Odour-based navigation behaviour in *Tritonia*: sensory systems and strategies

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Other Fundiing

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A model system for the neuroethology of SLOW odour-based navigation

Nudibranch mollusc: *Tritonia diomedea*

The Slugs Have Only Three Navigational Goals

1. mates (hermaphrodites; thus, no sex differences)

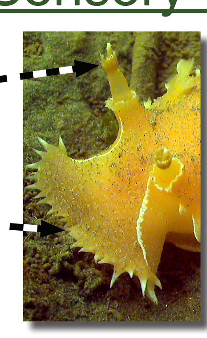
2. prey
(just one species: the soft coral *Ptylosarcus gurneyi*)

3. predators
(just one species: the sea star *Pycnopodia helianthoides*)

Finding prey and mates and avoiding predators based on <u>two cues</u>: **water flow** and **odours**[1,2]

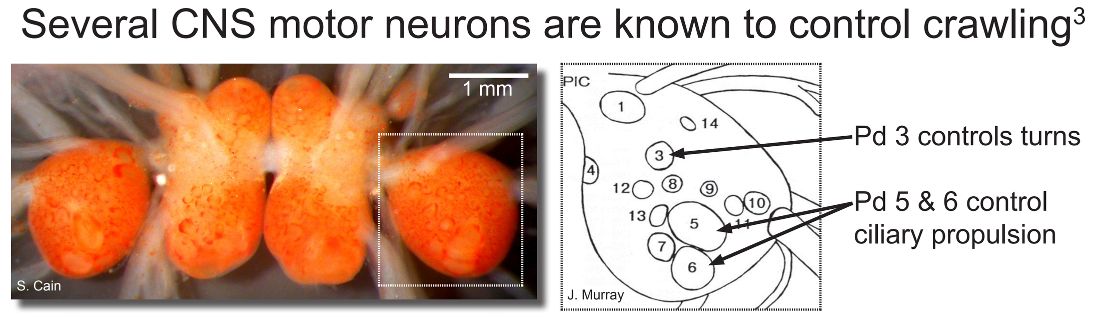
Cues Are Detected By Two Sensory Organs

1. Rhinophores
2. Oral Veil



Previous Data on Motor System

Several CNS motor neurons are known to control crawling[3]



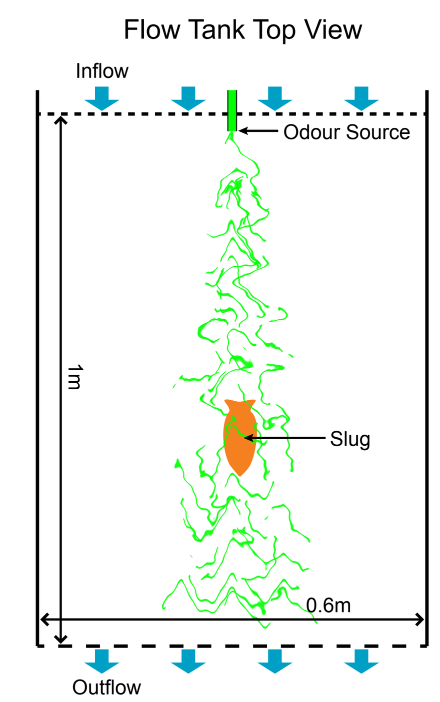
The Neuroethology of Odour-based Navigation

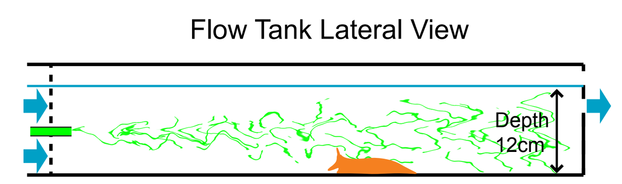
Our goal is to use the slow-moving *Tritonia* to complement work with faster animals (crabs, moths, etc.[4,5]) to understand adaptive navigational strategies for aquatic animals and how nervous systems generate them.

Our initial approach focuses on the sensory systems in *Tritonia*.

A single rhinophore is sufficient for navigation in *Tritonia*

<u>Method</u>: manipulate sense organs while testing navigation in a **turbulent odour plume**.

