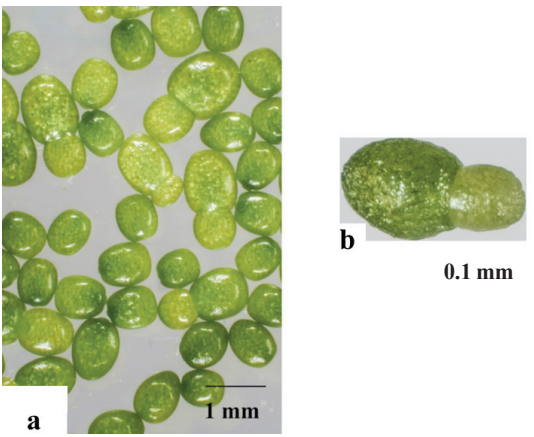

Fig. 19. *Wolffia columbiana*. **a.** From above. **b.** Group of two fronds from the side.

Habitat: Temperate to warm tropical, moderately dry climate.

General distribution: América.

Distribution in Venezuela: Aragua, Carabobo**,** Distrito Capital, Falcón, Guárico, Portuguesa, Trujillo, Yaracuy, Zulia (Fig. 20).

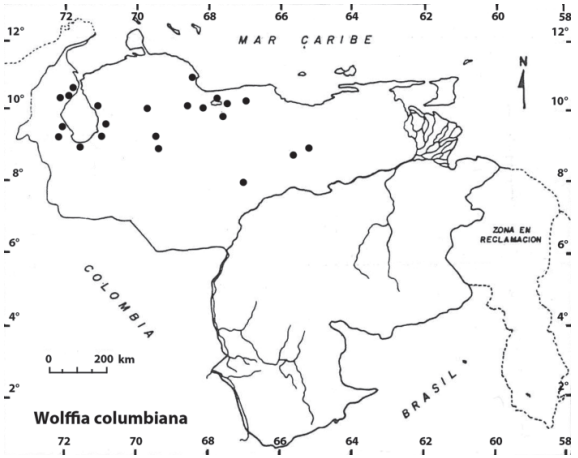

Fig. 20. Distribution of *Wolffia columbiana*.

Examined material: **Aragua**: Lake Valencia near Maracay Airport, 26/12/1938, *A.H.G. Alston 5680* (BM); Maracay, Jardín Botánico, 7/04/1970, *L. Cárdenas* (MY); laguna Taiguaiguay, 12/2/2005, *E. Landolt*, *E. Gordon & W. Lämmler 29/05* (VEN, ZT). **Carabobo:** El Aislado between Guacara and Lake Valencia, 26/12/1938, *A.H.G. Alston 5696* (BM, L, U, WIS); Maracay, Lago de Valencia, *P.J.M. Maas 2175* (U). **Distrito Capital**: La Mariposa, 11/02/2005, *E. Landolt & W. Lämmler 27/05* (VEN, ZT). **Falcón:** Parque Nacional Morrocoy, Tibana, carretera de Tocuyo a Sanare, 11/10/1993, *E. Melgueiro & M. Ballesteros MB 232, 233* (VEN). **Guárico**: Calabozo, 15/04/1986, *E. Zuber* (ZT); N of San Fernando, Corozo Pando, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 32/05* (VEN, ZT); N of El Socorro, Caro Herrado, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 40/05* (VEN, ZT). **Lara:** Jimenez, 1 km S of Quíbor, 26/10/1970, *S.S. Tillett 7010-55* (ZT). **Portuguesa:** Papelón, caño Maraca, 20/08/1984, *B. Stergios 8639* (PORT); Guanare-La Morita, 8/01/1986, *B. Stergios 8822-8824* (PORT). **Trujillo:** Buena Vista, 6/02/2005, E. *Landolt & W. Lämmler 22/05* (VEN, ZT). **Yaracuy:** between Chivacoa and Morón, 12 km N of Marín, 6/12/1970, *S.S. Tillett 7012-57* (ZT). **Zulia:** río El Palmar, 11/2004, *A. Fernández*, *G. Colonnello & E. Guzmán* (VEN); La Maroma, cerca de Santa

Bárbara, 21/11/1972, *B. Trujillo 12134, 12135* (MY); laguna cerca de río Apón, 10/01/1948, *T. Lasser 2462* (VEN); río El Palmar, sur Maracaibo, 11/2004, *G. Colonnello*, *A. Fernández & E. Guzmán 20786* (ZT); S of Maracaibo, Potrerito, 2/02/2005, *E. Landolt & W. Lämmler 2/05* (VEN, ZT); 2 km SW of Hacienda Alto Viento, near río Palmar, 2/02/2005, *E. Landolt & W. Lämmler 5/05* (VEN, ZT); Hacienda Alto Viento, 4 km SW of the Experimental Station of the Facultad de Agronomía, 2/02/2005, *E. Landolt & W. Lämmler 6/05* (VEN, ZT); road to La Represa, 3 km before turning to Villa del Rosario, *E. Landolt & W. Lämmler 7/05* (VEN, ZT); río Limón, 2.5 km S of Guardia Nat. Station, 3/02/2005, *E. Landolt & W. Lämmler 10/05, 11/05* (VEN, ZT); río Limón, 3/02/2005, *E. Landolt & W. Lämmler 12/05* (VEN, ZT); Parque Nacional Ciénagas de Juan Manuel, sector La Chamita, 5/02/2005, *E. Landolt & W. Lämmler 15/05, 18/05* (VEN, ZT); Bobures, 6/02/2005, *E. Landolt & W. Lämmler 20/05* (VEN, ZT); Los Olivitos, 7/02/2005, *E. Landolt & W. Lämmler 24/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1938.

