Evidence for motile suction traps in *Utricularia westonii* from *Utricularia* subgenus *Polypompholyx*

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Abstract: Here we report that traps of *Utricularia westonii* from *Utricularia* sect. *Tridentaria* are working with a very effective suction mechanism, which was revealed and recorded during feeding experiments with cultivated specimen.

The bladderworts (*Utricularia* spp., Lentibulariaceae) comprise more than 240 species with several life-forms (Fleischmann 2015). It is generally believed that they capture their prey with leaves that are modified into suction traps, commonly termed "bladders", which are the fastest trapping devices among carnivorous plants (Lloyd 1942). Suction is rendered possible by a complex interplay of functional-morphological, physiological and mechanical prerequisites (reviewed by Poppinga *et al*. 2016). Water pumps shift water from the trap lumen to the exterior, thereby generating a sub-ambient pressure inside the traps. The trap walls are elastically deformable and thereby store elastic energy. Furthermore, the traps are closed watertight by a thin and flexible trapdoor, which can swiftly open and close after touch by prey to allow the traps to perform their suction strike.

There has been some debate recently whether traps of phylogenetically early branching terrestrial or affixed aquatic species from *Utricularia* subg. *Polypompholyx* meet the above criteria, i.e. if they possess motile suction traps, or if they work as non-motile eel traps similar to those of *Genlisea* (Fleischmann *et al*. 2012). Especially *U. multifida* (*U*. sect. *Polypompholyx*) has been investigated in this respect: although Lloyd (1942) reported that the traps are motile, later analyses by Reifenrath *et al*. (2006), finding that they possesses exceptionally thick trapdoors, and Westermeier *et al*. (2017), which were unable to record suction events in laboratory experiments, have led to speculations that they might be non-motile on the contrary. Płachno *et al*. (2019) attributed the traps of *U. multifida* and *U. westonii* (*U*. sect. *Tridentaria*) to possess the structural prerequisites for suction, but could not definitively prove this trap functioning experimentally. *Utricularia tenella* (*U*. sect. *Polypompholyx*) has never been investigated in this respect. At least for *U. westonii*, which is endemic to Cape Le Grand National Park, southwestern Western Australia (Fig. 1A,B), the exact trap functional principle can be considered as revealed with this short communication.

Marco Pezzotta grew this species from November 2016 until March 2020 following a methodology proposed by Spence (2005). The seeds of this annual species, which grows during winter, were originally obtained from Allen Lowrie. The plants were cultivated outside for their whole life cycle in San Salvo (CH), Italy, which is characterized by a Mediterranean climate with winter temperatures never below 0°C. The sowing was carried out in late summer on a substrate consisting of peat and fine quartz sand in a ratio of 40/60 and with a superficial layer of sand only. The pots have been placed in a container, with a level of demineralized water slightly lower than the surface of the substrate. Then the pots have been covered with a transparent lid to avoid rain and to limit evaporation. During germination, which can take from a few weeks to a couple of months, direct sunlight illumination is not required. Once the seedlings had anchored to the substrate with their rhizoids, after

