

## FURTHER PROBLEM IN *GENLISEA* TRAP UNTANGLED?

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### Introduction

It is well known that plants in the genus *Genlisea* produce subterranean, Y-shaped, carnivorous trapping organs. The two branches of each trap function as unidirectional channels, directing prey towards the trap neck. At that point, prey travel along the trap neck (a long tunnel) to the vesicle, which is the enlarged digestion chamber.

While these aspects of *Genlisea* are well known, many aspects of how the traps work are still mysteries. Current research is focused on using physiological experiments to test several hypotheses. For example, it is being investigated which (if any) chemical substance attracts prey into the traps (Studnicka, 2002). There are even different opinions as to what kind of prey *Genlisea* tends to capture most frequently. Recent study suggests that *Genlisea* may be specialized to capture protozoa (Barthlott *et al.*, 1998), while Lloyd (1942, p. 94) wrote: "The captures consist of copepods, and the like, small water spiders, nematodes and plenty of other forms, many of which I have seen in the Brazilian material studied." I have observed in *G. pygmaea* many prey organisms, i.e. nematodes, remains of arthropods, etc. (Studnicka, 1996). Furthermore, while preparing the photographs of *G. violacea* glands for this article, I observed numerous nematodes as well as mobile, unicellular organisms in the traps. Some *Genlisea* species produce traps of two distinctly different sizes; this seems to imply some kind of prey specialization that differs between the trap types (Studnicka, 1996).

Another interesting question is how the *Genlisea* traps retain the nutrient molecules obtained by digesting prey items. Since the trap apparently remains open, such nutrient molecules might diffuse out the trap neck and would be lost to the plant. Meyers-Rice (1994) presented a mathematical argument suggesting that traps were active, i.e. constantly pumping water through vesicle glands, so the resulting flow through the trap neck would overcome diffusion effects. However, Adamec (2002) found that the flows predicted by this model were not present in *Genlisea* trap necks. In this paper, I present a novel explanation of how *Genlisea* traps may safeguard their precious, prey-derived nutrient molecules.

### Hypothesis: A Hitherto Unsuspected Valve?

The tunnel-shaped traps of *Genlisea* are situated in soggy soil and are thus submerged in water. The prey in the vesicle is processed and substances from it are dissolved. Since there is an uninterrupted, free path of water from the vesicle to the trap exterior (i.e. through the open tube to the trap neck), nutrients released by digestion processes in the vesicle could diffuse through the neck and be lost to the plant. Careful descriptions of the trap (i.e. Lloyd (1942)) have demonstrated that there are no plant structures in place that would prevent such nutrient losses.