Wolffia elongata Landolt, Veröff. Geobot. Inst. E.T.H. Stiftung Rübel Zürich 70: 27. 1980.

Fronds 0.6-2.5 mm long, 11/2- 4 times as long as wide, ovoid to cylindrical, with 0-5 stomata on the upper surface near the base, often one of the fronds of a group bent downwards (characteristic feature which is restricted to this species!). Often flowering.

Habitat: Warm tropical, dry climate with distinct dry periods. Water often seasonal.

General distribution: Northern Colombia, Curazao.

Distribution in Venezuela: No locality. Next known station: Curazao, 50 km N of the borderline, also Barranquilla (Colombia).

Remarks: The species might be found in the northwest coastal region of Venezuela or on one of the Caribbean Islands. Under certain conditions fronds are not bent downwards, and the plants are difficult to distinguish from *W. columbiana* or *W. globosa*.

Wolffia globosa (Roxb.) Hartog & Plas, Blumea 18: 367. 1970 (Fig. 21)
Lemna globosa Roxb.

Fronds 0.6-1.5 mm long, 11/4-12/3 times as long as wide, suborbicular to broad ovate from above, with 0-10, rarely up to 30 stomata on the upper surface. Often flowering.

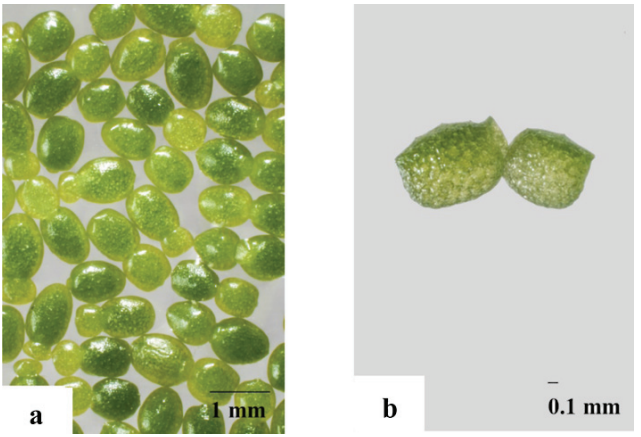

Fig. 21. *Wolffia globosa*. **a.** From above. **b.** Group of two fronds from the side.

Habitat: Temperate to warm tropical, moderately dry climate.

General distribution: Temperate to tropical regions of eastern Asia; introduced in Hawaii, California, Florida, northern South America (Ecuador, Colombia, Venezuela).

Distribution in Venezuela: Aragua, Distrito Capital, Guárico, Nueva Esparta, Sucre, Trujillo, Zulia (Fig. 22)

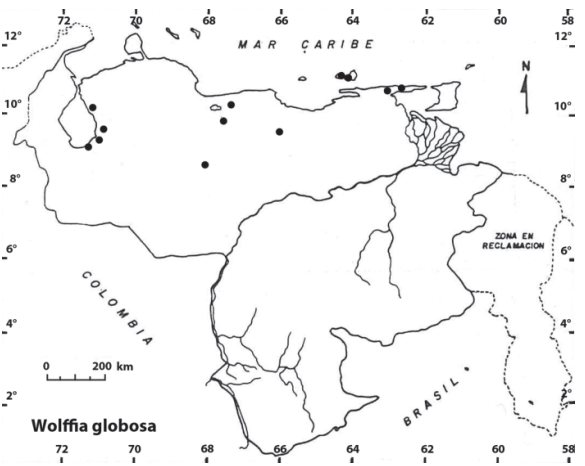

Fig. 22. Distribution of *Wolffia globosa.*

Examined material: **Aragua:** above Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 42/05* (VEN, ZT). **Distrito Capital**: La Mariposa, 11/02/2005, *E. Landolt & W. Lämmler 27/05*

(VEN, ZT). **Guárico:** Camaguán, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 33/05* (VEN, ZT); SE of Valle de La Pascua, 14/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 36/05* (VEN, ZT). **Nueva Esparta**: Margarita Island, laguna El Macho, Vergel, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 70/05* (VEN, ZT); Margarita Island, Embalse de San Juan (Valle Hondo), 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 71/05* (VEN, ZT); Margarita Island, Sillero, vía la Isleta, 23/02/2005, *E. Landolt*, *J. Velásquez & W. Lämmler 72/05* (VEN, ZT). **Sucre:** río Seco 1, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 55/05* (VEN, ZT); Bohordal, vía Tunapuy-Yaguaraparo, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 61/05* (VEN, ZT). **Trujillo:** Buena Vista, 6/02/2005, *E. Landolt & W. Lämmler 22/05* (VEN, ZT). **Zulia:** río Limón, 2.5 km S of Guardia Nat. Station, 3/02/2005, *E. Landolt & W. Lämmler 10/05, 11/05* (VEN, ZT); Bobures, 6/02/2005, *E. Landolt & W. Lämmler 20/05* (VEN, ZT); Los Olivitos, 7/02/2005, *E. Landolt & W. Lämmler 24/05* (VEN, ZT).

Remarks: Probably introduced. First voucher specimen: 2005. The identity of the South American plants with *W. globosa* has to be checked.

WOLFFIELLA Hegelm., Bot. Jahrb. 21: 303. 1895.

Fronds one to several cohering together, 1-10 mm long, 1-8 times as long as wide, flat, not surrounded at the base by a small scale-like leaflet; no red colour; air spaces present between the upper and the lower surface; *veins* no present; papules mostly missing; no crystal cells present. *Roots* no present. At the base of the frond one pocket present from where daughter fronds develop. *Flowers* in a cavity on the upper frond surface, without utricular leaflet, with one pistil and one 2locular stamen present. Ovary with one ovule. *Seeds* globoid, nearly smooth. 10 species.