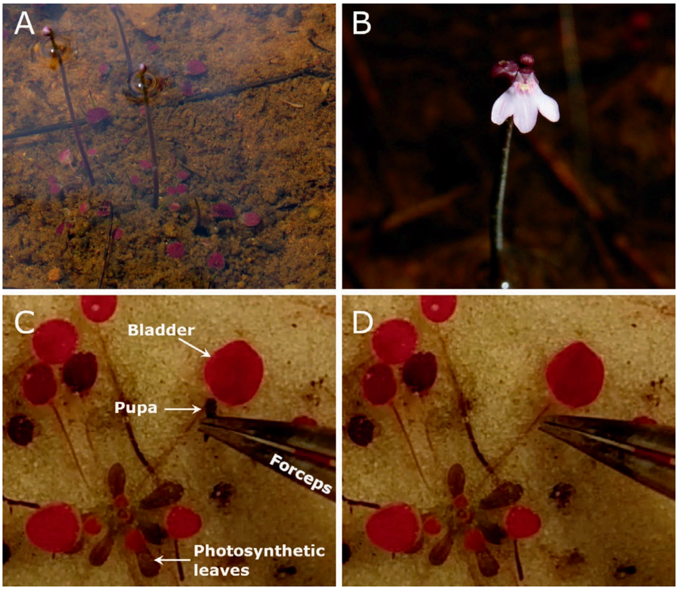

Figure 1: *Utricularia westonii*. A) Submerged plants in the Cape Le Grand National Park. B) Flower. C) Feeding of a cultivated plant with a dipteran pupa. The pupa is handled with forceps and brought to the entrance zone of the trap. D) The pupa has been sucked into the trap. The two frames C) and D) are from a movie, which can be seen on Marco Pezzotta's YouTube channel (FreakyPlants Marco Pezzotta), or be obtained from the authors upon request. The movie was recorded with 30 fps, the time duration between the two frames hence is ~33 ms. However, the real duration of suction is likely to be even faster. The movement of the lateral trap walls is not visible in this recording. Photos A, B by A. Fleischmann, C, D by M. Pezzotta.

reaching about 3-4 leaves, the water level was raised about 2-5 cm above the substrate in order to submerge the plants. The water in which the plants were grown contained crustaceans such as copepods and ostracods for allowing the plants to capture prey essential for growing and flowering. The flower scapes began to emerge in spring and, when possible, the plants were cross-pollinated. In all the other cases, plants were allowed to self-pollinate. Both procedures led to the production of fertile seeds.

Marco was able to film suction in his cultivated plants with a mobile phone camera (Xiaomi Redmi Note 5) (Fig. 1C,D). A video of the suction action can be seen on his YouTube channel (FreakyPlants Marco Pezzotta, https://www.youtube.com/watch?v=UOKThdl1JFg), or be obtained from the authors upon request. The video shows that suction is triggered during feeding with an immobile dipteran pupa (3.1 mm length on average, n=5), which is handled with a pair of forceps. Indeed, this is a very elegant method of feeding prey to the traps (3.4 mm length on average, n=5, without appendices). Marco regularly observed suction actions during the feeding procedures, so that the suction event presented in Figure 1C,D (and in the respective video) is not an exception. Indeed, *U. westonii* is described to possess trigger hairs on its trapdoor (Płachno *et al*. 2019), which are responsible for trap activation upon touch in bladderworts in general (Lloyd 1942). The swift displacement of the dipteran pupa between two frames of the recording (relating to a duration of ~33 ms [milliseconds] according to 30 fps recording speed) is indicative of a rapid suction action. However, we believe that the timescale is presumably even (much) smaller, as suction in *Utricularia* can be ultra-fast: about 9 ms were measured in aquatic *U. australis* by Poppinga *et al*. (2017). Due to the triangular shape of the *U. westonii* trap (as seen in transverse section) (Taylor 1989) and the orientation of the recording camera, the movement of the lateral trap walls is not visible. The trap motion can be resolved in full temporal resolution only with adequate high-speed camera setups and remains an interesting aspect for future approaches, e.g. for studying fluid dynamics.

Until now, we do not know which prey is being caught by species of *Utricularia* subg. *Polypompholyx*. Probably, the conspicuous trap shapes in combination with the terrestrial/affixed aquatic lifestyles represent adaptations to capture shelter-seeking crustaceans like small ostracods. We also do not know if these traps are capable of sucking spontaneously, i.e. without being triggered mechanically by prey. This autonomous behaviour is reported from many aquatic and non-aquatic species (Vincent *et al*. 2011; Westermeier *et al*. 2017) and helps these plants to accumulate digestible biomass like algae in their traps (Koller-Peroutka *et al*. 2015). In conclusion, many functional aspects remain unclear for these phylogenetically early branching species.

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