Since there are no structures (based upon plant tissues) that block nutrient

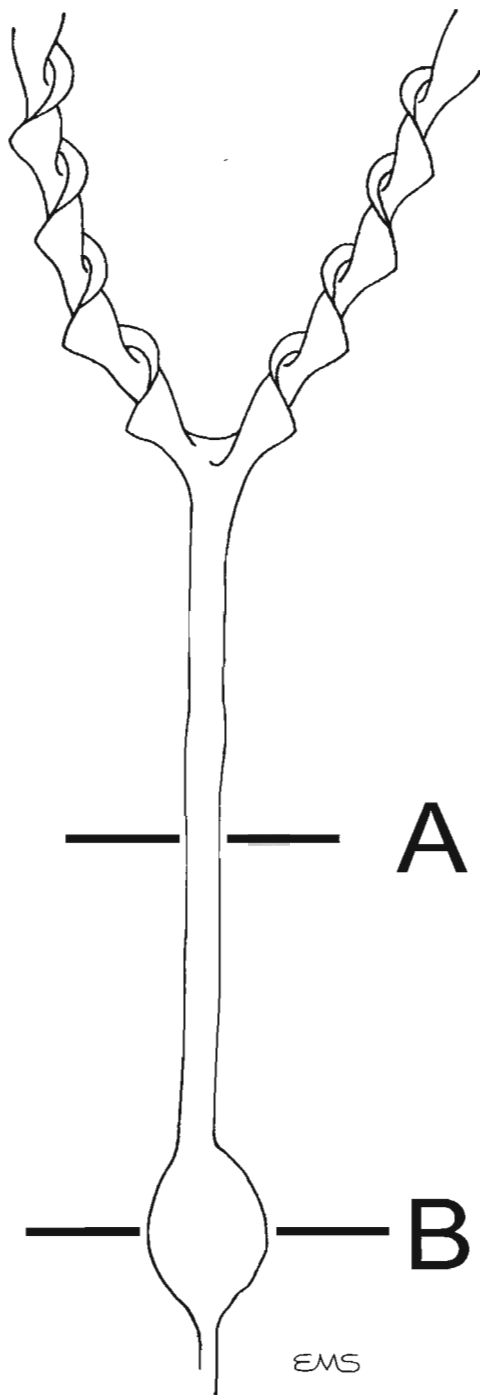


Figure 1: Diagram showing the locations of the slices in the comparisons of the traps to a glass capillary tube. Drawn by E. M. Salvia.

losses from the traps, I have hypothesized that there could be some other kind of barrier or valve holding the dissolved nutrients near the digesting glands. This paper describes laboratory tests and new observations on the nature of internal trap glands which support this hypothesis.

Furthermore, I have found it useful to divide the trap neck (i.e. the trap tunnel that extends from the vesicle to the trap bifurcation) into two portions: the proximal neck (the tunnel near the vesicle) and the distal neck (the part of the tunnel that extends from the trap bifurcation to the proximal neck area). Previous researchers have not recognized the value of dividing the trap neck into two such zones.

### Material and Methods

I used *G. hispidula* in the physiological experiments since it produces the largest traps of all the plants in our greenhouse collection. If the trap neck were truly an uninterrupted, fluid filled, hollow tube, it could be considered a capillary tube. As such, it should be similar in many ways to a simple glass capillary tube.

For my first experiment, I used a syringe to pierce the vesicle of an intact trap, and injected a small volume (approximately 0.5 mm<sup>3</sup>) of very dilute gentian anilin (known also as methylosanilini chlorati, approximately 40 ppm dilution). Even at such low concentrations, the purple gentian anilin was clearly visible to the unaided eye. The diffusion of the dye was monitored.

In my second experiment, I prepared a small frame to hold both glass capillary tubes and *Genlisea* traps in a vertical orientation, above a glass Petri bowl filled with water. I prepared a glass capillary tube with the same approximate inner diameter of a *Genlisea* trap neck (i.e. approximately 0.2 mm). I also prepared two *G. hispidula* trap necks. On "Trap A" I removed the vesicle and proximal neck (i.e. the cut was made through the central neck portion), while on "Trap B" I cut through the vesicle (see Figure 1). The glass capillary tube and the prepared trap fragments (oriented cut-side downward) were mounted on the frame, and were then lowered so the ends of all three contacted the water in the glass Petri bowl. Water was immediately drawn into the tubes by capillary action, so the three tubes could be considered similar, water-filled capillary tubes. Subsequently, several drops of violet anilin solution were added to the water in the Petri bowl.

### Surprising Results

In the first experiment (where purple anilin dye was injected into the *Genlisea* vesicle), the colouring did not spread beyond the proximal neck area (see Figure 2). Even after an hour had passed, the anilin dye did not spread beyond the proximal neck area. This experimental result was the same whether the trap was submerged in water or kept in the air.

In the second experiment, involving the glass capillary tube, *G. hispidula* Trap A, and *G. hispidula* Trap B, there was a very interesting result. The glass capillary rapidly became coloured as the dye solution diffused into the water column. Similarly, in Trap A, the anilin quickly diffused throughout the distal neck (see Figure 3). In contrast, in Trap B, the dye was unable to diffuse out of the vesicle and proximal neck area!

### Gland Observations

The trap neck has numerous glands on the internal tube surface. The glands of *G. violacea* were studied by coloring them with iodine tincture, which stains cellulose in particular. The heads of the glands in the proximal neck area of the *Genlisea* trap are multicellular (see Figure 4). Searching for similar glands in related genera, we find near-



Figure 2: The *Genlisea hispidula* vesicle and proximal neck area after the injection of purple anilin into the trap vesicle. The dye cannot diffuse into the central neck area.

