Lemna yungensis, a new duckweed species from rocks of the Andean Yungas in Bolivia

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Summary

Lemna yungensis, a new species from the Yungas in Bolivia growing on perpendicular wet rocks is described. It belongs to the section *Uninerves* Hegelmaier and is related to *L. valdiviana.* Its geographical distribution seems to be very limited.

Keywords: Bolivia, duckweed, *Lemna yungensis,* rock plants, water plants, Yunga

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Introduction

On a visit to Bolivia in 1991, I revised the Lemnaceae material in the Herbarium LPB, La Paz. One specimen attracted my attention. It was a *Lemna* similar to *L. valdiviana.* However, the fronds were of rather large size, and they grew in a region with very high precipitation where otherwise no members of the family occur: Bolivia, Province of Nor-Yungas, Departamento of La Paz: 89.5 km NE, below Chuspipata (20.2 km S of Yolosa. 16°17' S, 67°49' W; 2350 m a.s.l.; cloud forest, in permanently wet places; J.C. Solomon 8101, 19 July 1982).

On our way to the Beni lowland we passed the place. However, the road crossing the steep slope of the Andes was narrow and busy, and we could not stop at the right place. Dr. S. Beck, Herbario Nacional de Bolivia, was so kind to send the herbarium specimen later to our Institute for further investigation. When I sent the voucher back to La Paz together with duplicates of all Lemnaceae which I collected in Bolivia, it was lost and with it the unicate voucher from the Yungas. Therefore, I went for a second trip to Bolivia to look for the new *Lemna.* This time we walked along the road and were able to find the plant. In addition, we detected it at three other places in the same region.

Description of *Lemna yungensis*

MORPHOLOGY AND SYSTEMATIC POSITION

Fronds 3–6 mm long and 1.5–4 mm wide, 1.5–2 times as long as wide, ± symmetric, three to few coherent in small groups, ovate to lanceolate, flat, without small papillae along midline of adaxial surface; sometimes with a slightly reddish violet colour along the margins of the fronds; nerve 1 prominent, running through at least 3/4 of the distance between node and apex, longer than extension of air spaces; largest air spaces shorter than 0.2 mm; turions absent. Root up to 2 cm long; tip rounded or slightly pointed; sheath unwinged; flowers and fruits not known (Fig. 1c).

