Carniflora Australis

Journal for the Australasian Carnivorous Plant Society Inc.

Number 1. March 2003

ISSN 1448-9570 PRICE $6.00 Free with Membership

Subscription

All members, single, family and overseas AU $25.00

Please make cheques or money orders payable to the Australasian Carnivorous Plant Society Inc. Membership and correspondence should be forwarded to the Secretary at

www.carniflora.com

P.O. Box 4009 Kingsway West
NSW 2208 (AUSTRALIA)

Meetings are held on the second Friday of each month

Time: 7:30pm – 10.00pm
Venue: Woodstock Community Centre,
Church Street Burwood

Contents

Front Cover: *Drosera macrantha* grown and photographed by Greg Bourke

SPEAKERS AND EVENTS FOR 2003

Date	Subject	Speaker
June	Gemmae collection	Greg Bourke
July	Tuberous Drosera (Slide show)	Greg Bourke
August	Spiders (Slide Show)	Anthony Bowdler
September	TBC	
October	General discussion	
November	Auction	

Contributions, including articles, letters, photographs and drawings, to the journal are greatly appreciated and may be forwarded to the above address. The views expressed in this journal are not necessarily those of the Australasian Carnivorous Plant Society Inc. Articles, photographs and drawings remain copyright of the author and may not be reproduced without the author's permission.

Figure 1.(**How to Grow Happy *Drosera pauciflora* in Sydney**) Flower of D. pauciflora grown and photographed by Fuzzy.

Ecophysiological comparison of green Polish and red Australian plants of *Aldrovanda vesiculosa*

Dr. Lubomír Adamec

INTRODUCTION

Aldrovanda vesiculosa L. (*Droseraceae*) is a very rare aquatic carnivorous plant spread on all continents of the Old World, from north Russia to southeast Australia. Despite items of information on recent plant populations from Africa and tropical Asia and on their general characteristics are lacking, all recently known and cultivated world populations (so-called accessions) of *Aldrovanda* can be divided into two distinct and striking groups, i.e., green temperate European and Japanese plants and red (sub)tropical Australian ones (Adamec 1999a). As reported by the author the main differences between these two groups of plants are: the colour of the plants, their overwintering characteristics, formation of axillary buds, and sensitivity to boron. Very attractive plants of three Australian populations have been growing over the world for five years more and general knowledge of how to grow them is increasing. As the both groups of plants are grown together in the Institute of Botany at Trebon (49^{o}N, 15^{o}E), Czech Republic, it has been possible to compare the both plant groups from an ecophysiological point of view. In this study, the following ecophysiological characteristics are compared in green *Aldrovanda* plants from east Poland and in plants from three red Australian populations: growth characteristics, photosynthetic CO_2 affinity, turion overwintering and germination, sugar content in turions, and macro- and microelement content in plants.

MATERIALS AND METHODS

Plants of *Aldrovanda* from east Poland (EPO) were grown outdoors in a 1-m^2 plastic

container (Adamec 1997a,b). Temperate plants from Saitama Prefecture in Japan (Kondo et al. 1997) and Switzerland (originally from S Germany) were grown in 3-l aquaria outdoors (Adamec and Tichý 1997). Plants of three Australian populations were grown either in 3-l aquaria indoors for the year round (Adamec 1999a) or in 3-20 l aquaria outdoors from late May to mid-November, till the first ice formation (Adamec and Tichý 1997). They were: SEA, from Batemans Bay near the East Coast, southeast Australia, NSW; NA, from Girraween Lagoon near Darwin, north Australia, NT (see Adamec 1999a); NWA, from Mertens Falls in Kimberley, northwest Australia, WA (Lowrie 1998).

A 21-d growth experiment (14 June – 5 July 1999) was conducted outdoors to compare the growth rate of EPO and SEA plants growing under the same conditions. Ten non-branched EPO plants growing in the 1-m^2 container (mean length 13.5 cm, SE 0.24 cm; mean number of leaf whorls 15.9, SE 0.36) were put in a floating plastic bottom- and topless enclosure, with a diameter of 0.3 m. To estimate the growth rate as a production of new leaf whorls d^{-1}, the internode between the third and fourth adult whorls was tagged by a fine thread. SEA plants from an outdoor aquarium had grown in the same container for 10 d before 10 non-branched plants (mean length 10.0 cm, SE 0.59 cm; mean number of leaf whorls 15.6, SE 0.67) were put in the same floating enclosure. Total shoot length, number of adult whorls, and position of the tag were estimated in all plants at 3-6 d intervals (see Adamec 2000). During the experiment, minimum water temperature on the level of plants was within 11.8-21.6 ^oC, while maxima were within 16.1-31.5 ^oC. pH was 7.04-7.34, $[HCO_3^-]$ 0.68 mM (=$mmol.l^{-1}$), and $[CO_2]$ 0.07-0.15 mM. To find the growth rate of plants at low autumnal temperatures (maxima 6.0-19.0 ^oC), a similar 35-d growth experiment (2 October – 6 November 1999) was repeated with 8 adult SEA plants in the same container. Position of the tag was estimated at 7 d intervals.

At the end of the first experiment (5 July 1999), 5-cm long apical

shoot segments were used for estimation of CO_2 compensation points of photosynthesis by means of the final-pH method (see Adamec 1995a,b; 1997b). The segments were closed in 10-ml test tubes in 0.95 mM $NaHCO_3$ + 0.1 mM KCl, pH 7.56, at 29+1 ^oC in natural light for 4 h. This experiment was repeated with EPO and SEA plants from the same outdoor container and with NA plants from an outdoor aquarium, on 2 August 1999.

Degree of dormancy was compared in ripe turions of EPO and all three Australian populations. Turions were collected from ice-cold water from outdoor cultivations on 19 November 2000 and stored in a refrigerator at 2 ^oC in darkness in filtered cultivation medium till 28 November. Ten turions of each population, put in small glass vials in filtered cultivation medium, were exposed at 22+1 ^oC in a miniphytotron equipped with fluorescent white light (14 h L:10 h D; 280+30 μmol photons. $m^{-2}.s^{-1}$ of photosynthetically active radiation) for evaluation of turion germination. Turions being regarded as germinating reflexed distinctly basal leaf whorls and opened themselves (at least slightly). The same germination test was conducted with the same batches of turions stored in a refrigerator on 3 April 2001.

Starch and free sugar content was estimated in ripe turions of the three Australian *Aldrovanda* populations growing in outdoor aquaria at the end of the growing season, on 16 November 1999 and 2000. Totally, 10-25 turions (DW 19-68 mg) were dried at 80 ^oC and analyzed for starch (anthrone method) and sucrose, glucose, and fructose content (HPLC; for details see Adamec 2000). EPO turions were collected on 4 November 1998.