Wolffiella caudata Landolt, Ber. Geobot. Inst. E.T.H., Stiftung Rübel Zürich 58: 121. 1992 (Fig. 23)

Fronds 2-3 cohering together, submerged, mostly near the base reaching the water surface 2-7 mm long, 2-4 times as long as wide, distinctly narrowed into a flat tail-like appendix towards the somewhat pointed tip, with 0-4 stomata; area of air spaces as wide as long throughout the wider part of the frond; pocket asymmetric (other *Wolffiella* species show a nearly symmetric pocket), with an angle of 100-150°; tract of elongated cells near the median line of the lower pocket wall. Flower one per frond. Rarely flowering.

Habitat: Warm tropical, rather humid climate.

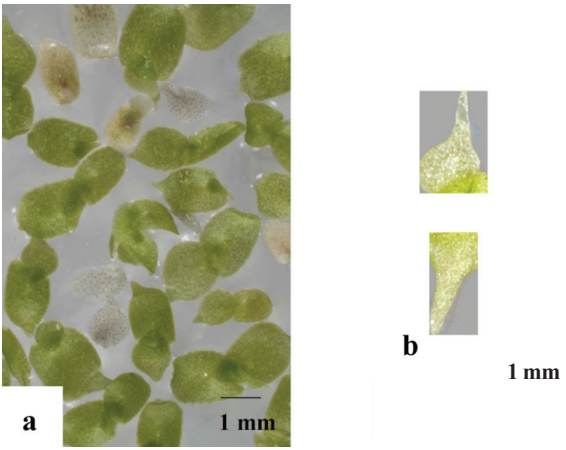

Fig. 23. *Wolffiella caudata*. **a.** From above. **b.** Group of two fronds from the side.

General distribution: Western Amazon basin (Bolivia, Brazil).

Distribution in Venezuela: No locality in Venezuela; next known station in Manaus (Brazil), 500 km S of the borderline.

Remarks: The species might occur in the Amazonas State.

Wolffiella lingulata (Hegelm.) Hegelm., Bot. Jahrb. Syst. 21: 303. 1895 (Fig. 24)

Wolffia lingulata Hegelm.

Fronds 2-3 cohering together, submerged, with the base near the surface of the water, 3-9 mm long, 11/4-4 times as long as wide; not much narrower

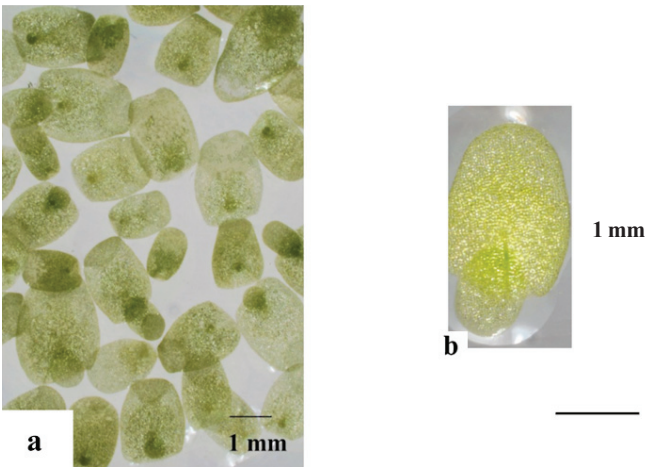

Fig. 24. *Wolffiella lingulata*. **a.** From above. **b.** Group of two fronds from the side.

at the tip than at the base, rounded at the tip, with 0-10 stomata; area of air spaces nearly as long as wide; tract of elongated cells somewhere between the edge and the median of the lower wall of the pocket. *Flower* one per frond. Rarely flowering.

Habitat: Subtropical to warm tropical, moderately dry to rather humid, suboceanic climate.

General distribution: Warm regions of America.

Distribution in Venezuela: Apure, Aragua, Barinas, Bolívar, Carabobo, Delta Amacuro, Distrito Capital, Guárico, Monagas, Portuguesa, Sucre, Yaracuy, Zulia (Fig. 25).

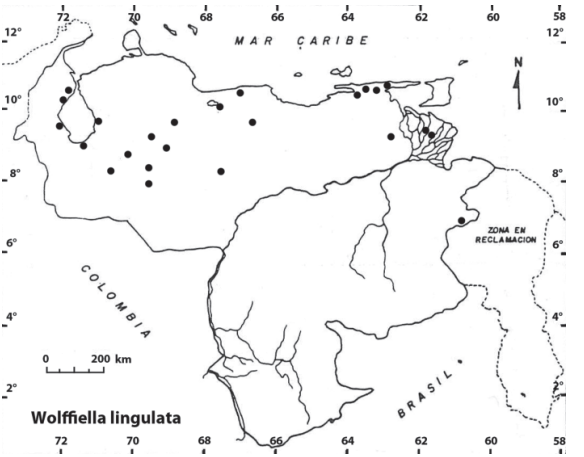

Fig. 25. Distribution of *Wolffiella lingulata*.

Examined material: **Apure:** S of Bruzual, río Arauca, 21/07/1997, *J. Bramley* (ZT). **Aragua:** above Embalse de Camatagua, 16/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 42/05* (VEN, ZT). **Barinas:** Reserva Forestal Ticoporo, Socopo, 10/04/1983, *B. Stergios*, *D. Taphorn & C. Lilyestrom 5674* (PORT); cerca de Barinas, 17/04/1986, *E. Zuber* (ZT); between Bruzual and Dolores, near río Apure, 17/04/1986, *E. Zuber* (ZT). **Bolívar:** distrito Roscio, río Venamo, confluencia con el río Cuyuní, 02/1980, *F. Delascio-Chitty& R. López 8837* (VEN). **Carabobo:** Maracay, Lago de Valencia, *P.J.M. Maas 2175* (U). **Delta Amacuro:** entre Tucupita y Los Guires, *G. Agostini & Th. Agostini 1623* (MY); between Tucupita and Cocuina, 12/10/1977, *J.A. Steyermark*, *R. Liesner & F. Delascio 114544* (VEN). **Distrito Capital:** Caracas, laguna near El Valle, 03/1854, *Gollmer* (STU). **Guárico:** Camaguán, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 33/05* (VEN, ZT).