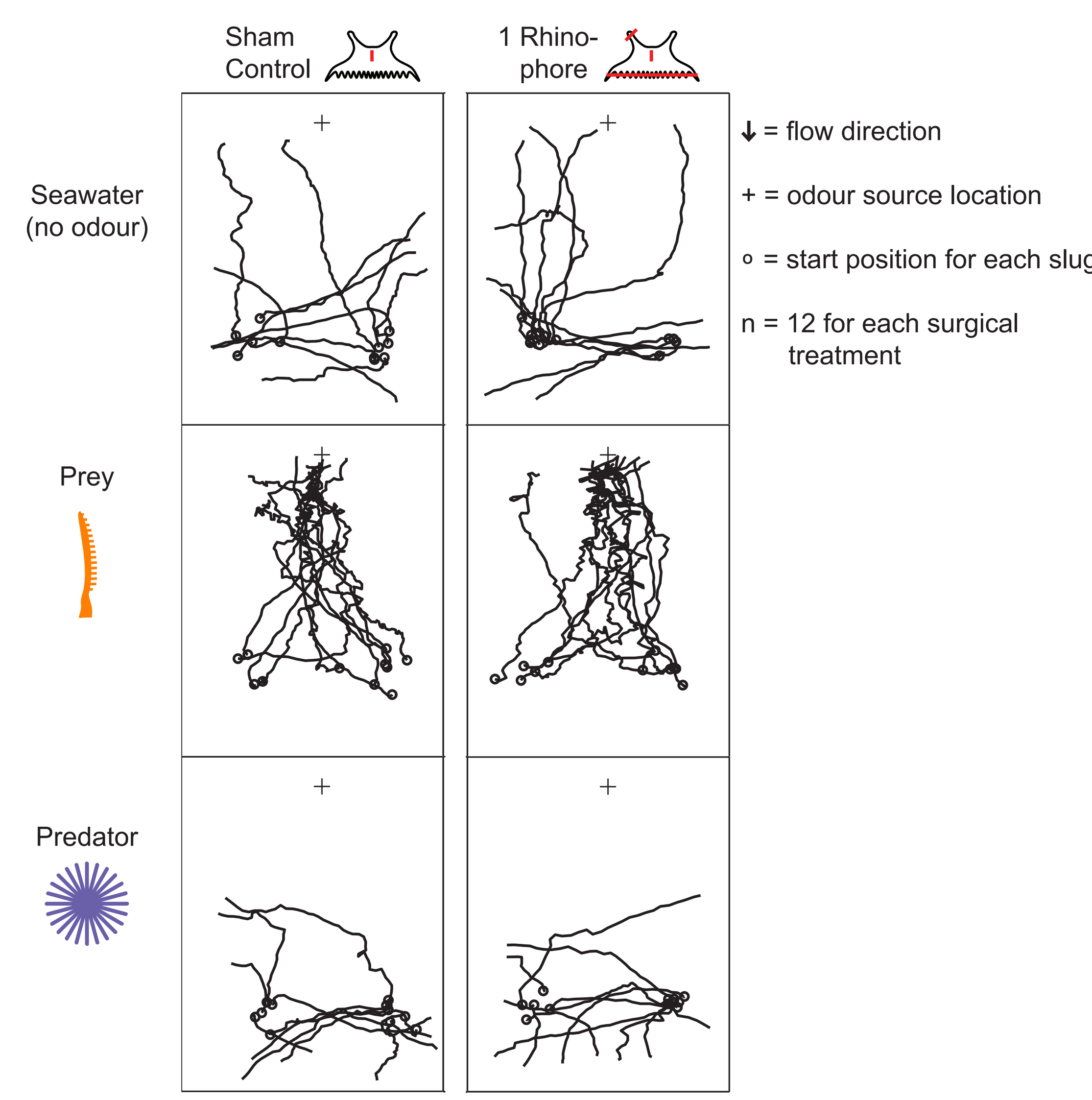




Slug movements in prey and predator odour plumes were tracked to compare animals with denervated sensory organs to control animals.

<u>Previous Result</u>: removing both rhinophores eliminated any response to prey or predator plumes[2]

<u>New Results</u>: denervating the oral veil and one rhinophore had little effect on navigation in predator or prey plumes