To reveal a possible reason for the disease of *Aldrovanda* shoot apices (see Adamec 1997a, 1999a), macro- and microelement content was analyzed in 1.5-2.5 cm long apical segments of indoors or outdors grown healthy or ill plants. Dry plant material (11-24 mg) was mineralized with 0.2 ml of 65 % HNO_3 (140 ^oC for 30 min). The content of Zn, Cu, Mn, Fe, Co and, in some samples, of K, Ca, and Mg was

analyzed in diluted samples using an atomic absorption spectrometer. For comparison, K, Ca, and Mg were also analysed in dry biomass of EPO plants from a growth experiment in which the effect of feeding on prey was investigated and only N and P content has been analyzed so far (Adamec 2000). Blank samples were used. Boron content was estimated in four plant samples (17-30 mg DW) collected on 6 November 2001: EPO turions collected from an artificial site at Karstejn, S Bohemia, Czech Republic, having ripened in the outdoor container; 4-cm apical segments of indoor-grown ill SEA plants; 1-cm apical segments of indoor-grown healthy NWA plants; 4-cm long subapical segments of the latter NWA plants. Dry samples were mineralized in teflone vials with highest analytical grade HNO_3 + H_2O_2. B was analyzed in mineralizates using an ICP-OES spectrometer. Blank samples were used.

RESULTS AND DISCUSSION

As shown in Fig. 1 EPO plants grew considerably faster (0.31-0.80 new whorls.d^{-1}) than SEA ones (0.26-0.65 whorls.d^{-1}), under the same conditions. Over the whole 21-d growth period, the mean growth rates were 0.51+0.01 (EPO) vs. 0.41+0.02 whorls.d^{-1} (SEA) and statistically significantly differed at $P<0.001$ from each other. However, except for the last week of the experiment, water was relatively cold (esp. at night; 11.8-18.7 ^oC) which might be limiting for SEA plants. As it follows from the fact that neither plants branched during the experiment, growth conditions ($[CO_2]$, prey availability) were not at optimum for the both populations. Totally, the EPO plants were more robust than the SEA ones (Fig. 1), while the latter ones grown in an indoor culture can be as robust as the Polish ones (Adamec 1999a). Thus, it is possible to assume that Australian *Aldrovanda* plants can grow as rapidly as temperate European plants at high water temperature and favourable growth contitions. As suggested by Adamec (1999a) Australian plants can be grown successfully outdoors, from May to October-November, until a thin ice cover is formed. The measurement of autumnal growth rate of SEA

plants showed a very slight growth rate of 0.009-0.089 whorls.d^{-1} between 2-23 October (maxima 6-19 ^{o}C), while their growth stopped totally after 23 October. On 30 October, distinct turions were formed. EPO plants would stop their growth by one month earlier.

Green EPO plants had a higher photosynthetic affinity to CO_2 than together growing slightly reddish SEA plants (CO_2 compensation points 6.2-8.8 vs. 8.8-10.2 μM; Tab. 1), while dark-red SEA plants had a very low affinity (18.9 mM). Thus, the more the Australian plants contain anthocyanins, the lower is their CO_2 affinity. The lower CO_2 affinity in SEA plants could partly explain their lower growth rate in the growth experiment. However, the values of CO_2 compensation point lay well within the range reported for aquatic plants (cf. e.g. Maberly and Spence 1983).

In Central Europe, plants of the three Australian *Aldrovanda* populations, grown outdoors at high natural irradiance, form turions at maximum water temperatures of 6-13 ^{o}C in the course of October, while the plants grown indoors at lower irradiance do so already at about 18 ^{o}C (Adamec 1999a). Then, all outdoor-grown plants are resistant to zero water temperatures. European and Japanese plants form turions one month earlier (Adamec 1999a,b, c). Freshly collected turions of all three Australian *Aldrovanda* populations started germinating as early as 4 days after their transfer to long-day conditions at 22 ^{o}C and a 50 % germination was attained after 8-12 days (Fig. 2; cf. Adamec 1999a). Similarly, after the parallel turions had been transferred to indoor aquaria in natural light at 19-22 ^{o}C they all started germinating and sprouting by 7 days. The low germination of NA turions shown in Fig. 2 (30 %) was caused by the rotting of remaining turions, which could be caused by B deficiency. On the contrary, the EPO turions stayed strictly dormant (data not shown) and required 2-month cold treatment for breaking their innate dormancy (Adamec 1999c). After overwintering in a refrigerator on 3 April, all Australian turions started

germinating in long days at 22 °C within 25-35 h and germinated fully within 55 h, while full germination of EPO turions was delayed by about 15-20 h (Fig. 3).

Thus, although all the three Australian *Aldrovanda* populations form morphologically distinct turions as a result of low temperatures and low irradiance the degree of dormancy of ripe autumnal turions is very slight, as compared to strictly dormant turions of European and Japanese plants. Furthermore, ripe EPO turions are much larger (DW 8-10 mg) than those of all three Australian populations (DW 1.7-3.1 mg; see Tab. 2) and are easily separated from senescing mother shoots as soon as they ripen, while the Australian turions are firmly attached to mother shoots for the whole winter. EPO senescing mother shoots strictly cannot resume their grow at higher temperatures, either, and die, but those of all three Australian populations form big axillary buds (Adamec 1999a). Although turions of SEA plants are considerably larger (mean DW 2.8-3.1 mg; Tab. 2) than those of NA and NWA plants (1.7-2.0 mg) their degree of dormancy was the same (Fig. 2). It was found preliminarily in ripe SEA turions in November that the bigger they were the later they started germinating. However, in spite of very slight dormancy of turions of Australian plants, at least SEA turions were found to be comparably as frost resistant as EPO turions (cf. Adamec 1995b). Eight ripe SEA turions were stored on the wet bottom (5 mm deep) of the plastic cultivation container without water over winter. Here, the turions experienced the temperatures of ca. –10 to – 15 °C. At the end of February, 7 out of 8 turions were in a good shape and 4 turions germinated in early April. Seven SEA turions overwintered successfully under water in a small dystrophic pool at Branna, Trebon region, Czech Republic, to which dozens of SEA plants were introduced experimentally in 2000. Although all Australian *Aldrovanda* populations occur at natural (sub)tropical sites without ice cover, safe overwintering at least of SEA plants should also be possible in temperate zones

with thick ice cover.
Surprisingly, starch content in ripe turions of all three Australian populations was usually greater (23-53 % DW; Tab. 2) than that in EPO turions (22.5-27 %; see also Adamec 1995a, 1999c). Free sugar content was comparable in the both turion groups. Thus, ripe turions of all three Australian *Aldrovanda* populations are well stored with saccharide resources over winter.

No clear relationship has been found between the content of Zn, Cu, Mn, Fe, and Co in apical shoot tissue and state of health in Australian and European *Aldrovanda* plants (Tab. 3). Ranges of microelement contents in ill plants usually overlapped greatly with contents in healthy plants. The mean content of Cu, Mn, and Fe in *Aldrovanda* shoots was about one order of magnitude lower than that estimated in aquatic *Utricularia* shoots, while Zn content was comparable (Dykyjova 1979). Thus, symptoms of "*Aldrovanda* disease" (damage of shoot apices) cannot be attributed to deficiency of Zn, Cu, Mn, or Fe. Also, the shoot content of K, Ca, and Mg was similar in healthy and ill *Aldrovanda* plants (Tab. 3) and could not account for the disease. K, Ca, and Mg content in Australian plants was about the same as that in EPO plants (cf. Tab. 4 or Adamec 2000). Additional K, Ca, and Mg analyses of shoot tissues in *Aldrovanda* plants having been grown with or without prey (as a supplement of data by Adamec 2000) revealed about the same K and Mg content in both groups but Ca content was increased in plants without prey (Tab. 4). These results support the view that the only data on tissue nutrient content in carnivorous plants does not reflect nutrient uptake by the plants from prey (Adamec 2000).