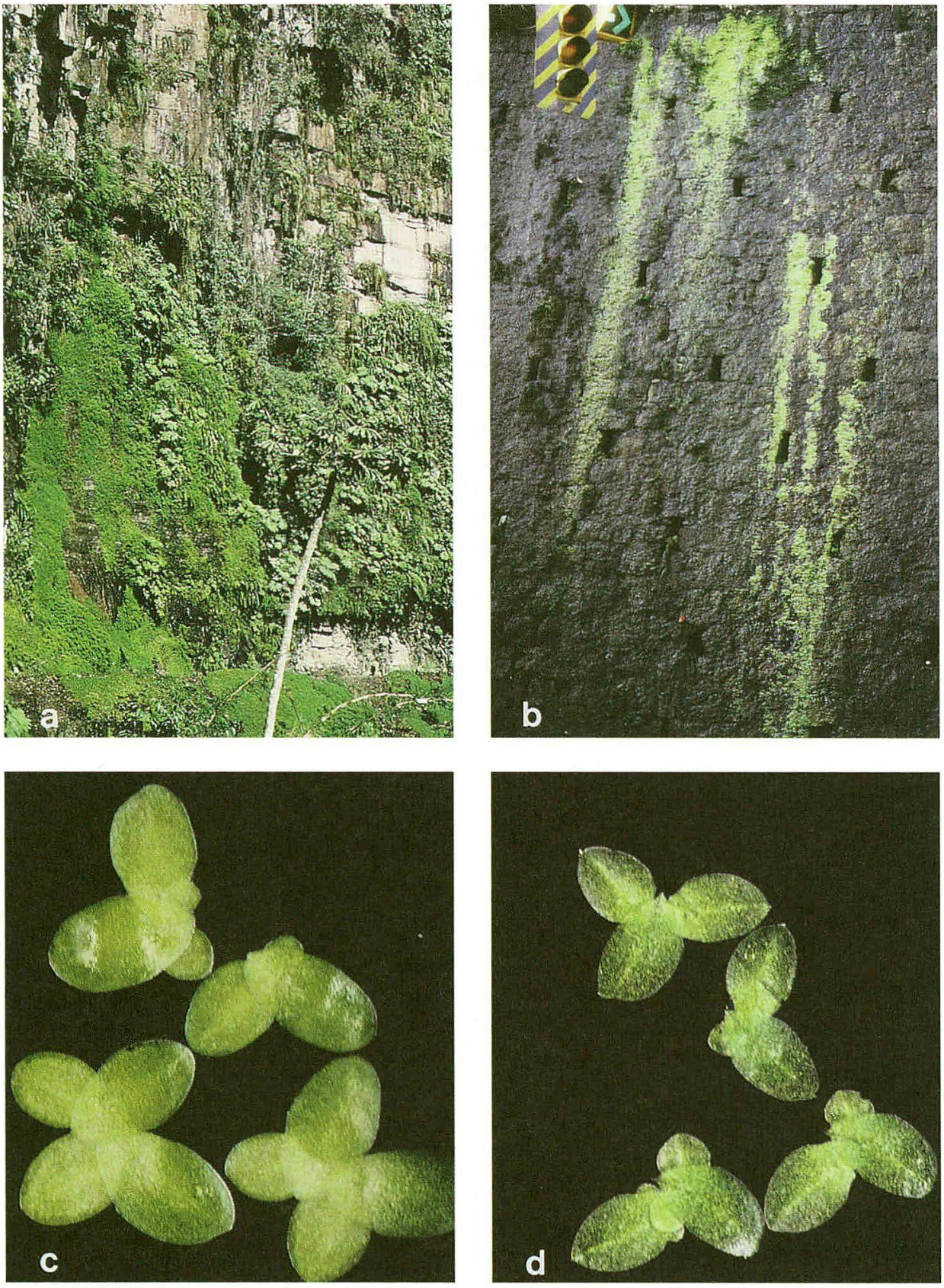

Fig. 1. *(a) Natural habitat (rock wall) of* Lemna yungensis *between Chuspipata and Yolosa, (b) street wall in La Paz with* Lemna valdiviana, *(c) cultivated fronds (5x) of* Lemna yungensis *Nr. 9207, and (d)* Lemna valdiviana *Nr. 9222.*

The species belongs to section *Uninerves* Hegelmaier and is most related to *L. valdiviana* Phil. (Fig. 1d). It differs from this species by its larger size and the more or less symmetric shape (in *L. valdiviana* fronds are usually narrower than 2.5 mm and often distinctly asymmetric at the base of the frond), by the absence of small papillae along the midline (in *L. valdiviana* often present) and by the sometimes slightly reddish violet colour of the frond margin (in *L. valdiviana* no reddish violet colour present).

HABITAT

Lemna yungensis grows on permanently wet rocks between c. 1400 and 2500 m a.s.l. (Fig. 1a). The rocks are more than 100 m high and perpendicular. They consist of a clayey schist without calcium carbonate (HCl test negative). The water is relatively low in nutrient content. The conductivity varies between 45 and 75 $\mu S\ cm^{-1}$ at the four different localities (64, 75, 72, 45 $\mu S\ cm^{-1}$).

The localities are situated within the wet tropical mountain climate; the vegetation is a tropical mountain rainforest (medio Yunga). *Cecropia* trees (Moraceae) are typical for this forest as well as tree ferns. The species diversity is very high. There is no climate station near the localities. However, the amount of precipitation (2000–3000 mm $year^{-1}$) is estimated according to a map of Roche & Rocha (in Hanagarth 1993). The rain is distributed throughout the year with a peak in the southern summer (December–March). During day-time, the sky is mostly cloudy. Therefore, the air humidity is always high. Temperatures are relatively constant throughout the day and the year. The monthly means vary probably not more than 5 °C throughout the year. Calculated from the values of climate stations along the foothills of the Andes (Rurrenabaques and Villa Tunari), the mean yearly temperatures are 15–20 °C according to the altitude. The temperature drops rarely below 10 °C, frost never occurs.