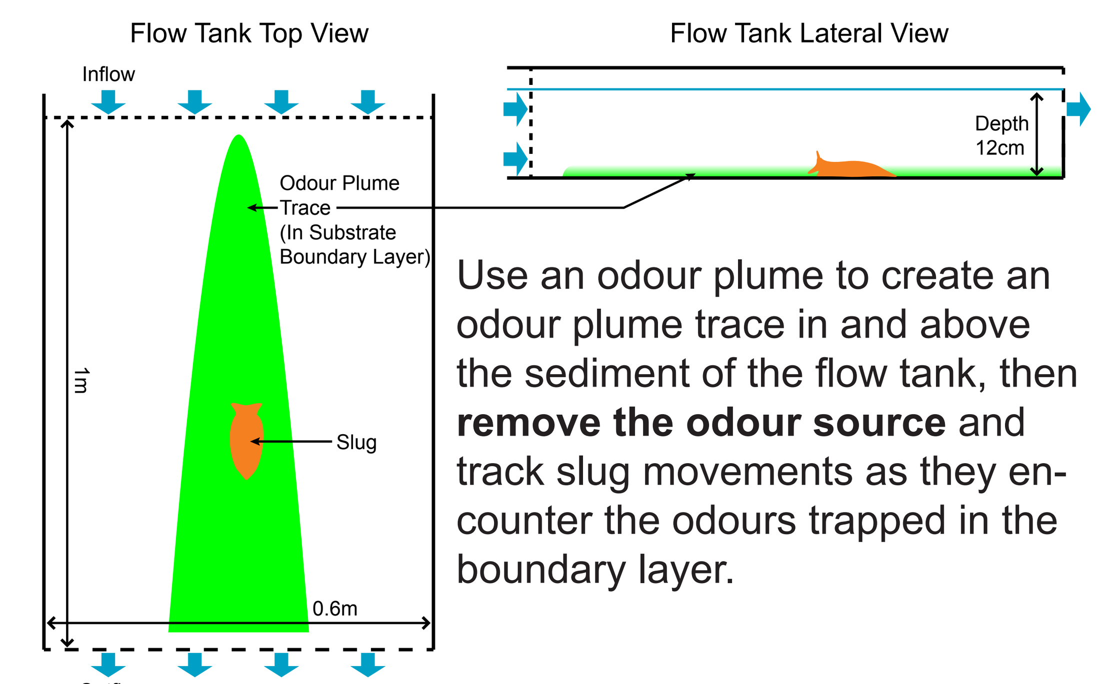
<u>Conclusion</u>: the rhinophores are both **necessary and sufficient** for long-distance navigation in odour plumes.

<u>Implication</u>: both flow and odours are detected by the rhinophores since odour-gated rheotaxis (orienting to flow based on odour detection) is the likely strategy used by the slugs.

Can *Tritonia* navigate using the trace of an odour plume in the boundary layer?

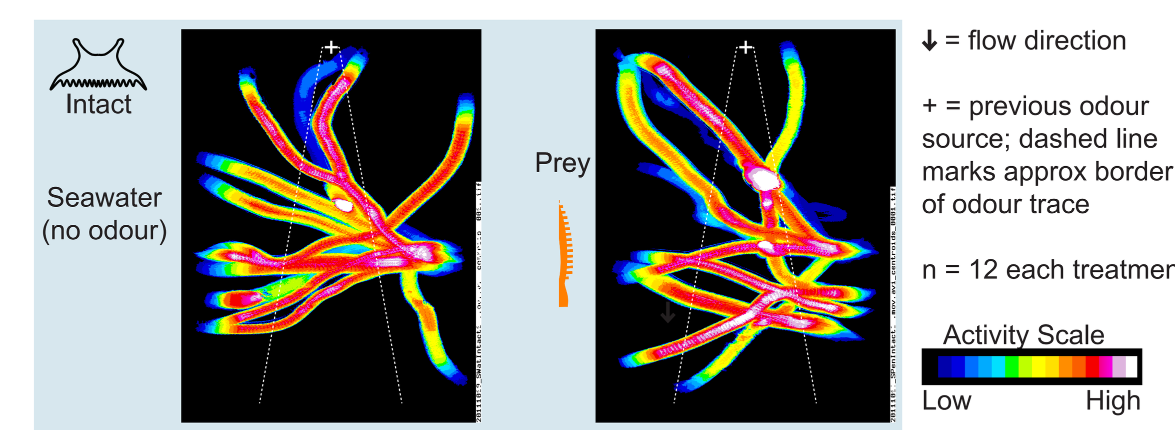
<u>Hypotheses</u>: the oral veil detects odours trapped in the substrate boundary layer and the slugs can use these as navigational cues.

<u>Method</u>: manipulate sense organs while testing navigation in **odours trapped in the substrate boundary layer**.