Boron deficiency has been considered to be the main reason for the "*Aldrovanda* disease" (Adamec 1997a, 1999a). Theoretically, boron deficiency is well-known to cause distinct damages of shoot apices in terrestrial plants (e.g. Marschner 1995). Since 1996, it has been confirmed repeatedly by myself and other *Aldrovanda* growers that an addition of H_3BO_3 at a

final concentration of 0.5-0.6 mg. l^{-1} (i.e., 0.087-0.10 mg.l^{-1} B) cures ill EPO plants. However, the positive effect of the boric acid addition was sometimes relatively weak and was only attained after a combined addition of boric acid with a mixture of microelements. In some cases, it was difficult to cure ill plants of other green European or Japanese populations even by this combined microelement addition. The more the plants were ill, the lesser was the chance to cure them.

The "*Aldrovanda* disease" was very often observed in all three Australian populations, mainly in SEA and NA plants. It was found in Australian plants that a transfer of ill plants to healthy ones neither led to an infection of the healthy ones nor the ill plants cured. Generally, the symptoms of the disease are manifested the more and the faster, the more rapidly plants grow and the more they are fed on prey. Thus, a microelement(s) with a poor re-utilization (recycling) efficiency, which is not taken up from prey, could be lost with senescing shoot biomass. Then, at reduced availability of this microelement (s) in water, the faster the plants grow, the faster is this microelement(s) "diluted" in shoot tissues and becomes limiting for normal plant growth. Obviously, green temperate *Aldrovanda* populations differ in the microelement requirement from Australian ones. After a microelement mixture was added to ill green Ukrainean and NA plants growing together, only Ukrainean plants cured. It was found that an addition of boric acid at 1 mg.l^{-1} (i.e., 0.17 mg.l^{-1} B) could cure ill Australian plants. Thus, Australian plants are probably more B requiring than the green temperate ones and the conlusion on B toxicity in Australian plants (Adamec 1999a) is not valid.

However, B analyses in all samples using up-to-date equipment, have revealed that B concentrations in the samples were not statistically significantly different from those in blank samples. It follows from this fact that the true B tissue content was well below 20 mg.kg^{-1} DW (ppm), both in healthy and ill

plants. As reported by Glandon and McNabb (1978) B content in many aquatic plants ranged within 10-3200 ppm, mean about 30-80 ppm, and in ecologically relative *Utricularia* species hundreds of ppm. Thus, there is a great discrepancy between the high B requirement for *Aldrovanda* in water medium and a very low B shoot content, even in healthy plants. This discrepancy might be explained as a very low efficiency of B uptake from water. In any case, B functioning in *Aldrovanda* requires a further study.

REFERENCES

Adamec L., 1995a. Photosynthetic inorganic carbon use by aquatic carnivorous plants. Carniv. Plant Newslett. 24: 50-53.

Adamec L., 1995b. Ecophysiological study of the aquatic carnivorous plant *Aldrovanda vesiculosa* L. Acta Bot. Gall. 142: 681-684.

Adamec L., 1997a. How to grow *Aldrovanda vesiculosa* outdoors. Carniv. Plant Newslett. 26: 85-88.

Adamec L., 1997b. Photosynthetic characteristics of the aquatic carnivorous plant *Aldrovanda vesiculosa*. Aquat. Bot. 59: 297-306.

Adamec L., 1999a. The bi*Aldrovanda vesiculosa*. Carniv. Plant Newslett. 28 (4): 128-132.

Adamec L., 1999b. Seasonal growth dynamics and overwintering of the aquatic carnivorous plant *Aldrovanda vesiculosa* at experimental field sites. Folia Geobot. 34: 287-297.

Adamec L., 1999c. Turion overwintering of aquatic carnivorous plants. Carniv. Plant Newslett. 28 (1): 19-24.

Adamec L., 2000. Rootless aquatic carnivorous plant *Aldrovanda vesiculosa*: physiological polarity, mineral nutrition, and importance of carnivory. Biol. Plant. 43: 113-119.

Adamec L., Tichý M., 1997. Flowering of *Aldrovanda vesiculosa* in outdoor culture in the Czech Republic and isozyme variability of its European populations. Carniv. Plant Newslett. 26: 99-103.

Glandon R. P., McNabb C. D., 1978. The uptake of boron by *Lemna*

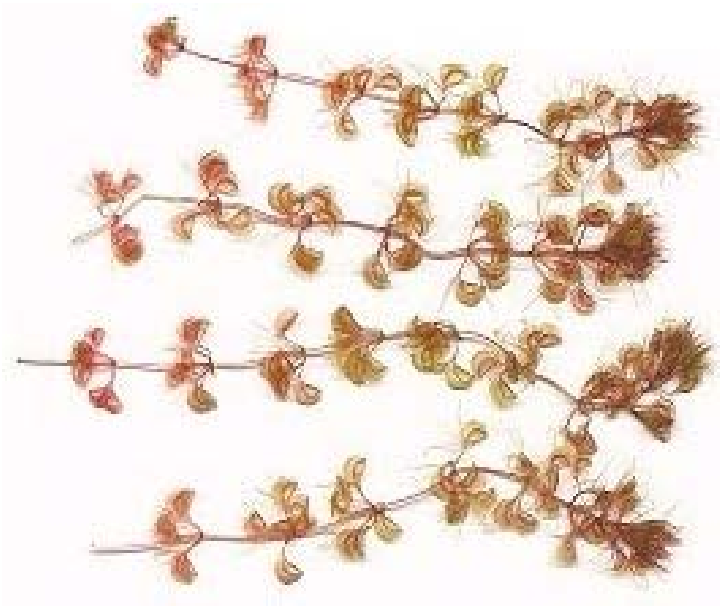
minor. Aquat. Bot. 4: 53-64.
Kondo K., Kokubugata G., Varghese S. B., Itoyama M., Breckpot C., Kromer K., Kamiński R., 1997. Conservation of endangered *Aldrovanda vesiculosa* by tissue culture. Carniv. Plant Newslett. 26: 89-92.
Maberly S. C., Spence D. H. N., 1983. Photosynthetic inorganic carbon use by freshwater plants. J. Ecol. 71: 705-724.
Marschner H., 1995. Mineral Nutrition of Higher Plants. Academic Press, London, UK.