Monagas: río Morichal Largo between Temblador and El Silencio, 27/10/2005, *J.A. Steyermark*, *R. Liesner & F. Delascio 115374* (VEN). **Portuguesa:** Guanare-La Morita, 8/01/1986, *B. Stergios 8822-8824* (PORT); SE of Guanare on road to Guanarito, 14/03/1982, *R. Liesner & A. González 12701* (VEN); Papelón, caño Maraca, 20/08/1984, *B. Stergios 8639* (PORT). **Sucre:** Benítez, east of Pozotes between Guaraunos and Ajíes, 18/02/1980, *J.A. Steyermark*, *R. Liesner & V. Carreño 121281* (VEN); Platanillo, Bajos de Guayana, 20/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 52-53/05* (VEN, ZT); río Seco 1, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 55/05* (VEN, ZT); río Chiquito Abajo, Irapa, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 58/05* (VEN, ZT); río Grande Arriba, finca of Mr. Subero, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 60/05* (VEN, ZT); Bohordal, vía Tunapuy-Yaguaraparo, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 61/05* (VEN, ZT); Vuelta Larga, Guaraunos, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 62/05* (VEN, ZT). **Yaracuy:** between Chivacoa and Morón, 12 km N of Marín, 6/12/1970, *S.S. Tillett 7012-57* (ZT). **Zulia:** La Maroma, cerca de Santa Bárbara, 21/11/1972, *B. Trujillo 12134, 12135* (MY); río El Palmar sur Maracaibo, 11/2004, *G. Colonnello*, *A. Fernández & E. Guzmán 20786* (ZT); Hacienda Alto Viento, near río Palma, 2/02/2005, *E. Landolt & W. Lämmler 5/05* (VEN, ZT); Hacienda Alto Viento, 4 km SW of the Experimental Station of the Facultad de Agronomía, 2/02/2005, *E. Landolt & W. Lämmler 6/05* (VEN, ZT); río Limón, 3/02/2005, *E. Landolt & W. Lämmler 12/05, 13/05* (VEN, ZT); Parque Nacional de Juan Manuel, sector La Chamita, 5/02/2005, *E. Landolt & W. Lämmler 17-19/05* (VEN, ZT); Bobures, 6/02/2005, *E. Landolt & W. Lämmler 20/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1854.

Wolffiella neotropica Landolt, Veröff. Geobot. Inst. E.T.H. Stiftung Rübel Zürich 70: 242. 1986 (Fig. 26)

Fronds mostly two cohering together, normally submerged or partly on water's surface, 3-8 mm long, 11/3-4 times as long as wide, not much narrower at the tip than at the base, rounded at the tip; with 20-35 stomata; area of air spaces about as long as wide; angle of the pocket 100-120°; tract of elongated cell near the median line of the lower wall of the pocket. *Flower* one per frond. Rarely flowering.

Habitat: Warm tropical, rather humid climate.

General distribution. Northeastern South America, from Rio de Janeiro to Sucre in Venezuela, inclusive Atlantic coast and lower Amazon basin.

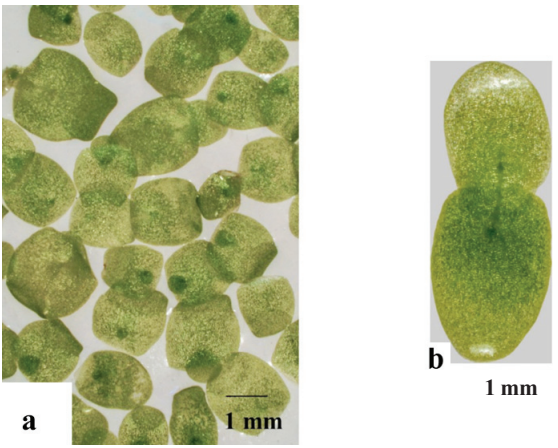

Fig. 26. *Wolffiella neotropica*. **a.** From above. **b.** From below.

Distribution in Venezuela: Monagas, Sucre (Fig. 27).

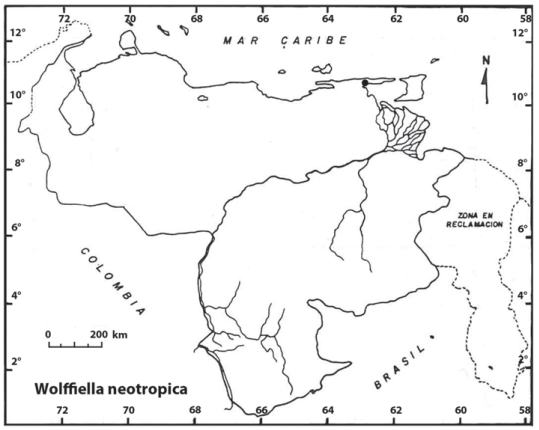

Fig. 27. Distribution of *Wolffiella neotropica.*

Examined material: **Monagas**: El Zamuro, *ca.* 15 km NE of Maturín, 1/06/1967, *R.A. Russel 9130* (PAC). **Sucre:** río Grande Arriba, finca of Mr. Subero, 21/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 60/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1967. The places in Monagas and Sucre are the northwestern most known localities of the species.