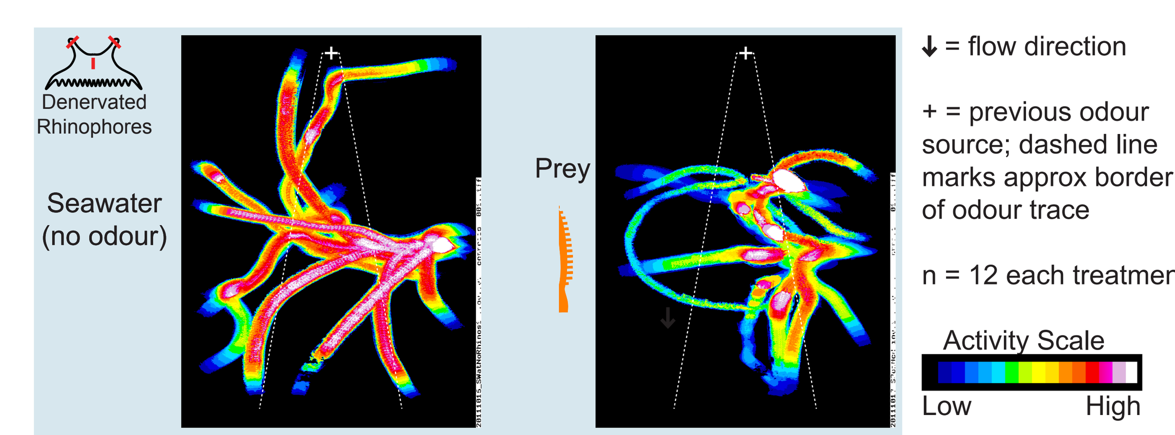


Use an odour plume to create an odour plume trace in and above the sediment of the flow tank, then **remove the odour source** and track slug movements as they encounter the odours trapped in the boundary layer.

<u>Preliminary Result 1</u>: slug tracks were no different between controls with no odour and prey odour traces (& predator, not shown)

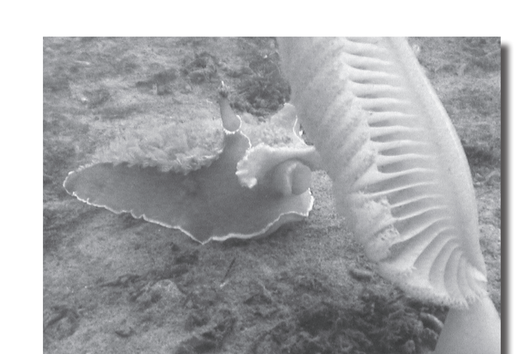


<u>Preliminary Result 2</u>: slugs with denervated rhinophores and intact oral veils paused crawling when entering prey odour traces



<u>Tentative Conclusion</u>: the oral veil can detect odour in the substrate boundary layer, but these odours are not used in long-distance navigation.

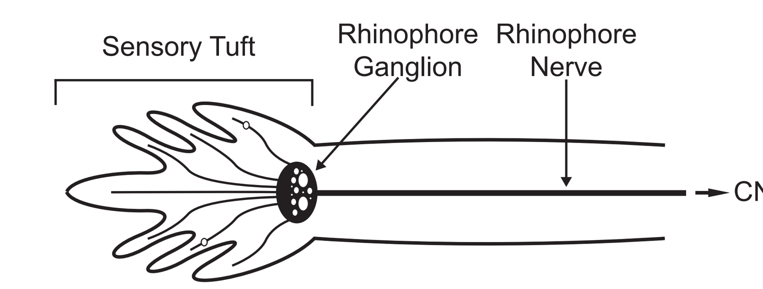
<u>Speculation</u>: the oral veil detects odours before predatory attacks.



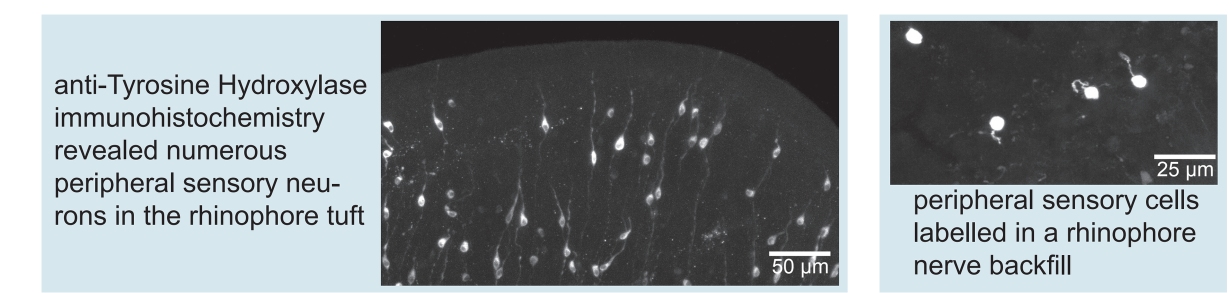
Long-distance navigation may be controlled by both peripheral and central circuits.