Material and type of culture	**Final pH**	**Final [CO_2] (µM)**
A. E Poland, outdoor container	8.36	8.75 (0.31)a
A. SE Australia, outdoor container	8.29	10.2 (0.20)b
B. SE Australia, outdoor aquarium	8.03	18.9 (n=2)
C. E Poland, outdoor container	8.56	6.23 (0.23)a
C. SE Australia, outdoor container	8.42	8.79 (0.63)b
D. N Australia, outdoor aquarium	8.35	10.2 (0.31)b

Table 1. Final pH values and final CO_2 concentrations as CO_2 compensation point of photosynthesis for different *Aldrovanda* strains, measured in 1 mM $NaHCO_3$ in final-pH experiments at natural irradiance. Apical shoot segments 3-6 cm long were used. Plants denoted by the same letter were grown together in the same container, under the same conditions of pH and [CO_2]. 1.SE is shown in brackets; n=4. Results of two experiments with different plants are separated by dotted line. Within each experiment, different letters denote statistically significant difference at P=0.05.

Plant origin	Turion DW (mg)	DW (% FW)	Starch (% DW)	Suc	Glu	Fru	Total free sugars	Total sugars
SE Australia	3.1(2.8)	22.8 (29.5)	45.2 (48.6)	3.2	7.6	2.0	12.8	58.0
N Australia	1.8(2.0)	18.8 (23.4)	46.3 (22.6)	3.2	7.1	2.3	12.6	58.9
NW Australia	1.7(1.8)	21.4 (21.4)	50.9 (53.2)	3.9	7.4	1.9	13.2	64.1
E Poland	8.7	22.5	24.3	6.4	6.7	1.3	14.4	38.7

Table 2. The comparison of starch, sucrose (suc), glucose (glu), and fructose (fru) content in weakly dormant turions of three Australian strains of *Aldrovanda vesiculosa* grown outdoors, on 16 Nov 1999 and 16 Nov 2000 (data in parentheses). Sugar content is given in % of DW. Mean dry weight (DW) of one turion and DW of turions in % of fresh weight (FW) are also shown. For comparison, data on dormant turions of outdoor grown E Polish plants (4 Nov 1998) are shown.



Scanned Aldrovanda plants from N Australia with small turions grown in an outdoor aquarium, 1st Nov 1998; Lubomir Ademec

Origin of plants and type of culture	Status of health	Zn	Cu	Mn	Fe	Co	K	Ca	Mg
		mg.kg^{-1} (DW)					% DW		
SE Australia, indoor aquarium	healthy	41.6	8.6	26.9	71.5	-	-	-	-
SE Australia, indoor aquarium	healthy	79.9	2.3	-	84.2	-	3.42	0.65	0.132
SE Australia, indoor aquarium	ill	67.0	3.2	-	324	-	1.87	0.86	0.080
N Australia, indoor aquarium	ill	417	2.6	-	385	-	2.27	0.73	0.067
E Poland, outdoor container	healthy	224	11.0	134	196	1.74	-	-	-
Switzerland, outdoor aquarium	ill	58.1	3.8	327	107	-	-	-	-
Japan, outdoor aquarium	ill	457	9.8	-	67.3	0.71	2.77	1.20	0.092

Table 3. Macro- and micronutrient content in dry mass of 2-3-cm long apical parts of *Aldrovanda vesiculosa* plants with different status of health. Ill plants exhibited evident features of micronutrient disorder ("*Aldrovanda* disease").

	With prey					Without prey				
Shoot segments	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Apices	1.18	0.35	2.42	0.30	0.14	1.28	0.43	2.44	0.36	0.15
1st-6th whorls	0.79	0.20	2.93	0.67	0.14	0.85	0.25	2.84	0.81	0.14
7th-10th	0.69	0.16	2.73	0.86	0.10	0.65	0.16	2.97	1.14	0.12

Table 4. Nitrogen and phosphorus content in shoot segments (% DW) of successive ages of E Polish *Aldrovanda* at the end of the growth experiment with or without prey, after 17 d. Mean of two parallel determinations is always shown. The data for N and P wee published by Adamec (2000).

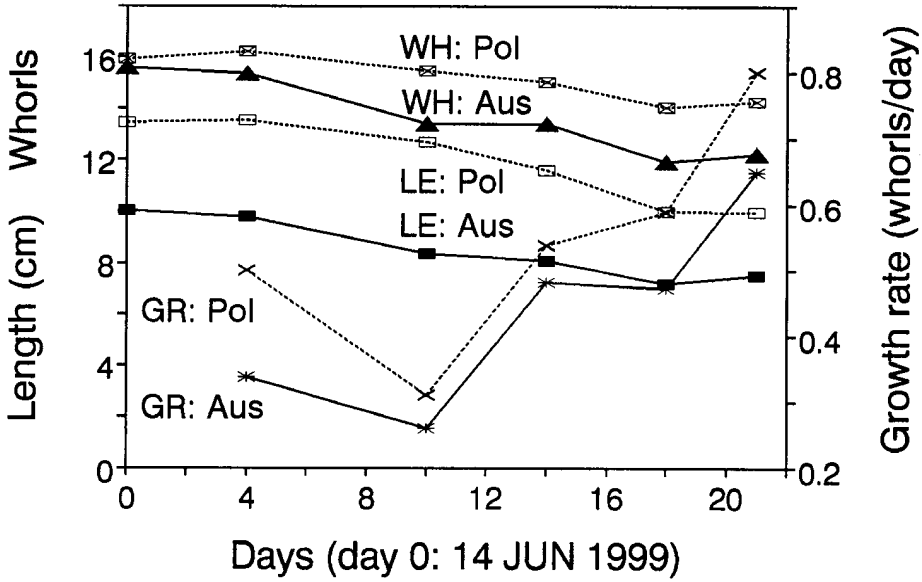


Fig. 1. Results of growth experiment with E Polish (Pol, dotted lines) and SE Australian (Aus, full lines) *Aldrovanda*. WH, number of leaf whorls; LE, total length of plants, GR, growth rate in new whorls.d^{-1}.

Do your carnivorous plants produce seed?

How about donating some to the societies seed bank! For the seed bank to work successfully it relies on donations. Any spare seed you have can be forwarded to the societies address but it must be clean and labeled.

What do we mean by clean?

You must ensure the seed is separated from all other flower parts. If you live within Australia and you do not wish to do so or are unsure how to, simply send the entire scape!

How should it be labeled?

With the full species name eg. Drosera rotundifolia not D. rotundifolia. If sending seed from outside Australia, it must also have a customs declaration stating what is in the package. This avoids delays with Australian customs.

If you wish to donate seed, it is advisable to contact the Seed Bank Manager (sydneycarnivorous@hotmail.com) to ensure that it is ok to donate the particular species ie. Some species are protected by CITES while others are listed as potential weeds.

Please donate seed and help others enjoy growing carnivorous plants!