Wolffiella oblonga (Phil.) Hegelm., Bot. Jahrb. Syst. 21: 303. 1895 (Fig. 28)
Lemna oblonga Phil.

Fronds 1-8 cohering together, submerged, mostly near the base reaching the water surface 11/3-7 mm long, 21/2-6 times as long as wide, distinctly

narrower at the tip than at the base, rounded or somewhat pointed at the tip, with 0-8 stomata; area of air spaces narrower than long; pocket with an angle of 45-90°; tract of elongated cells near the edge of the lower pocket wall. *Flower* one per frond. Rarely flowering.

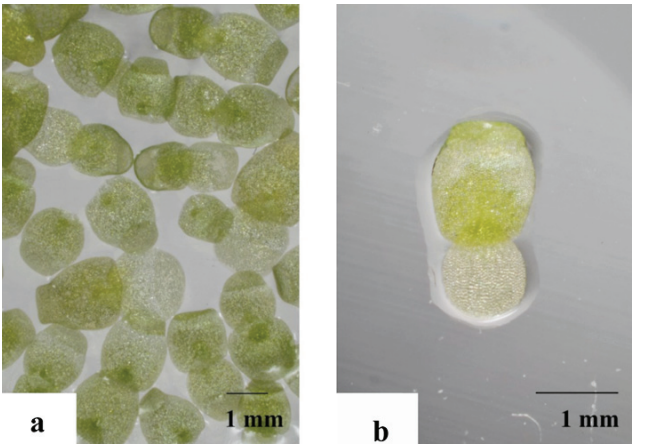

Fig. 28. *Wolfiella oblonga*. **a.** From above. **b.** From below.

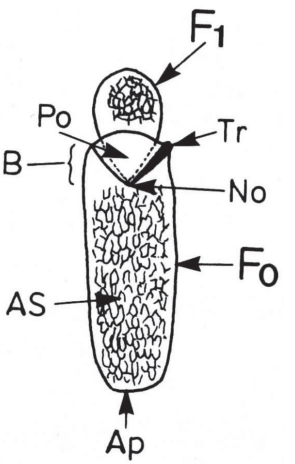

Fig. 28.2. *Wolffiella oblonga.* Group of fronds (after Hegelmaier 1868) (x 7). **Ap** = apex; **AS** = air spaces; **B** = base; **F_0** = mother frond; **F1** = daughter frond of the first generation; **No** = node; **Po** = pocket; **Tr** = tract of elongated cells connecting stipe and node. After Landolt (1980).

Habitat: Warm temperate to subtropical, moderately dry, suboceanic climate, up to 4000 m asl.

General distribution: Moderately warm regions of America.

Distribution in Venezuela: Mérida, Monagas, Portuguesa (Fig. 29).

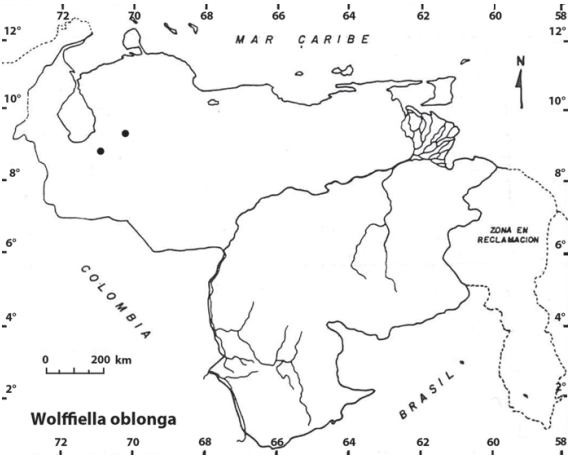

Fig. 29. Distribution of *Wolffiella oblonga*.

Examined material: **Mérida:** Zea, Laguna Negra de Mariño, c. 2004, *G. Colonnello* (VEN). **Monagas:** El Zamuro, *ca.* 15 km NE of Maturín, 1/06/1967, *R.A. Russel 9130* (PAC). **Portuguesa:** Guanare-La Morita, 8/01/1986, *B. Stergios 8822-8824* (PORT).

Remarks: Indigenous. First voucher specimen: 1967. Probably more widespread in the cordilleras.

Wolffiella welwitschii (Hegelm.) Monod, Mém. Soc. Hist. Nat. Afrique N., Hors Sér. 2: 242. 1949 (Fig. 30)

Wolffia welwitschii Hegelm.
Wolffiopsis welwitschii (Hegelm.) Hartog & Plas.

Fronds 2-3 cohering together, submerged, mostly near the base reaching the water surface 3-7 mm long, 11/4- 21/2 times as long as wide, not much narrower at the tip than at the base, rounded at the tip, with 0-12 stomata; area of air spaces wider than long; pocket with an angle of 100-120°; tract of elongated cells in the median line of the lower pocket wall. *Flowers* mostly two per frond. Often flowering.

Habitat: Subtropical and warm tropical, moderately dry climate, with a prominent dry period.

General distribution: Warm regions of Africa and America.

Distribution in Venezuela: Anzoátegui, Bolívar, Barinas, Delta Amacuro, Distrito Capital, Guárico, Sucre, Zulia (Fig. 31).

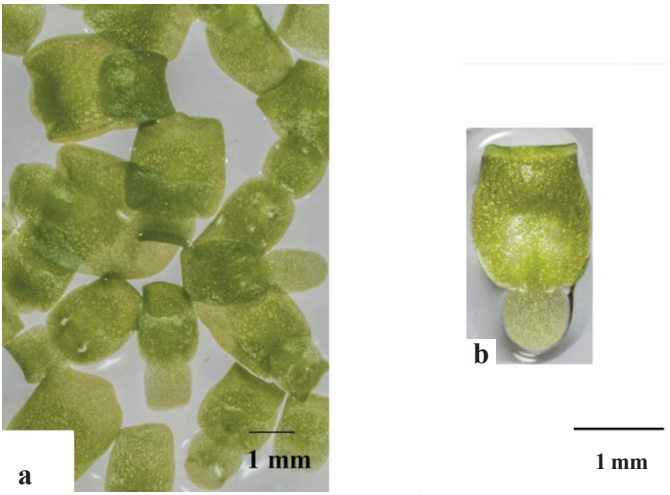

Fig. 30. *Wolffiella welwitschii*. **a.** From above. **b.** From be1ow.