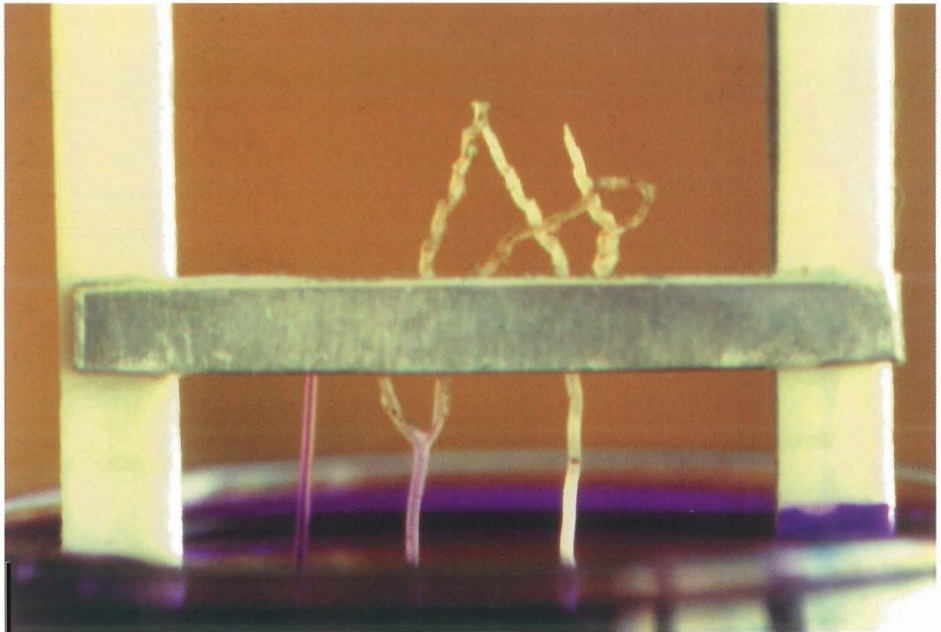


Figure 3: Diffusion of the violet anilin colour into the glass capillary tube (left) and Trap A (center). No diffusion is evident in Trap B (right).

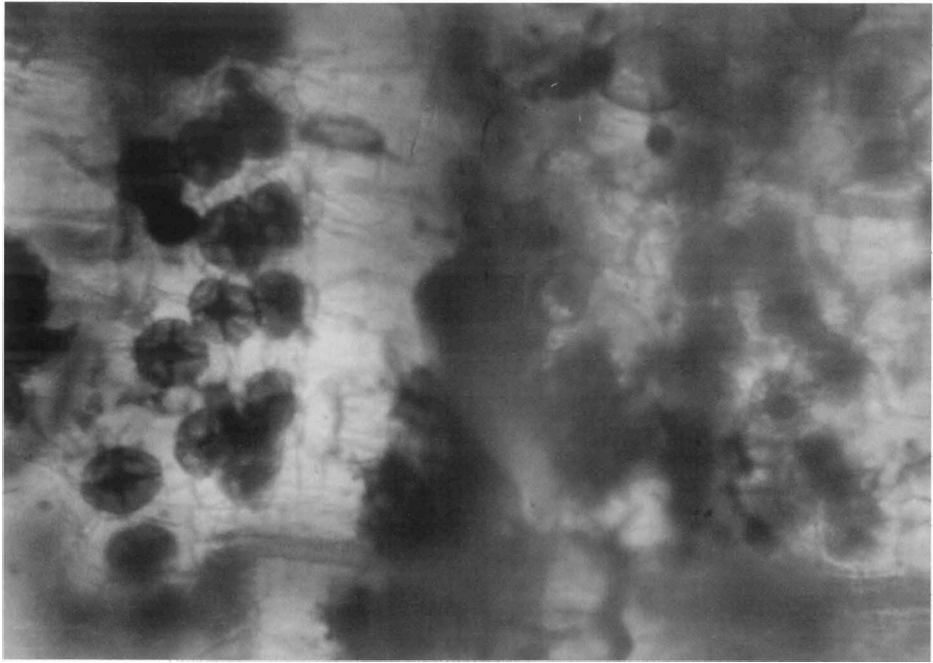


Figure 4: Glands in the proximal part of the *Genlisea violacea* trap neck.