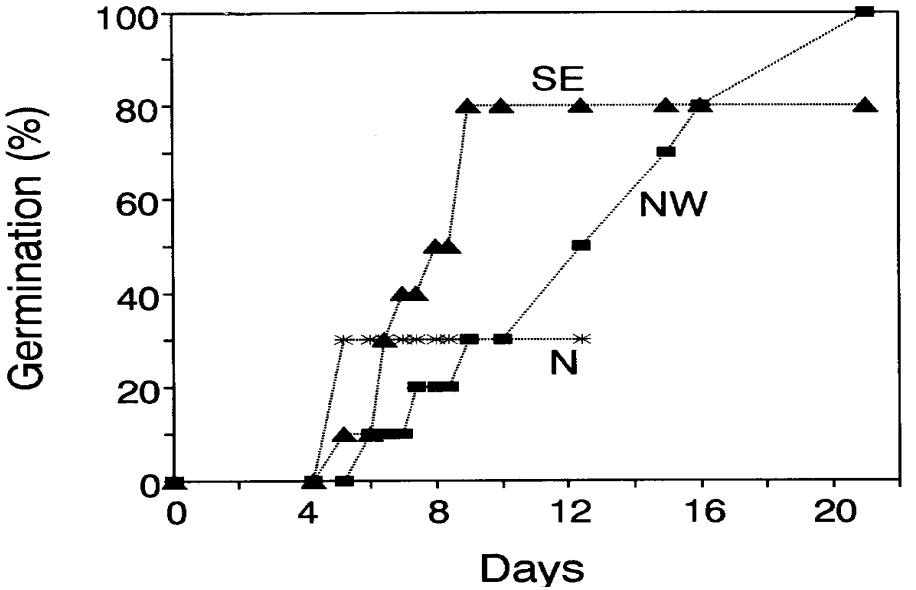


Fig. 2. Germination rate of freshly collected ripe turions (28 Nov) of *Aldrovanda* from N, NW, and SE Australia in long day at 22 °C.

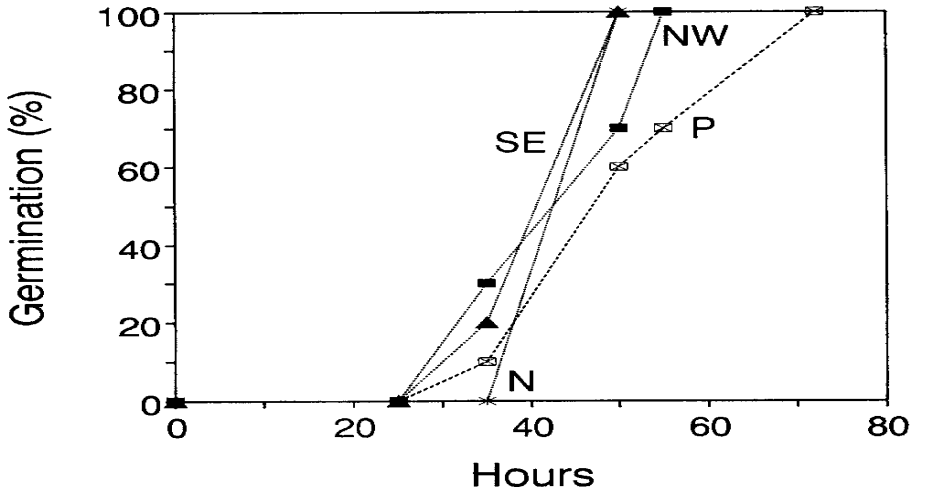


Fig. 3. Germination rate of *Aldrovanda* turions from N, NW, and SE Australia and E Poland (P) in long days at 22 °C on 3 April. The turions overwintered in a refrigerator.

A note on possible prey selectivity in the Waterwheel Plant (*Aldrovanda vesiculosa*) and a possible method of prey attraction.

Chris Schell (chrisschell15@hotmail.com)

The Waterwheel Plant (*Aldrovanda vesiculosa*) is a free-floating, rootless aquatic. Although it has a wide distribution throughout the old-world, it is considered rare. Within Australia, this species is listed under the Threatened Species Conservation Act, 1995 and is protected under such legislation. Much empirical studies have investigated aspects of this species biology and physiology, however some aspects such as mechanisms involved in initial trap closure and prey attraction remain obscure. In addition, no chemical prey attractant has been isolated from this species. In this paper, I report my observation regarding prey capture in this plant and also put forward my hypothesise regarding morphological structures that would aid prey selectivity in this species.

Having grown *Aldrovanda vesiculosa* for may years, I have observed a predominance of a single type of crustacean (ostracods) within the traps of this species, despite it's cultivation within a mixed community of freshwater aquatic plankton (cyclopse, *daphnia* spp. ostracods, insect larvae, nematodes, snails, etc..). In addition, other species of organism that have been trapped have all been consumers of filamentous algae (*ie*. small snails). I put forward that it is the morphology of the trap that mimics the presences of filamentous algae that attracts prey. Prey selectivity has been reported in other species of carnivorous plants (ie. *Nepenthes* and *Utricularia*) and it is plausible that *Aldrovanda* may have developed selectivity for one type of prey. From my observations I have observed specific functions of trap morphology and the general process of prey capture begins with the prey item swimming close to the plant and then settling upon the Bristles of the

plant (see figure 1A). Once upon these bristles, the prey items generally pause and appear to 'graze'. From this position, they are guided down towards the mouth of the bilobed trap, which is orientated to receive prey. Within the trap are long trigger hair spines, which have been previously noted to affect trap closure. I am of the opinion that the long filaments have a duel role that not only serves to 'spring' the trap, but also mimic long filaments of algae (see figure 1B). Upon entering the trap, the prey generally progresses slowly towards the base of the trap, where they may be observed to slowly move in a motion similar to that made during feeding. By this time that trap has usually closed and prey capture is complete. Although the testing of this hypothesis is beyond the scope of this author, it would be interesting to observe whether a chemical attractor replicating chemical cure liberated by filamentous algae is produced by the traps of this species.

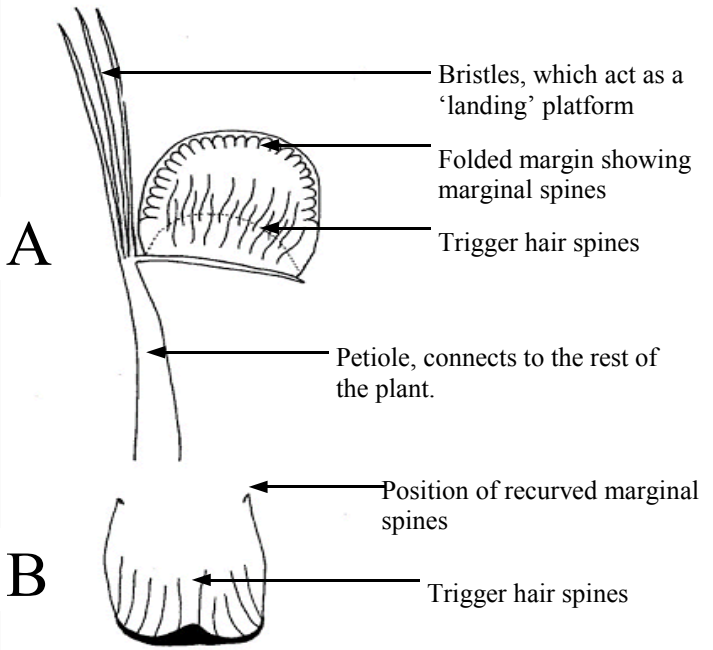


Figure 1. Diagrammatic representation of a *Aldrovanda vesiculosa* trap complete with petiole and bristles. One of the lobes of the trap has been removed (**A**). Transverse section through the trap of *A. vesiculosa* detailing size and position of trigger hairs in relation to trap (**B**).