GEOGRAPHICAL DISTRIBUTION

The new species was found at the following places which are all situated in the department of La Paz (Fig. 2):

1. Main road between Chuspipata and Yolosa, northnortheast of Sacramento, 2440 m a.s.l.; vertical rock northwest to west exposed, steadily overflown by water; growing on the wet rock or within mosses. 19.7.1996. Landolt 1/96. ETH Nr. (of living Lemnaceae clones) 9207. *Typus location!*
2. Same locality and similar habitat as in Nr. 1, but 100 m down the road. 19.7.1996. Landolt 2/96. ETH Nr. 9208.
3. 6 km southeast of Coroico, near San Jacinto, 1700 m a.s.l.; water fall; northeast exposition; growing on wet rocks or between mosses. 20.7.1996. Landolt 3/96. ETH Nr. 9209
4. Road between Sta. Rosa and Undulavi, 300 m south of Velo de la Novia, 2000 m a.s.l.; water fall, east exposed; growing on wet rock. 21.7.1996. Landolt 4/96. ETH Nr. 9210.

We looked at other places with water falls but the species was not found: along the main road between Chuspipata and Yolosa above 2500 m a.s.l. and below 2200 m a.s.l.; along the main road between Yolosa and Caranavi (700–1200 m a.s.l.); around Choripata and Chulumani; in the surroundings of Sorata (cf. Fig. 2).

There is a chance of finding the species on other wet rocks at similar altitude in the yungas between Cochabamba in the Southeast and Peru. However, it looks as if the species has a rather limited distribution. No herbarium specimens are known from other rocky places in the Andes except one from