<u>Summary</u>: the previous experiments indicate that the sensory neurons in the rhinophore provide input to navigation circuits.

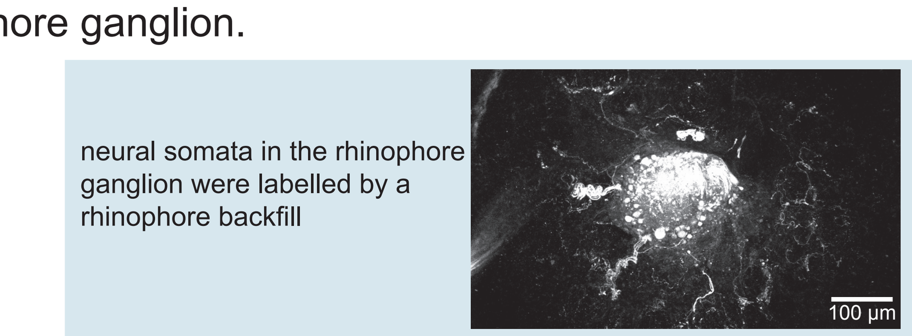
<u>Rhinophore Neuroanatomy</u>



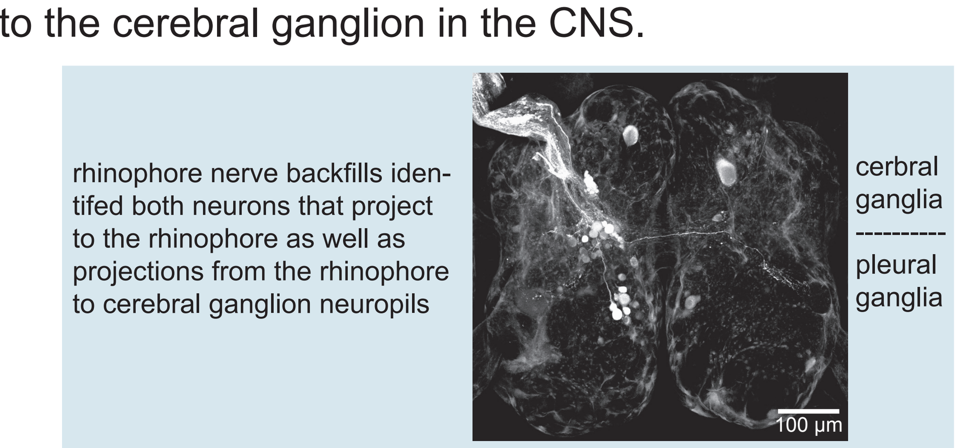
Numerous peripheral sensory neurons were present, and at least some projected centrally.



Neurons with central projections were also present in the rhinophore ganglion.



Central projections to and from the rhinophore are primarily confined to the cerebral ganglion in the CNS.



<u>Conclusion 1</u>: either peripheral or central sensory neurons in the rhinophore could detect flow and odours for navigation.

<u>Conclusion 2</u>: sensory integration underlying odour-gated rheotaxis could occur in either the rhinophore or cerebral ganglia.

References

1. Wyeth, R. C., O. M. Woodward, and A. O. D. Willows. 2006. Orientation and navigation relative to water flow, prey, conspecifics, and predators by the nudibranch mollusc *Tritonia diomedea*. Biol. Bull. 210: 97-108.
2. Wyeth, R. C. and A. O. D. Willows. 2006. Odours detected by rhinophores mediate orientation to flow in the nudibranch mollusc, *Tritonia diomedea*. J. Exp. Biol. 209: 1441-1453.
3. Redondo, R.L., and J.A. Murray. 2005. Pedal neuron 3 serves a significant role in effecting turning during crawling by the marine slug *Tritonia diomedea*. J. Comp. Phys. A 191: 435–444.
4. Weissburg, M. J. 2000. The fluid dynamical context of chemosensory behavior. Biol. Bull. 198: 188-202.
5. Vickers, N. J. 2000. Mechanisms of animal navigation in odor plumes. Biol. Bull. 198: 203-212.