Observations and tests on cultivated tropical *Byblis*

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Keywords: *Byblis*, cultivation, hybridization, enzyme test, trichome motion.

Introduction

The annual *Byblis* species (Byblidaceae, Lamiales) are predominantly Australian endemics with *B. liniflora* extending also north to Papua New Guinea (Cross *et al*. 2018). Beside their features as sticky carnivorous plants, many enthusiasts especially appreciate their bushy appearance with many showy hermaphroditic flowers. The following report features our experiences with the cultivation and hybridization *of B. filifolia* and *B. liniflora* over two decades at our heated greenhouse in Weil am Rhein (Germany).

Soil, germination, and growing conditions

During several field trips in northern Australia (1990-2001), we encountered many *Byblis* in the tropical wetlands, often growing in almost pure silica sand or various sand-laterite mixes mostly under full sunlight. Frequently, the plants occurred together with different large spider leg sundews (*Drosera* section *Arachnopus*). Due to the successful cultivation of these sundews in our heated greenhouse over years, we decided to keep our *Byblis* species the same way. Our standard soil for that purpose was a mix of high-quality peat (source Thomas Carow, Germany) with 25-35% lime-free silica sand (0.4-1.2 mm grain size) and about 10-15% perlite or alternatively 5 mm pumice granules. However, this is just one possibility that worked fine for us, probably also other peat-sand mixes may do it. Beware of too high amounts of or even pure sand, which is dangerous because the pots dry out very quickly in the sun, which may be fatal for the plants. On the other hand, we experienced *B. liniflora* growing nicely from a dropped seed in a thin carpet of algae on the side wall of the water bowl in which the actual pots were standing (Fig. 1). It flowered and set seeds for a whole season with its roots just growing into the pure water.

Figure 1: *Byblis liniflora* rooting in a carpet of algae and water without soil (left). A potted *B. liniflora* fed with *Drosophila* (right).

For our experiments on enzyme production (2007) and hybridization (2011), we treated most seeds for 24 hours with an 0.1% aqueous solution of gibberellic acid (GA3) to increase germination rate. Indeed, these seeds germinated after only 5-7 days, which is very fast. However, during the following seasons we found out that fresh *Byblis* seeds (directly sown or from the former season) germinated quite nicely even without any special treatment. Therefore, we meanwhile forego the GA3 treatment for fresh seeds, even if germination may take a week or two longer.

Very important for a good germination and growth are high temperatures between 25-40°C, which are usual summer day temperatures in our greenhouse. From October to April, we added 400-watt HQI lamps to provide sufficient light and additional heating during winter; however, the best growth always occurred when we sowed the seeds in March/April so the plants could grow up under full sun during the hot season.

Nutrition is another important point to get healthy and rapidly growing *Byblis*. We usually feed *Byblis* and *Drosera* seedlings first with crushed fish food flakes, using magnifying tweezers. Do not give too much at once, to avoid mold or even rotting leaves. As soon as the plants reach a size sufficient to capture fruit flies (*Drosophila*), this diet is recommended. If you have enough seedlings, it is an interesting test to leave some of them unfed. Even after a few weeks, the difference between fed and unfed plants is unambiguous. As an alternative to manual feeding, which may be time consuming if you have numerous plants, we tried fertilizing the plants. In 2018, we placed a ball (about a teaspoon of pearls) of Osmocote (16% N, 7.5% P_2O_5, 9% K_2O) 5 cm above the bottom of a 15 cm pot with *B. filifolia* and kept several plants without Osmocote in the usual 9 cm pots. The difference in growth speed and date of flowering was remarkable. Especially eye-catching was the strong branching of the fertilized *B. filifolia*, one reason for their bushy appearance. The unfertilized plants produced no branches and fewer flowers at a later time (Fig. 2 left). The different pot sizes were certainly not essential for the different growth during this experiment. However, every coin has two sides: One of the branched plants developed a fasciation (Fig. 2 right) and all fertilized plants withered in late autumn 2018. But two of the unfertilized plants are now, at the end of February 2019, still alive, even if unbranched and much less impressive.

Figure 2: Left: Contemporary *B. filifolia* grown from the same seed batch. Slender unbranching, flowerless unfertilized plants on the left and bushy, strongly branched, flowering plants fertilized with Osmocote on the right. Right: Fasciated *B. filifolia* fertilized with Osmocote.

Figure 3: Anthers and stigma of a self-pollinating *B. liniflora* (left). *B. filifolia* seedpod with ripening hybrid seeds (center). *B. filifolia* x *liniflora* F1-seeds (right).

Pollination and hybridization

It may be difficult to successfully pollinate *Byblis* flowers and obtain seeds. However, you just need to know how to do this properly. The easiest are self-pollinating species like *B. liniflora*, where everything works automatically: flowers self-fertilize, seed pods swell, dry out, open, and release healthy seeds only a few weeks after flowering. However, other species like *B. filifolia* depend on a so-called buzz-pollination where, in nature, pollen is only released by the buzzing wings of pollinating insects. A simple method to release such *Byblis* pollen in cultivation is to imitate the buzz either with a tuning fork or with the tip of an electrical tooth brush (without brush attachment). Just hold a piece of paper below a flower to collect the released pollen and hold the "buzzer" close to the yellow anthers. Now you can pollinate other flowers quite easily.