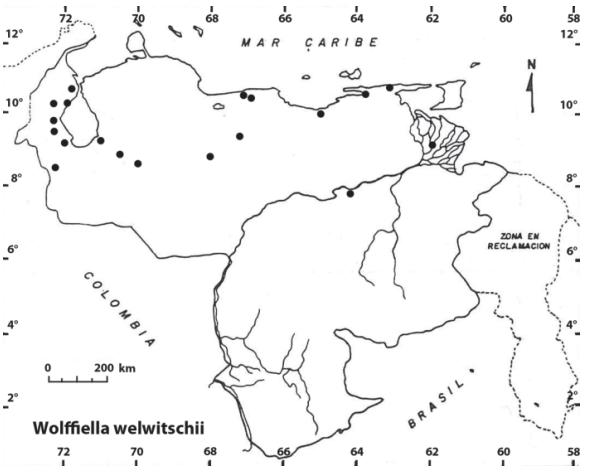

Fig. 31. Distribution of *Wolffiella welwitschii*.

Examined material: **Anzoátegui:** S of Barcelona, Potreros, 19/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 47/05* (VEN, ZT). **Apure:** between Bruzual and Dolores, near río Apure, 17/04/1986, *E. Zuber* (ZT). **Barinas:** near of Barinas, 17/04/1986, *E. Zuber* (ZT). **Bolivar:** E of Cerro El Picacho, Deborah, 5-8/02/1962, *J.A. Steyermark 89138* (VEN). **Delta Amacuro**: between Tucupita and Cocuina, 12/10/1977, *J.A. Steyermark*, *R. Liesner & F. Delascio 114544* (VEN). **Distrito Capital**: Caracas, la Laguna de Espino, 19/04/1869, *A. Ernst* (FI, STU); Caracas, laguna near

El Valle, *Gollmer* (GOET, STU); Caracas, 8/1870, *A. Ernst* (H, K). **Guárico**: Camaguán, 12/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 33/05* (VEN, ZT); SE of Valle de La Pascua, 14/02/2005, *E. Landolt*, *E. Gordon & W. Lämmler 36/05* (VEN, ZT). **Sucre:** Lago de Guanoco, 08/1955, *T. Lasser & V. Vareschi* (VEN); Platanillo, Bajos de Guayana, 20/02/2005, *E. Landolt*, *W. Lämmler & S. Pacheco 52-53/05* (VEN, ZT). **Zulia:** La Maroma, cerca de Santa Bárbara, 21/11/1972, *B. Trujillo 12134, 12135* (MY); 38 km from Rosario on road to San José de los Altos, 26/11/1977, *C. Jeffrey & B. Trujillo 2367* (MY), río El Palmar sur Maracaibo, 11/2004, *G. Colonnello*, *A. Fernández & E. Guzmán 20786* (ZT); S of Maracaibo, Petrorito, 2/02/2005, *E. Landolt & W. Lämmler 2/05* (VEN, ZT); Hacienda Alto Viento, near río Palma, 2/02/2005, *E. Landolt & W. Lämmler 5/05* (VEN, ZT); Hacienda Alto Viento, 4 km SW of the Experimental Station of the Facultad de Agronomía, 2/02/2005, *E. Landolt & W. Lämmler 6/05* (VEN, ZT); río Limón, 3/02/2005, *E. Landolt & W. Lämmler 12/05* (VEN, ZT); near Puerto Concha, 5/02/2005, *E. Landolt W. Lämmler 14/05* (VEN, ZT); Parque Nacional Ciénagas de Juan Manuel, sector La Chamita, 5/02/2005, *E. Landolt & W. Lämmler 15/05, 17-19/05* (VEN, ZT).

Remarks: Indigenous. First voucher specimen: 1869.

Habitat and plant sociological behaviour

The occurrence of the Lemnaceae is restricted to stagnant or slowly flowing waters relatively rich in nutrients. In the lowland of the tropics the water will become too diluted if the amount of yearly precipitation exceeds 2500 mm. If the soils are poor in minerals as on old rocks or on peaty soil the waters will not have enough nutrients to support growth of Lemnaceae even at less precipitation. Therefore, the South of the country including the Amazon region and the shield of Guiana has not been visited on this trip. In the distribution maps these regions show nearly no Lemnaceae. Herbarium material is scarce. This does not mean that no duckweed at all is present there. But certainly plants are very rare and restricted to places with locally more nutrients. From the other parts of Venezuela the region of the cordilleras, the dry region of northern Falcón and the floodplains of the Orinoco Delta could not be visited due to shortness in time. It is possible that it was overlooked or that there are other species in these regions. The cordilleras might contain some species not or very rarely documented from Venezuela: *Lemna gibba*, *L. minuta* and *Wolffiella oblonga* are characteristic for cool mild and not too humid climate. They are frequently present at higher altitudes in

Colombia (Landolt & Schmidt-Mumm 2009), Ecuador (Landolt 2000), Peru and Bolivia (Landolt 1992, 1999). *Wolffia elongata*, an endemic species of northern Columbia and Curazao, grows perhaps in Falcón and bordering regions; and *Wolffiella neotropica*, a species of humid tropical forests of northeastern South America, which was detected in Sucre (Table 2, No. 60) is probably also growing in the Orinoco Delta.

