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The flowers of *Wolffia australiana* (*Lemnaceae*)

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1. INTRODUCTION

In 1990 BERNARD et al. published a paper on the flower structure, anatomy and life history of *Wolffia australiana*. In a flowering culture of *W. australiana*, the authors observed that the anther is bilobed with two separate dehiscent lines. To date, it was believed that all representatives of the subfamily of *Wolffioideae* had a single stamen with a spherical bilocular anther provided with only one apical dehiscent line, in contrast to the subfamily of *Lemnoideae* (two stamens with bilobed tetralocular anthers and separate dehiscent lines on each lobe). These findings for *W. australiana* if correct for all strains would change the systematics of the *Wolffioideae* giving *W. australiana* a transitional position between the two subfamilies. Since *W. australiana* has otherwise no special features which would justify such a position I decided to investigate more flowers from different strains. BERNARD et al. (1990) also remarked that out of the c. 25 investigated flowers two developed abnormally. "One had a second stamen coming from the cavity, while in the other the filament was very long and supported an anther with a very rough, lumpy surface". In the discussion the authors write: "The bilobed anther is similar to that of *L. minor* (SCULTHORPE 1967), *L. perpusilla* (= *L. aequinoctialis*) (SHIH 1979), *Wolffia arrhiza* (DAHLGREN et al. 1985) and *W. microscopica* (MAHESHWARI and CHAUHAN 1963). MAHESHWARI and KAPIL (1963) reported a tetralocular anther in *L. paucicostata* (= *L. aequinoctialis*), although their diagram shows a bilobed external appearance". Since this statement does not coincide with the findings of the cited authors it was desirable to check the references.

2. SOME LITERATURE INDICATIONS ON ANTHERS OF *LEMNACEAE*

Since HEGELMAIER (1868) who investigated the development of the anthers of all genera in the *Lemnaceae* very carefully and meticulously, it is well known that *Spirodela* and *Lemna* have bilobed but four-locular anthers and *Wolffia* scarcely lobed but bilocular anthers. DAHLGREN et al.(1985) write erroneously of a one-locular anther in *Wolffia* while all the above cited authors confirmed the findings of HEGELMAIER. The dehiscent line marks the edge of a septum which divides the anther in *Wolffia* vertically in two locules (Figs. 1, 2, 3). The anther might be slightly bilobed as in Fig. 1 or spherical. In *Spirodela* and *Lemna* the anthers are distinctly bilobed and always tetralocular. The two dehiscent lines of the bilobed anther of Fig. 1 of BERNARD et al. (1990) point to a tetralocular anther. It seems that the dehiscent lines cross the anther lobes apically (as in *Spirodela polyrrhiza*) and not horizontally (as in *Lemna*). In Fig. 2 of BERNARD et al. a longitudinal section shows a stamen with apparently only one dehiscent line (and two locules) which is normal for other *Wolffia* species. Some years ago I brought a *Wolffia australiana* strain (7819 from Glencoe West, South Australia) experimentally to flower in a 1/5 Hutner solution + 0.01 g/l EDDHA + 1% sucrose (25°C, 12 hours light of c. 15000 lux). The flowers showed no difference to flowers of other species of *Wolffioideae* (see plate XIV b, p. 526 in LANDOLT 1986). I checked only very few flowers and did not look for abnormalities.

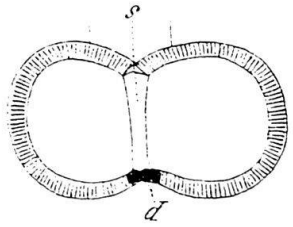


Fig. 1. Longitudinal section of a stamen of *Wolffia arrhiza* (120x) (from HEGELMAIER 1868) p = pigment cells, s = septum