Cephalotus follicularis giant forms "Myth or Reality"

Agustin Franco, Ph.D

This article is dedicated to those who spend their lives growing this beautiful, but unusual carnivorous plant.

Cephalotus follicularis [labillardiere, 1806 #1], commonly known as the West Australian pitcher plant, Albany pitcher plant or Australian ground pitcher, is the only species of the genus *Cephalotus*. The word "Cephalotus" comes from the greek "kephale" meaning "headed", which refers to the filaments of the stamens. The word "follicularis" refers to follicles or small sacs, which describes the shape of the carnivorous pitchers Fig. 1.

Fig. 1 *Cephalotus follicularis* in the wild. Photo courtesy of Mrs. Pat Johns Australian Wildflowers society, Perth, Western Australia

The plant's original habitat is Southwestern Australia, its range of distribution is about a 400 km strip from regional Albany to Eusselton (Western Australia). This plant naturally grows in a meso-mediterranean climate characterized by cool and wet winters followed by hot summers. However, the temperature fluctuations in this area almost never reach below 5ºC in winter and hardly exceed 25ºC in summer, but it can rise up to 40ºC [Cheers, 1992 #6]

As most carnivorous plants, it prefers a humid environment and loves to grow amongst grasses and shrubs. In other words, it prefers shaded areas. If the plant grows under direct sunlight, it ac-

cumulates anthocyanin, a pigment responsible for the red colouration of the pitchers. In nature, *Cephalotus* mainly grows in a mixture of sand, grass, and peat while dieting on mainly crawling insects such as ants and gnats.

Cephalotus follicularis has two types of leaves: non-carnivorous and carnivorous. The non-carnivorous leaves are usually spear-shaped; even though, during the winter, round non-carnivorous leaves are produced. The carnivorous leaf or pitcher is one of nature's masterpieces. It has a peristome or mouth filled with inner pointing teeth. The lid has translucent segments alternating with darker ones and has three functions: The first one involves attracting insects by showing the reflection of the water at the bottom of the pitcher through its semi-transparent segments. The second function is to keep the rain-water out of the pitcher; and the third function is to maintain the internal humidity in hot days, by superimposing over the mouth of the pitcher. As the levels of humidity return to normal, the lid would move back to its original position.

The outer walls of the pitcher have a T-shaped central rib with hairs along the sides and two lateral ridges also with hairs that serve as ladders for the insects attracted by the sweet nectar contained within the pitcher. The mouth or peristome has around 24 inward pointing teeth [Lloyd, 1976 #7]. Mature pitchers have these teeth of up to 4mm long in the center of the mouth, while other varieties with similar size pitcher have smaller teeth of up to 2.5 mm long. The inner wall of the pitcher is coated with wax creating a very slippery surface. The inward pointing teeth, in combination with the slippery inner surface of the pitcher, makes any insect's attempt to escape futile. The lid also varies in shape. While some *Cephalotus* pitchers have an inverted spoon-shaped lid, others have a half shell-shaped lid. The pitcher is filled with bacteria and digestive enzymes, which will break down and absorb proteins and other nutrients from the prey. (Lowrie, 1998).

There are some variations in the shape of the pitcher as well. The

most common pitcher type has an elliptical-shaped mouth. There is another variety with a very narrow and cylindrical mouth and a sausage-shaped pitcher. This variety of *Cephalotus* produce fairly long pitchers (up to 5 cm long) and wide non-carnivorous leaves (Phill Mann's collection).

One of the most interesting topics amongst carnivorous plant growers is *Cephalotus follicularis* pitcher size. The "Typical form" of *Cephalotus follicularis* pitcher size ranges from 1 cm (less than ½ inch) to 5 cm (1.96 inches) with an average of 2.5 cm (1 inch) in length [Lowrie, 1998 #2]. However, several experts in the field do recognize that some plants of *Cephalotus follicularis* can have pitchers that measure more than 5 cm long, but they also imply that this event is very unusual [Lloyd, 1976 #7; Lecoufle, 1990 #8; Cheers, 1992 #6] Fig. 2.

Measurements of *Cephalotus* pitcher size have generally been taken from the bottom of the pitcher to the uppermost portion of the lid. For practical purposes, in this article, measurements were taken from the bottom of the pitcher to the mouth, since the lid can move up and down, depending on the relative humidity levels. Final pitcher size was calculated based on object-size proportion.

In September 1986, an American

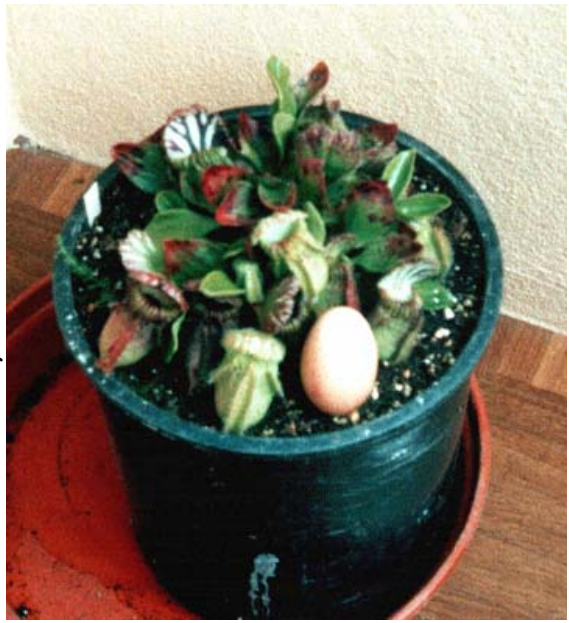


Fig 2: Young giant *Cephalotus* plant (unknown origins) next to an extra large size egg:. Average size of egg (6.5 cm or 2.55 inches). Size of pitchers (5.6 cm). Measurements were made to scale. Photo Courtesy of Julie Jones, Poonsanooth Village, Cornwall, U.K.

carnivorous plant grower by the name of John Hummer, received about a half-dozen of mature plants, from a pen pal in Adelaide-Australia, named Steve Beckwith. All had a nice maroon colouration and their pitchers were at least 5 cm long (1.96 inches) in length that had overwintered from the previous year's growing season. The plants had been dormant and were starting their growing cycle once again. He distributed the plants to some of his colleagues and started growing the rest in a terrarium. Couple of years later, John Hummer obtained plants with pitchers around 6 cm long (2.4 inches) in length and 2.5 cm (1 inch) in width. He has been propagating and distributing this plant all over the world Fig. 3.

Under artificially controlled conditions this plant can reach up to 8 cm long (3 inches) (Bill Mclaughlin of the US botanical Gardens). John Hummer has established this plant as a cultivar, naming it *Cephalotus follicularis* "hummer's giant". He coined the name in April 3rd, 2000; even though this cultivar name has been used years prior this date [Hummer, 2000 #3].