Table 2. *Lemno aequinoctialis-Wolffielletum welwitschii*. Relevés with cover abundance values from + to 5. The localities of relevés can be seen on the map of the trip with visited localities (Table 1).

	N° Relevé															
Species	**18**	**17**	**33**	**20**	**6**	**15**	**13**	**14**	**37**	**5**	**2**	**73**	**SF1**	**SF2**	**12**	**60**
Wolffiella welwitschii	1	1	2	+	2	1	4	+	2	2	2	3	V	V		
Lemna aequinoctialis	3	3	+	2	3	2	1	2	+	1	+	1	V	V	1	+
Pistia stratiotes	3	3	+	3	+	5		4	+	4		+	IV	IV	4	
Wolffiella lingulata	+	1	2	+	1	1	1			1	2		IV	IV	1	
Utricularia sp.	+	1							3			+	I	II		
Wolffia columbiana	+				1					3	1		I	III		
Wolffia brasiliensis			+	+	1		3						I	I		
Spirodela intermedia	1	1				1							I	I		1
Salvinia rotundifolia	2					2	1	1	+				II	0	1	
Limnobium laevigatum	+	+		+									I	I		3
Eichhornia crassipes	3		+					+					I			
Salvinia minima	+	1											I	IV		
Lemna valdiviana			2										I	I	1	
Azolla caroliniana													0	II	+	+
Wolffiella neotropica													0	0		3
Conductivity [µS/cm]	309	352	174	235	321	215	301	201	280	494	342	460			37	304
Number of species	11	8	7	6	6	6	5	5	5	5	4	4			6	5

SF1 = species frequencies from the Venezuelan relevés. SF2 = species frequencies from 34 other South American localities (No. 60 incl.).

Sociological communities with Lemnaceae

From the 73 investigated collections one third consisted only of fragments of an association. The numbers 1-73 correspond to numbers of the distribution map. There is no strict distinction between the different sociological units occurring in the country. Transition stages between two different associations are possible. So far six different associations could be observed in the Northwest of South America (Landolt 2000). However, only four associations could be observed frequently in Venezuela; the other two are either present only as fragments or not yet observed.

The associations of Lemnaceae in Venezuela are the following:

1) Lemno aequinoctialis-Wolffielletum welwitschii Landolt 1999

The association is quite common in the middle and northern part of the country (Table 2). It is characterized by *Wolffiella welwitschii* in the second layer and by *L. aequinoctialis* in the first. *Wolffiella lingulata* and *Pistia stratiotes* are frequent companions. *Wolffia columbiana* and *W. brasiliensis* often occur here. Small *Utricularia* species can be found and point to relatively low content of nutrients (phosphorus and nitrogen). On the other hand *Lemna valdiviana* and *Azolla caroliniana* Willd. are rare or missing in this unity. The association is typical to a relatively arid climate with marked dry periods. In some places the water is drying out during the dry period.

2) Lemno aequinoctialis-Wolffielletum lingulatae Landolt 2000

This association is the most frequent Lemnaceae association in humid tropical countries of South America. In Venezuela it is probably restricted to the more southern and eastern relatively humid part of the country regions. Instead of the missing *W. welwitschii*, *W. lingulata* is common. *Azolla caroliniana* is characteristic for this association. The water is mostly higher in nutrients than in the *Lemno aequinoctialis-Wolffielletum welwitschii.* In Table 3 No. 12 is the only representative of this association.

3) Lemno aequinoctialis-Landoltietum punctatae Landolt 2000 (Table 3)

The association was already presented in Landolt (2000) from Ecuador and must be a relatively new association. The most important species are probably introduced: *Landoltia punctata* and *Wolffia globosa*; *Spirodela polyrhiza* has not yet been observed in Venezuela, a species which is not known if is native or introduced in South America. Typical relevé of the association *Lemneto aequinoctialis-Landoltietum punctatae* is No. 27 of Table 3. Beside *Spirodela polyrhiza* which is restricted to Ecuador the following species are frequently present: *Landoltia punctata, Wolffiella lingulata, Wolffia brasiliensis, Wolffia globosa* and *Lemna aequinoctialis*. The association is distributed in regions with moderately humid suboceanic climate in Venezuela and Ecuador. Similar related communities occur in the eastern part of Brazil and in the southeastern part of the U.S. (with *Wolffiella gladiata* as characteristic species).

Table 3. *Lemno aequinoctialis-Landoltietum punctatae* in Venezuela. Relevés with cover abundance values from + to 5. The localities of relevés can be seen on the map of the trip with visited localities (Table 1).

	N° Relevé									
Species	**42**	**27**	**62**	**55**	**61**	**58**	**43**	**72**	**SF1**	**SF2**
Landoltia punctata	3	3	2	1	5	3	+	1	V	V
Wolffiella lingulata	+	+	+	+	2	+			IV	III
Wolffia brasiliensis	4	+	+		2	+	+		IV	II
Wolffia globosa	1	3			+			4	III	II
Lemna aequinoctialis	1	1		+				2	III	IV
Azolla caroliniana	4	2	2						II	IV
Pistia stratiotes			+	2			+		II	0
Spirodela polyrhiza									0	V
Lemna valdiviana			2	2					II	II
Conductivity [µS/cm]	225	-	307	331	270	160	215	330		
Number of species	6	6	6	5	4	3	3	3		

SF1 = species frequencies from the Venezuelan relevés. SF2 = species frequencies calculated on the basis of the Ecuadorian relevés.