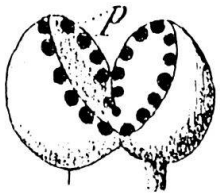
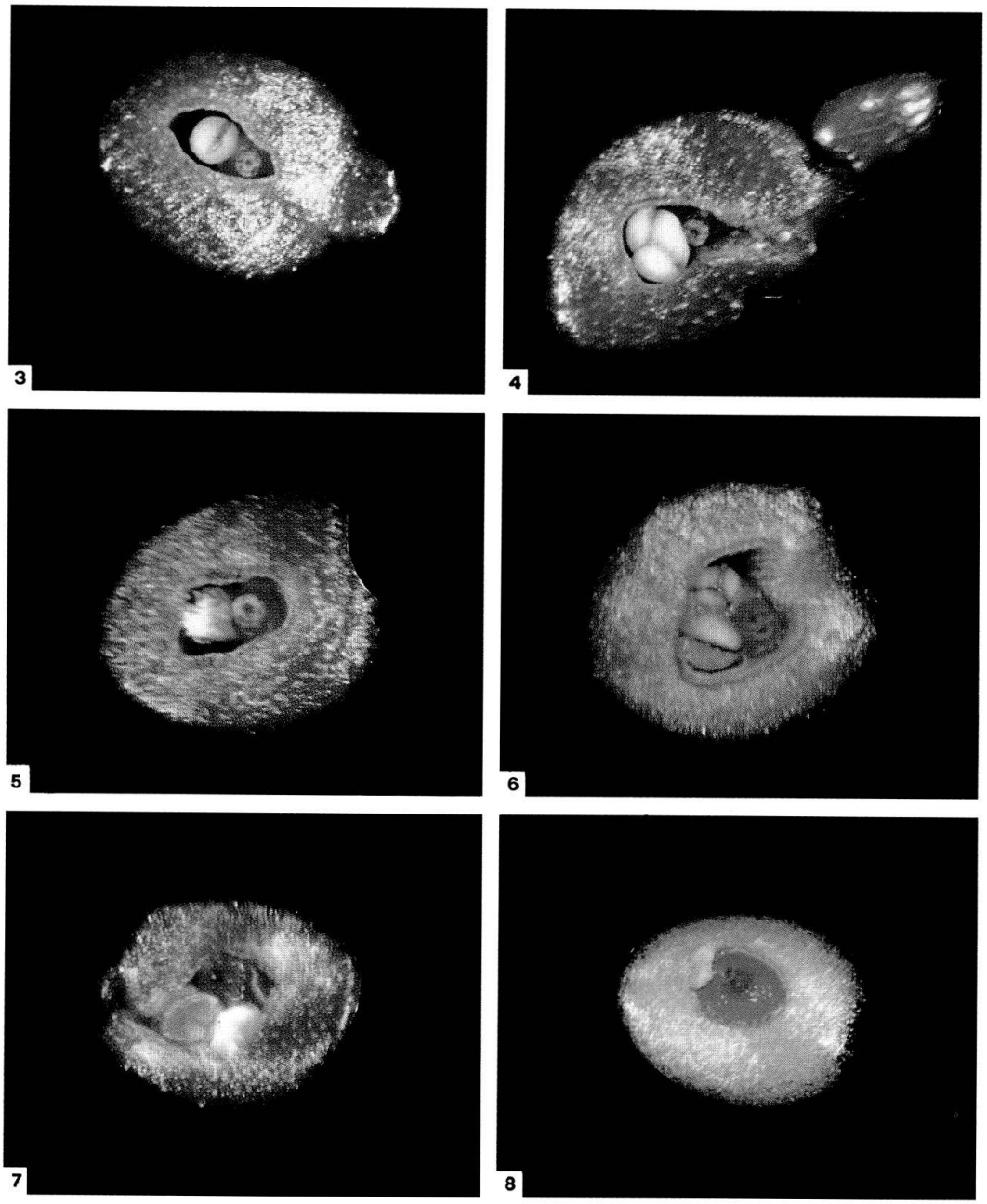


Fig. 2. Stamen of *Wolffiella repanda* with opening anther (120x) (from HEGELMAIER 1868)