Mr. Steve Beckwith obtained the hummer's giant clone from another cp grower by the name of Michael Ceple who used tissue culture to grow his collection of carnivorous plants, including Dionea, Darlingtonia, etc. Unfortunately, Michael Ceple passed away several years ago; therefore, the exact growing conditions, as well as, the region of Western Australia where this hummer's giant clone was picked up from remains a mystery. (Steve Beckwith, personal communication).

Hummer's giant growing conditions

Mr. Jeff Mathesson, a very successful cephalotus grower, uses 2 parts peat moss to one part sand and one part perlite. The plant in Figure 2 grew under natural light, but with at least 75% humidity. He has attempted to use fluorescent lights, but he never had the same results as those obtained with natural sunlight. When fluorescent light is used, the lights are on for at least 14 hours a day. He recommends dormancy to achieve maximum pitcher size.

The clone hummer's giant, according to him, is different from other large cephalotus plants. The T-shaped ridge, which goes along the central portion of the pitcher, grows very wide and long early on during development.

***Cephalotus follicularis* 'giant form or true giant'**

A year after John Hummer had received his hummer's giant, another well-known cp grower by the name of Harold Weiner introduced another giant variety form to Germany. This particular plant has pitchers that can reach over 8 cm long and it is often referred as the as "giant or true giant" (Figs 3-4).

Jan Schlauer, a cultivar registrar from ICPS (International carnivorous plant society) contends that Harold Weiner may have had this clone many years before it was commercially available in Germany. Several attempts were made to contact Harold Weiner without success. He left Germany in the late 80's and he is living in mamba village, Kenya, where he is directing a carnivorous plant botanical garden. Mr. Weiner, according to his former colleague and friend, Helmut Kibelis, never used tissue culture techniques to grow his plants.

Furthermore, Harold Weiner and John Hummer have never met and there is no evidence to sug-

Fig. 3 *Cephalotus follicularis* "hummer's giant"
Approximate size of pitcher next to an american quarter:
6.1 cm (2.4 inches) from bottom of pitcher to peristome. Diameter of coin:
2.5 cm (1 inch). Measurements were made to scale.
Photo courtesy of Mr. Jeff Mathesson, Rhode Island, U.S.A

Fig 4. **(Cephalotus follicularis giant forms "Myth or Reality")**"True giant" form of *Cephalotus follicularis*: Palmengarten, Frankfurt, Germany;

Top: Adult plants. Size comparison of the pitchers and the tree logs (photo by Andreas SieglerÓ, Lohr am Main, Germany);

Bottom left: Young "true giant"
photo courtesy of Dr. Heilke Steinecke, Palmengarten.

gest that either the "true giant" is the same as the hummer's giant. As a matter of fact, empirical knowledge from many *Cephalotus* growers suggest that the "true giant" grows very slowly while the hummer's giant grows like the "typical form" (Tony Paroubek, Martin Reiner, Jan Schlauer, and Charles E. Brewer, personal communication).

Cephalotus follicularis 'true giant' growing conditions

The medium used in Palmengarten, Germany, according to Dr. Hilke Steinecke, consists of a mixture of peat moss and sand in nearly the same proportions with some sphagnum moss placed under the soil and some on the soil surface. The medium is highly humid, but plants are not waterlogged. The plants grow with quicksilver vapor bulbs (600 Watts). The bulbs are switched on for 12 hours every day, all year round. Whenever the sun is out, the computer controlled lighting system is switched off. The time it takes for the plants to reach maximum size depends a lot on the local weather conditions. In Frankfurt, the weather is highly variable, so it is difficult to give an accurate amount of time. However, plants grown

from cuttings may take 4-5 years to reach maximum size.

Tissue culture techniques to propagate plants have been performed at least since the late 1960's. The propagation of seedlings and cuttings *in vitro*, as a matter of fact, promotes the doubling, tripling, and even quadrupling of chromosomes in plant cells [Demoise, 1969 #4]. This phenomenon is known as polyploidy. When plants have extra chromosomes, they usually have larger characters: larger fruits, flowers, and leaves.

Why are there giant cephalotus?

The use of alkaloid chemicals in horticulture such as colchicine, a known polyploidy inducer, naturally produced by a plant *Colchicum autumnale* or Autumn crocus, has been a common practice since the mid 1940's to improve physical characteristics of plants [Dawe, 1998 #5]. It is by no means implied that the origins of the "hummer's giant" and the "true giant" are due to chromosome duplication or to exposure to polyploidy inducers. Scientific data is needed to confirm or discard the hypothesis of chromosomal duplication. It is, however, a very plausible explanation on how these giant clones arose, keeping in mind that the general consensus regarding *Cephalotus follicularis* pitcher size is that they are small and no larger than 5 cm (1.96 inches).

While this may be true, there is another hypothesis about the so-called "giant forms". Many carnivorous plant growers believe that the so called "giant forms", are due to excellent growing conditions such as the optimal potting mixture, humidity, light, and temperature which have a dramatic effect on the pitcher size. This hypothesis is based on the fact that, in many instances, as witnessed by some cephalotus growers, "the giant forms" don't develop full size and these are only up to 10% larger than the typical form. On the other hand, *Cephalotus follicularis* "typical form" plants, can have pitchers up to 5 cm long or perhaps more, again if the conditions are optimal for their development. Fig 5

One important aspect is not being considered though, many believe

that because *Cephalotus follicularis* is the only member of the genus *Cephalotus*, homogeneity in the genetic make up of these plants is obligatory. In other words, it is expected all plants to be the same or look the same. This statement without doubt is erroneous. There are variations in pitcher and lid shape, not to mention pitcher size within the same plant (genetic polymorphism). As result, Cephalotus plants in Denmark, W.A for example, are expected to have some minor genetic differences from Cephalotus in Albany, W.A. The presence of minor variations in a specific gene coding sequence, as well as variations in gene content form part of a "gene pool". Whether these differences are obvious to the eye or not is irrelevant, because genetic variation almost always exists within any plant or animal population. This hypothesis is supported by the fact that humans or homo sapiens belong to one species, but yet there are different races within this species. Doesn't this mean we must look the same? : obviously not.

The never-ending debate of environmental conditions vs. genetic make up applies to *Cephalotus* as well. Both play a role in the development of a plant. There are plants with the predisposition to develop large pitchers, but if these are not in an environment that encourages optimal growth, these will never reach maximum size. On the other hand, a so called "typical form" plant might be subjected to optimal growing conditions for pitchers to reach maximum size, but if the parent plant only produces small pitchers up to 3 cm long, the next generation of pitchers from the same plant will be no big-

Fig 5: **(Cephalotus follicularis giant forms "Myth or Reality")**
Large Cephalotus follicularis plant: Courtesy of Jeno Kapitany,
Paradisia Nurseries, Victoria, Australia.

ger than 3 cm in length (Mendelian genetics).