4) Wolffio globosae-Lemnetum obscurae Landolt 2000

The association grows in Colombia (Landolt & Schmidt-Mumm 2009) and Ecuador (Landolt 2000) under moderately dry climate with waters of relatively high nutrient content. The three localities with *L. obscura* visited during the trip in Venezuela contained only *Wolffia columbiana* or *W. brasiliensis*. This seems to point to the fact that *L. obscura* is probably newly introduced in Venezuela and has not yet many stable stands. In Colombia and Ecuador the association contains beside *L. obscura, W. columbiana, W. globosa and L. aequinoctialis,* in Ecuador also *Spirodela polyrhiza.* In addition *Wolffiella lingulata* and rarely *W. welwitschii* can be found.

5) Lemno minutae-Lemnetum gibbae Libermann Cruz *et al.* 1988, and **6) Azollo filiculoides-Wolffielletum oblongae Landolt 2000**

Both associations are described from the Cordilleras. They occur at higher elevations (2000-4100 m asl) in arid regions. In Venezuela no station of these associations has been observed. However, the presence of these

associations at dryer places of higher altitudes in the states of Cojedes, Mérida, Trujillo and Táchira is probable.

The values for the conductivity of the studied waters vary between 37 and 1950 µS/cm (Table 2). In general there is no strong correlation between the value of conductivity and the presence of a species. However, samples with *L. obscura* show higher values of conductivity (464, 1284 and 1950 µS/cm) than all the other samples. This is in accordance with results from other parts of the distribution area. *L. obscura* is a species needing a high nutrient content and is also moderately salt-tolerant. The conductivity is not always representative for the nutrients available to the plants because it just represents a momentary situation and does not strongly correlate to the nutrient content of the whole cycle within the ecosystem.

ACKNOWLEDGEMENTS

Many thanks go to Dr. Otto Huber, Dr. Fred Stauffer, L. Herrera, President INISPA and many regional and local scientists for their successful assistance. We are thanking Lic. Sergio Pacheco who accompanied us during long parts of the trip, driving us safely through the country and solved many difficulties. Many thanks to Dr. José Rincón and Lic. Maria Nelly Soto from the Zulia University (LUZ) and the ICLAM, respectively, for the logistic for the travel to around the Zulia State. Many thanks to Curators of the herbarium mentioned for their assistance in reviewing the collection of the Lemnaceae family. Also, to the Environment Ministry for the permission of collection of the botanical material object of this work.

BIBLIOGRAPHY

Cabrera, L.I., G.A. Salazar, M.W. Chase, S.J. Mayo, J. Bogner & P. Dávila. 2008. Phylogenetic relationships of aroids and duckweeds (Araceae) inferred from coding and noncoding plastid DNA. *Amer. J. Bot.* 95(9): 1153-1165, doi: 10.3732/ajb.0800073.

Hegelmaier, F. 1868. *Die Lemnaceen*. Eine monographische Untersuchung. Engelmann, Leipzig.

Holmgren, P.K., N.H. Holmgren & L.C. Barnett (eds.) 1990. *Index Herbariorum*. Part I. The herbaria of the world. 8th edition. *Regnum Veg.* 120: 1-693.

Landolt, E. 1986. The family of Lemnaceae – A monographic study. Vol. 1. In: Landolt, E. (ed.), Biosystematic investigations on the family of

duckweeds (Lemnaceae). *Veröff. Geobot. Inst. E.T.H. Stiftung Rübel Zürich* 71: 7-566.

Landolt, E. 1992. *Wolffiella caudata*, a new Lemnaceae species from the Bolivian Amazon region. *Ber. Geobot. Inst. E.T.H, Stiftung Rübel, Zürich* 58: 121-123.

Landolt, E. 1998a. Lemnaceae. In: Kubitzki, K. (ed.). *The families and genera of vascular flowering plants. Monocotyledons,* vol. 4, pp. 264-270. Springer-Verlag, Berlin, Germany.

Landolt, E. 1998b. Anatomy of the Lemnaceae (duckweeds). In: Landolt, E., I. Jager-Zurn & R.A.A. Schnell (eds.). *Extreme Adaptations in Angiosperms hydrophytes*, pp. 1-127. Borntraeger. Berlin, Germany.

Landolt, E. 1999. Pleustonic communities with Lemnaceae in South America. *Appl. Veg. Sci.* 2: 7-16.

Landolt, E. 2000. Contribution on the Lemnaceae of Ecuador. *Fragm. Florist. Geobot.* 45(1-2): 221-237.

Landolt, E. & U. Schmidt-Mumm. 2009. *Lemnaceae*. Flora de Colombia Nº 24. Instituto de Ciencias Naturales, Universidad Nacional de Colombia. Bogotá, D.C., Colombia.

Mueller-Dombois, D. & H. Ellenberg.1974. *Aims and Methods of Vegetation Ecology*. Wiley & Sons. New York, USA.

Velásquez, J. 1994. *Plantas acuáticas vasculares de Venezuela.* Consejo de Desarrollo Científico y Humanístico, Universidad Central de Venezuela. Caracas, Venezuela.

Zambrano, J.O., D. Pacheco & L. Cabrera. 2007a. Micromorfología comparativa de las estructuras reproductivas de dos especies de *Lemna* L. en Venezuela. *Revista Fac. Agron. Univ. Zulia*, 24 Supl. 1: 148-151.

Zambrano, J.O., D. Pacheco & Y. Barrios. 2007b. Revisión de las Lemnaceae del Lago de Maracaibo y la desembocadura de algunos de sus afluentes. *Revista Fac. Agron. Univ. Zulia*, 24 Supl. 1: 411-414.

Zambrano, J. O., Y. Barrios, D. Pacheco & J. Fuenmayor. 2007c. Las lemnáceas de la Ciénaga "El Mene", municipio Santa Rita, estado Zulia, Venezuela. *Revista Fac. Agron. Univ. Zulia*, 24 Supl. 1: 399-404.