3. EXPERIMENTALLY INDUCED FLOWERS

I repeated the flower experiment using the same solution and the same conditions as described above. I also tried a solution with only 0.005 g/l EDDHA



Figs. 3-8. Flowering and fruiting fronds of *Wolffia australiana* (40x)
Fig. 3. Flowering frond with a normal bilocular anther (one dehiscent line) (No. 7543)
Fig. 4. Abnormal anther with three dehiscent lines (No. 7543)
Fig. 5. Abnormal anther with two lobes each of which with a dehiscent line (No. 7543)
Fig. 6. Flower with two stamens (one anther with three dehiscent lines) and one pistil (but two stigmas) (No. 7543)
Fig. 7. Flower with two pistils (No. 7317)
Fig. 8. Fruiting frond (No. 7819)

and a control without EDDHA. Besides strain 7819, two other strains (7317 from Ballarat, Victoria, and 7543 from North Canterbury, New Zealand) were used. After 16 days all three strains began to flower in the solutions with EDDHA. For 7819 and 7543 the lower concentration of EDDHA was more effective. For 7317 the opposite was true. The controls without EDDHA did not flower. I checked 55 flowers in No. 7543, 26 in No. 7819 and 20 in No. 7317. The following could be distinguished:

1) Normal flowers with one pistil and one anther with an apical dehiscent line (apparently bilocular) (Fig. 3)
2) Flowers with one pistil and one bilobed anther with two dehiscent lines (apparently tetralocular) (Fig. 5)
3) Flowers with one pistil (some of which with two stigmas) and two anthers (apparently either bilocular or trilocular) (Fig. 6)

Moreover a few flowers were detected with an apparently trilocular anther (Fig. 4), and one flower was found with two pistils (Fig. 7).

The flower types could not always be clearly distinguished. Sometimes it was too early or too late to recognize the necessary features. That's why the number of checked flowers was rather limited. The percentage of the various flower types within the checked flowers is given in Table 1.

BERNARD et al. observed pigment cells only in the dehiscent line. In some flowers I also saw pigment cells annularly arranged on the stigma and at the edge of the flowering cave (Figs. 6 and 8). The pigment cells probably show up only in dead or nearly dead tissue, explaining why they cannot always be detected. The strains 7819 and 7543 developed some fruits (Fig. 8). At least these strains are self-fertile and partly selfing.

According to BERNARD et al. the cavity opening is heart-shaped in *Wolffia australiana* and is oval in *W. angusta*. As visible in Figs. 3-8 the shape of the opening of *W. australiana* can vary considerably. In fronds with normal flower organs it is not much different from that of *W. angusta* and other *Wolffia* species.

Table 1. Percentage of flower types in three *Wolffia australiana* strains.

No. type	7543	7819	7317
1)	87	92	75
2)	9	4	20
3)	4	4	5

4. DISCUSSION

Lemnaceae are not very differentiated plants and stay, in many respects, on an embryonic level. KANDELER (1988) points out that "*Lemnaceae* show a predominance of irregular (adventitious) organ formation". It is therefore not surprising if these plants should produce some adventitious flowering organs under certain conditions. It may be that *Wolffia australiana* is especially susceptible to aberrations. But it might well be that other species also vary in their flowering parts, though to a lesser degree. For example, three stamens (instead of two) have been observed in *Spirodela polyrrhiza* (LACOR 1970) and *Lemna aequinoctialis* (WITZTUM 1966, SHIH 1979). In *Wolffia columbiana* two flowering cavities have been detected (LANDOLT 1986). There is also the possibility that EDDHA may have effected aberrations. In the higher concentrations of EDDHA (0.01 g/l) the fronds do not grow well, giving rise to abnormal and irregular shapes of the fronds. On the other hand, BERNARD et al (1990) observed their flowering in old, crowded cultures, untreated with EDDHA.

SUMMARY

The flowers of *Wolffia australiana* are in most cases typical for *Wolffia* flowers with one pistil and one bilocular anther. Rarely, abnormal flowers with a tri- or tetralocular anther, with two anthers or with two pistils can be observed

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