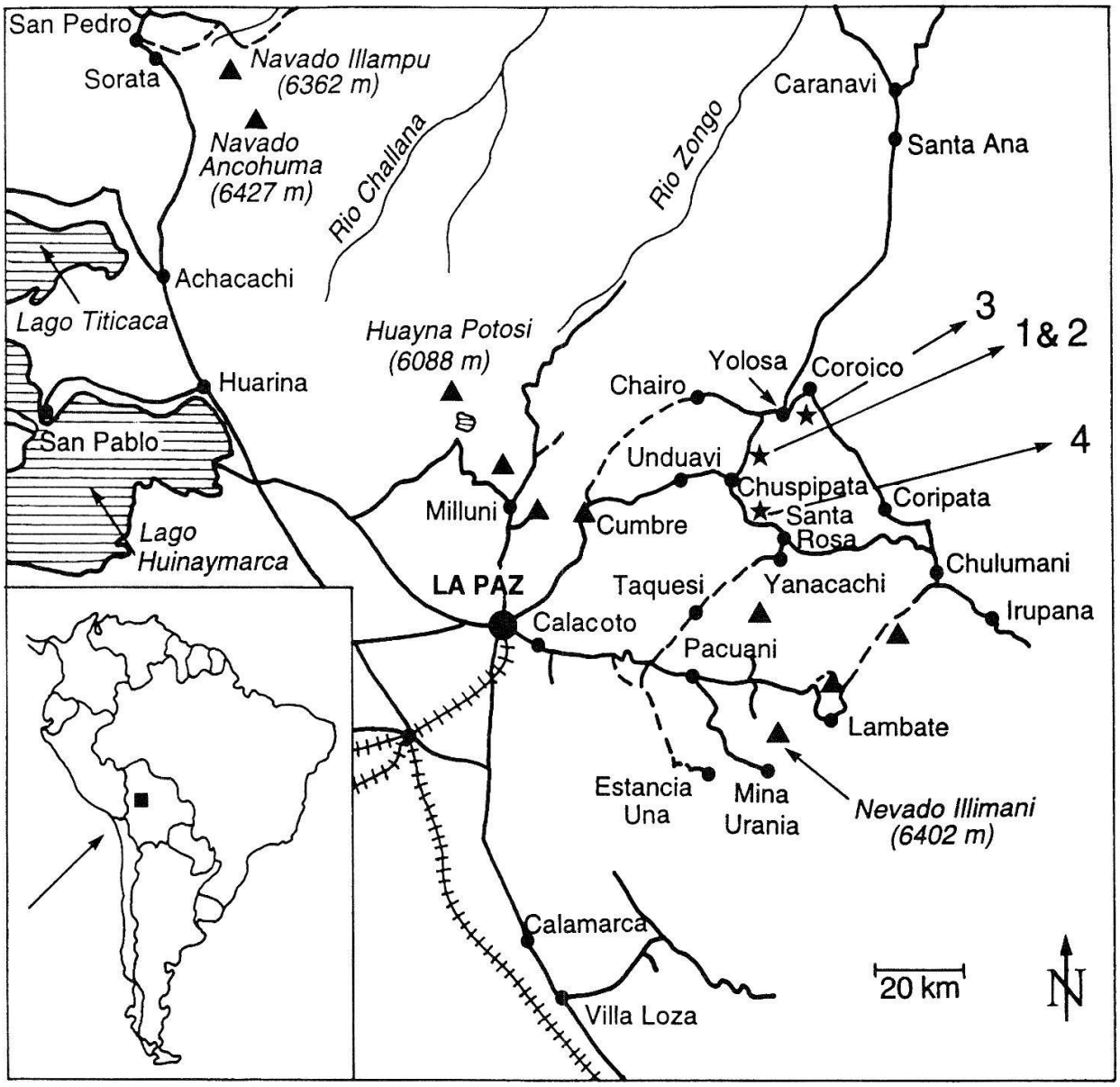

Fig. 2. *Map of the location of* Lemna yungensis *in Bolivia (description of the sites 1 to 4 in the text).*

Ecuador (Prov. Pichicha, Tandapi, 1450 m a.s.l.; growing on steep rocks by a creek. coll. Maas, Berg *et al.* 2894). Though these plants belong to the group of *L. valdiviana,* they are morphologically different from *L. yungensis;* they ressemble *L. minuta.*

Latin diagnosis

Lemna yungensis *spec. nov.*

Planta in rupibus ad perpendiculo directis crescens frondibus saxo humido nudo vel muscis adhaerentibus. Lemnae valdivianae valde affinis. Differt frondibus majoribus, usque ad 6 mm longis et 4 mm latis, concinnis (in L. valdiviana frondes usque ad 4.5 mm longis et 3 mm latis, parte proxima inconditis). Flores et fructus incogniti. Habitat in Yunga andina Boliviae inter circa 1400 et 2500 m.

Holotypus: La Paz, inter Chuspipata et Yolosa, 2440 m a.s.l. 19.7.1996. coll. E. Landolt 1/96. LPB. Isotypus: ZT.

Discussion

The special habitat of the species, wet, perpendicular rocks, is very rare but not exceptional for Lemnaceae. In Landolt (1986: 140–142), a survey of the known cases of Lemnaceae growing on rocks is given. Lemnaceae with long roots such as *L. minor* are sometimes able to live in waterfalls, the fronds hanging closely together by the roots (known examples from Massachusetts, Kaukasus and the Semien mountains, Fig. 4.1 in Landolt 1986). Short-rooting species depend on slowly flowing water in order not to get washed away. In Africa, there is an example of *L. aequinoctialis* known from a river near Brazzaville. Kolkwitz (1933) observed moist rocks near Rio de Janeiro partly covered with *Lemna*. In 1983, the present author collected *L. valdiviana* from steep southern exposed (shady) rocks south of Rio de Janeiro. The *Lemna* fronds stuck to the rough granitic rock (Plate XVId in Landolt 1986). In 1996, *L. valdiviana* was found in La Paz along Avenue del Libertador near junction of Ave. Copacabana growing on southeast exposed walls which are moistened by spring water (Fig. 1b). The duckweeds form 14 green stripes there. The difference in the habitat of *L. yungensis* and *L. valdiviana* growing on rocks follows below.