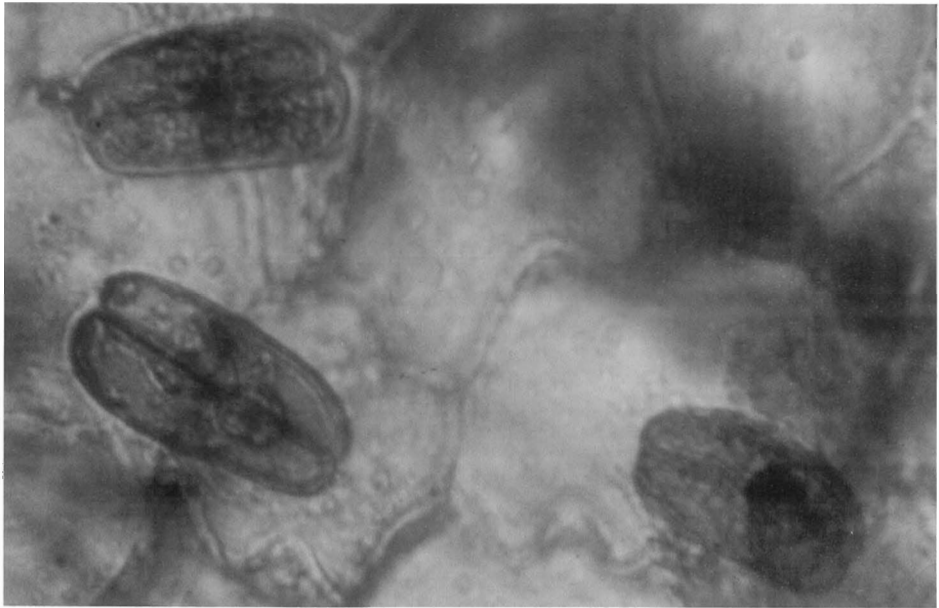


Figure 5: Glands in the distal part of the *Genlisea violacea* trap neck.

ly the same glands in *Pinguicula* (i.e. the sessile digesting glands; see Juniper, Robins & Joel 1989: 153).

In contrast, the heads of the glands in the distal portion of the trap neck are only 2-celled (see Figure 5), and rather resemble the bifid glands found near the mouth of *Utricularia* bladders (Lloyd, 1933: 45; Sydenham & Findlay, 1975: 348).

### Interpretation of the Experiments

It seems very likely that the two different gland types have two different functions.

If we fix our attention on the glands in the proximal neck, we may infer that they may serve the same function as the similar glands found in plants in the related genus *Pinguicula*. Specifically, they may secrete a viscous compound which is not too easily miscible with water. (Indeed, *Genlisea* are well known to secrete mucous in other contexts, i.e. from the photosynthetic leaves, e.g. in *Genlisea aurea* as reported by Rivadavia (2002)). It is possible that such secretions would partially or even completely block the capillary-like trap tunnel. If this is indeed the case, nutrients dissolved in the vesicle would be prevented from diffusing from the vesicle and proximal neck into the distal neck (and, subsequently, escaping into the environment). On the other hand, an agile little animal could penetrate this viscous area by means of its own force. The secretion functions similarly to a semi-permeable membrane.

The inability of the anilin dye to diffuse from the vesicle and proximal neck areas into the distal neck areas (as shown by my experiments) supports this interpretation.

The presence of similar glands in both the vesicle and the proximal neck area in the *Genlisea* traps suggest a shared nature—indeed, the proximal neck may be an extension of the vesicle

It is still unclear what the function might be for the glands in the distal neck areas.

### Acknowledgement

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