In 2010, we tried to produce a *Byblis* hybrid at our greenhouse (Hartmeyer & Hartmeyer 2011), although we could not find any literature on such natural or artificially produced hybrids. We took the whole flower of a self-pollinating (non-branching) *B. liniflora* with visibly released pollen (Fig. 3) and rubbed it directly on the flower of an only buzz-pollinating large branching *B. filifolia*. To our great delight, we saw a seedpod developing that actually released healthy looking seeds after some weeks. To avoid any errors, we repeated the procedure and once again a seedpod developed and released healthy looking seeds (Fig. 3).

We immediately sowed the seeds and had a really happy day when they started germinating some weeks later. The final result was a branching and self-pollinating plant that reached a size intermediate between the parent plants (Fig. 4).

Figure 4: *B. filifolia* × *liniflora* "F1-hybrid" herbarium sheet (2011).

Enzyme production

In 1997, we conducted several enzyme tests with photo film (based on the digestible gelatin layer) on different carnivorous plants

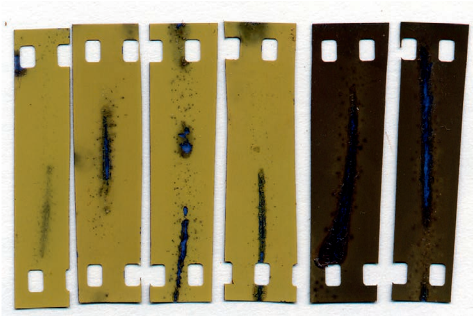

Figure 5: Six-fold enzyme tests with photo film (gelatin layer) on *B. filifolia* (2005).

(Hartmeyer 1997) and found no clear enzyme evidence for a self-pollinating *B. liniflora* that we had grown for several years at that time. For different *Drosera*, the enzyme tests were always unambiguous after only 1-3 days, but that was actually not sufficient for *Byblis*. In 2005, we repeated the enzyme test particularly for a large branching *B. filifolia* (Hartmeyer & Hartmeyer 2005); however, we extended the usual test period from three to six days. And indeed, after three days, first enzyme caused patterns emerged in the gelatin layer, and after six days the typical holes became clearly visible on the photo film. We repeated the test and obtained the same result. As such, *Byblis* was rehabilitated as a true carnivorous plant genus, able to produce its own digestive enzymes. Comparing the necessary time to achieve unambiguous results on the gelatin layer (~2 days *Drosera*, ~6 days *Byblis*) enabled an admittedly rough assessment of their digestive capacity. Accordingly, *Byblis filifolia* attains an estimated 20-40% of the "average *Drosera* digestive capacity" (Fig. 5).

Discussion

During three decades of cultivating tropical *Byblis* in a greenhouse, we can state that the plants tolerate various permanently wet peat-sand-mixes and may grow even in almost pure water. For rapid and healthy growth, the plants need nutrition, either by existing insect prey, by manual feeding, or alternatively from a soil fertilizer like Osmocote. A hybridization was successful with *B. liniflora* pollen on *B. filifolia*; however, we recommend to try even other combinations. This is certainly an interesting topic for future experiments. The conducted photo film (gelatin) tests finally confirmed that *Byblis* is in fact carnivorous, able to produce their own digestive enzymes.

In late 2018, the Byblidaceae again attracted particular attention regarding their prey capture due to thrilling time lapse videos by Dr. Gregory Allan (GB) on Facebook, clearly showing a movement of the sticky hairs. Darwin wrote that he had never heard of motile unicellular structures (Darwin 1875). The trichome stalks of *Byblis* are unicellular, so he regarded *Byblis* traps as non-motile. Even later observations that the trichomes move down to the leaf surface after contact with prey (Lloyd 1942) did not prompt further experiments, just like the more or less permanent leaf and pedicel movement by pulvini (Barnes 2009; Hartmeyer & Hartmeyer 2010). Gregory Allan's amazing videos (Allan 2019, p 51 this issue) encouraged us to conduct our own experiments with *B. aquatica*, *B. filifolia*, *B. liniflora*, and the hybrid. Our results fully confirmed the observation that *Byblis* trichomes are able to move after prey capture; documented in a video posted on YouTube (Hartmeyer & Hartmeyer 2018).

Acknowledgements: The authors thank Dr. Jan Schlauer for his helpful comments and expertise in many of the described *Byblis* experiments. We also thank Dr. Gregory Allan for a fruitful discussion on the motile *Byblis* trichomes and his kind permission to show parts of his original time-lapse videos in our documentary on YouTube. Further thanks go to the reviewers who helped improve the article.

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