The rocks with *L. valdiviana* are low in height (up to 5 m) and moistened by local spring water. The mineral content of the water is probably much higher than in the Yungas. The water of Rio de Janeiro had a conductivity of 366 µS cm^{-1}, which is about six times higher than the average value on places with *L. yungensis*. The water of walls with *L. valdiviana* in La Paz was not measured. However, the conductivity of seven other water samples around La Paz was measured between 301 and 571 µS cm^{-1}. In both places (Rio de Janeiro and La Paz), *L. valdiviana* was growing in ponds and lakes of the vicinity. The regions of both places are favourable for Lemnaceae growth in regard to precipitation. The factor of Martonne amounts to 2–3 for La Paz and 3–4 for Rio de Janeiro. The factor of Martonne corresponds to the amount of precipitation in cm divided by the temperature (°C + 10). It is a rough measure for the average nutrient content of the regional waters.

The rocks with *L. yungensis* are up to more than 50 m high, situated near a local waterfall. *Lemna* grows on places where the rock is permanently covered by a thin water coat and mostly sprayed by droplets from the fall. The rock is covered with mosses and some other plants like a *Calceolaria* sp. The conductivity of the water is low (45–75 µS cm^{-1}), the precipitation very high, and the factor of Martonne amounts to 8 to >10. Lemnaceae do not normally grow in such regions. *Lemna yungensis* is probably only able to survive on waters with low nutrient content because the water is flowing, and the plant can filter out the few nutrients from the permanently renewed water. It seems that the plants need a certain rate of water replacement to survive. Longer times of water shortage are detrimental. On the other hand, the plants get washed off if the water flows too rapidly. Therefore, the rock wall has to be so steep that a surplus of water flows directly to the ground.

The new species belongs to the American section *Uninerves* Hegelmaier. The two known species of this section, *L. valdiviana* and *L. minuta*, are morphologically difficult to distinguish. The differentiation is primarily ecogeographic. Whereas *L. valdiviana* grows in temperate to warm tropic regions with relatively high air humidity, *L. minuta* colonizes primarily waters in drier regions and cannot be found in the warm humid tropics. In con-

trast to *L. minuta, L. valdiviana* is able to grow submerged in water where competition from other Lemnaceae is high and the content of nutrient in the water low. Crawford *et al.* (1996) showed that the two species can be distinguished by enzyme electrophoresis. A total of 15 loci was scored and the genetic identity for the two species was 0.70. According to these authors, the genetic identity is similar to the mean value for congeneric species of flowering plants, but within Lemnaceae it is high for congeners. This means that compared with other members of the Lemnaceae, the differentiation within the group of *L. valdiviana* is rather recent. Only in the genus *Wolffiella,* higher values were measured (for *W. repanda* and *W. hyalina* 0.80, for *W. gladiata* and *W. lingulata* 0.82, for *W. gladiata* and *W. oblonga* 0.84, and for *W. lingulata* and *W. oblonga* 0.94; Crawford *et al.* 1997). The analysis for *L. yungensis* reveals that the four strains of this taxon are closely related to *L. valdiviana,* but are distinct at one PGD locus (D.J. Crawford, pers. comm.).

We conclude that *L. yungensis* is different from the other two species of the section in a few not very well pronounced morphological features as well as in one enzyme locus. Furthermore, the habitat of this species is quite special. The reddish violet coulour within the frond epidermis (especially along the margins), which can be observed in some fronds at the natural habitat, might be another characteristic. However, the pigments do not show up in cultures. Therefore, I am not sure if this pigment is really produced by the *Lemna* or if it is formed by endophytes in the frond. Since reddish pigments are not known from the section *Uninerves,* the ability of synthetizing the pigment would be an excellent distinguishing character.

It seems that *L. yungensis* is a geographically restricted species which developed from *L. valdiviana* in this specialized habitat. Its area is isolated by rather long distances from localities of *L. valdiviana* (and other Lemnaceae). The nearest occurence of Lemnaceae is on the western side of the Andes in the vicinity of La Paz, around 40 km air-line distance. Towards the eastern foothills of the Andes, the next localities are even more distant. Open water in the wet climate of the Yungas does not contain enough nutrients to support Lemnaceae growth. In addition, the spread of Lemnaceae is complicated by the fact that water fowl, which usually contribute to the dispersal of Lemnaceae, do not land on rocks. There are some birds in the Yungas associated with rocks (e.g. *Cinclus leucocephalus*). However, it is difficult to imagine how they dispers *Lemna* fronds from one rock to another.

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