The existence of "giant forms" of Cephalotus may be nothing more than a man-made selection of clones that are predisposed to reach maximum size under ideal, but artificial growing conditions. The growing conditions found in nature are limiting factors; therefore, the pitchers may never reach maximum size, due to the constant competition for nutrients by other plant and animal species co-inhabiting with *Cephalotus* such as *D. hamiltonii*. As a matter of fact, the development of plant carnivory may be the result of plant adaptation and evolution in relatively nutrient-poor soils, where the plant needs to use alternative sources of nourishment. There must be a fine balance between the energy spent and the energy acquired by a plant. In a nutrient deficient environment, a plant can not afford to spend much energy in developing large size pitchers. Perhaps this is why Cephalotus plants with pitchers larger than 5 cm in length are very difficult to find in the wild bush of Southwestern Australia, but it does not mean they don't exist. It would be interesting to find out why some of these plants have a predisposition to develop large pitchers, while others don't, when the presence of a large pitcher phenotype is apparently not needed for the survival of the species. After all, Cephalotus's victims are generally very small in size. How many of these would a Cephalotus plant need to trap to satisfy their nutrient requirements, considering that each plant has usually more than one pitcher?. Obviously these questions will need further study.

I would like to thank all those who contributed to the completion of this article: Mr. John Hummer, Mr. Jan Schlauer, Mr. Jeff Mathesson, Mr. Hilke Steinecke, Ms. Julie Jones, Mr. Andreas Siegler, Mr. Steve Beckwith, William DiLapi, and Mr. William McLaughlin for useful information. Special thanks to Mr. Allen Lowrie, Mr. Gordon Cheers, and Mr. Charles E. Brewer for helpful discussions.

How to Grow Happy *Drosera pauciflora* in Sydney

Kirk (Fuzzy) Hirsch

First off, for those who know that this plant is one of the sundews, but not just what exact kind of sundew, allow me some brief details of this species. Those die hard experts, the pinch hitters for their teams on the Trivia Night, these people will most likely know what I'm about to say and most likely could elaborate better than I too. I'll keep it simple. This sundew comes from South Africa, and it grows in the same habitat as *D. cistiflora*. Both of these species are known for the most showy flowers of the sundews. They're quite spectacular, as you can see in **Figure 1.**

Even though this pic doesn't have a size reference. It was a little over 3cm in diameter. These plants have rosettes of prostrate leaves with quite active glandular pubescence, as you can see in **Figure 2.**

Like tuberous sundews from Western Australia, this species goes dormant to survive the hot, dry summers of South Africa. Unlike tuberous *Droseras* though, this species and *D. cistiflora* don't grow tubers, rather staying dormant underground with fleshy roots during the hotter seasons. Its first growth will appear from the soil around mid May to early June. It stays green for a good number of months, finally dying back at about mid November.

Now, about cultivation tips – I'd stated before that the glandular hairs are quite active. This is a sundew that will fold its leaf over its prey quite readily. Like *D. burmanii*, there is even a dimorphism of the glands. **Figure 3.** should show the differences:

These outer glands are more sticky, more elongate, and more sensitive to motion than the others, bringing prey in within several hours of first gluing it. As a matter of fact, even the flower stem has glabrous drops of goo all over it; and the fungus gnats stuck on it looked as if digesting too. **Figure 4**. Look at the base, at the gnat stuck tight

To put it shortly, it's one of those sundews that loves to eat just about any 6 legged creature, or 8, or 10, or….

In fact, my success with it has been to feed it as frequently and as often as possible with live, or recently so food. When the buds first stick their green heads above the mix, this year I've taken to spraying a little mist of fertilizer over them. For my mounted orchid collection, I tend to fertilize them by spraying the aerial roots with a half strength fish emulsion or seaweed emulsion fertilizer, one with a good balance of trace elements, instead of the chemically inclined KNP fertilizers (Miracle Grow and the ilk). So, this year, I decided to spray the first few leaves as they were unfurling when I went on my fortnightly routine of feeding my other plants. Occasionally I have done this to other *Drosera* species as well as fully emerged *D. pauciflora*. They all seem to react favourably.

This year the theory worked, for this year my plant flowered. The trick, I think, to bring out this lovely inflorescence, is to feed it early. I like to take an old metal sieve strainer and find standing rainwater full of mossie wrigglers and pour that through. I find these larvae are chockers full of goodies for the plants and are easily digested by many *Droseras* and *Pinguiculas* alike, perhaps because of their moister nature and thinner exoskeleton.

So, how have I kept this sundew alive and going all these years? Let me start from the ground up, literally. The potting mix that I find works best is 80% river sand, 10% peat, and 10% organic matter, like mulch. I also find that a thin layer of mulch and leaf litter on top makes for a happier plant. I used to grow them in pretty much pure sand. This works better; not by heaps, but noticeably.

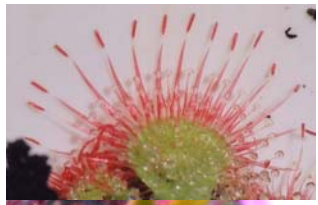
Let's start the cycle as fresh buds just breaking dormancy. At this stage feed them with a spray or two as I'd described above. Yet when the first leaves are unfurled and glistening with their glandular pubescence, it wants bugs. I have yet to see a *Drosera* that I can overfeed with insects and such. Also, one of

the gurus of carnivorous plants, Leo Song of the International CP society, told me long ago that if you ever prick your finger or such while gardening and you have a drop or two of blood, wipe it on a sundew leaf . The plant responds very well to it. I did that a few years back with the *D. pauciflora* when it was just three rosettes. The amount of rosettes doubled the next year. ("Feed me Seymour….")

At this stage too is when the plant becomes a bog plant. Set it in the tray and give it plenty of water. I tend to have a tray 2 cm high that it sits in, which I water with collected rainwater until it's overflowing the base's lip. I keep it as wet as I can for as long as the plant remains green. As for sunlight, it's a sun lover. I have mine exposed to about 5 hours of direct sun and the rest of the day it's in the dappled shade of a tree. I don't grow it in a black pot, but a green one, just in case the roots are sensitive, for it gets mid day sun.

Once *D. pauciflora* begins to die back, I remove it from its water tray and keep it where it was. I still water it, but don't let it bog, rather drain. I also stop feeding it. Within a few weeks it will die back much more. This is when I put it under the shelf, in a fairly dry place. After several months of being nice and wet, it has other things sprouting up in the pot, either some *Sellaginella* or other plants that have just spored or seeded. I let them be my indicator, for when they're all died off and crispy I bring the pot back out and set it along the bottom shelf. Here it will get watered when it rains, but I don't give it any, keeping it quite neglected. In this aspect, I treat it like the Western Australian tuberous sundews and completely forget about it until the cold weather is setting in and my attention shifts to the sleepers about to wake up.

Now, truth be told, I have killed three *D. cistiflora* plants which I have treated exactly the same. These plants just don't work for me. To use that wonderful American expression, 'Go figure!?!'. This South African sundew, however, is doing just fine, and should for other enthusiasts who follow this advice as well.



Drosera pauciflora Clockwise from top left: Figure 2. Shows group of plants with single glandular scape rising high above the pot.

Figure 3. Fast moving elongated marginal retentive glands top. *D. pauciflora* and *D. burmannii below*

Figure 4. This shows just how effective this species is at catching insects. Note the Gnat firmly attached to the scape!