A comparative study of axial neuromuscular control in *Polypterus senegalus*: Is walking really novel?

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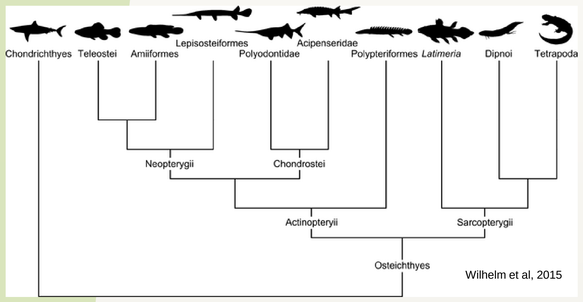
BACKGROUND



- *Polypterus senegalus* possesses behavioural and anatomical plasticity when raised in a terrestrial environment.
- Many features make them of particular interest in examining transitions from water to land including: a paired lung, lobed pectoral limbs, ability to breathe through their spiracle as well as observed terrestrial excursions both in the wild and in the laboratory.
- Member of the most basal extant clade of Actinopterygii.
- Adds to the knowledge of the evolution of the anatomy of Osteichthyes.

INTRODUCTION

- Aquatically raised fish were used.
- Hypothesized that in the short term, neuromuscular activation patterns in body muscle would be co-opted from existing behaviours, thus, walking behaviour should be more similar to what is seen in escape responses rather than routine swimming and should require more effort.
- Data was collected during the study using high-speed videography, camera calibration, and video and motion analysis in Matlab.
- By examining the similarities and differences between the neuromuscular controls of different behaviours, it can be determined if and how the systems that dictate the “novel” walking behaviour are adjusted from the control mechanisms the fish would regularly use.

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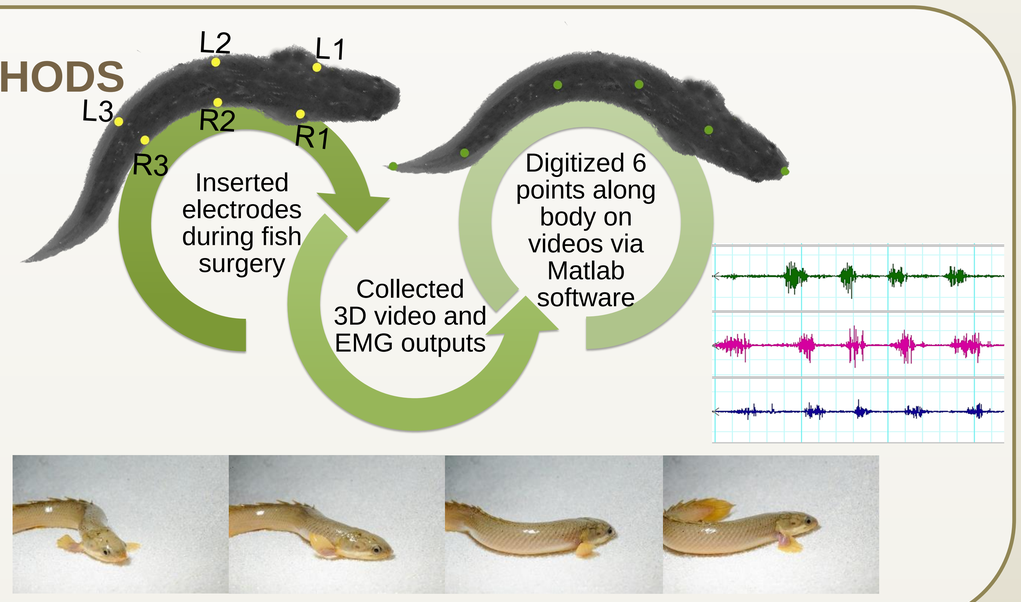
METHODS



RESULTS

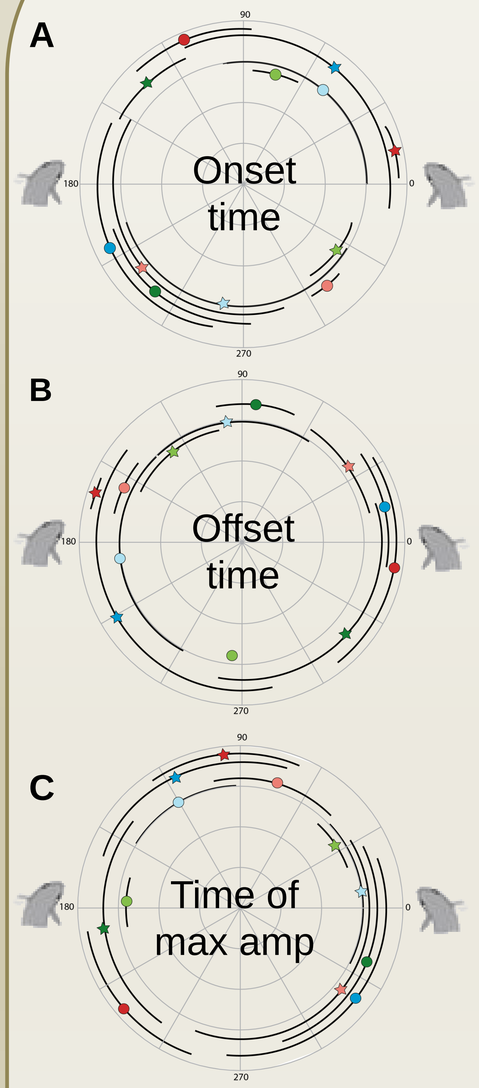


Figure ABC. Muscle activation timing in swimming and walking fish. A shows the first muscle burst onset time. **B** shows the first muscle burst offset time. **C** depicts the time of maximum burst amplitude.

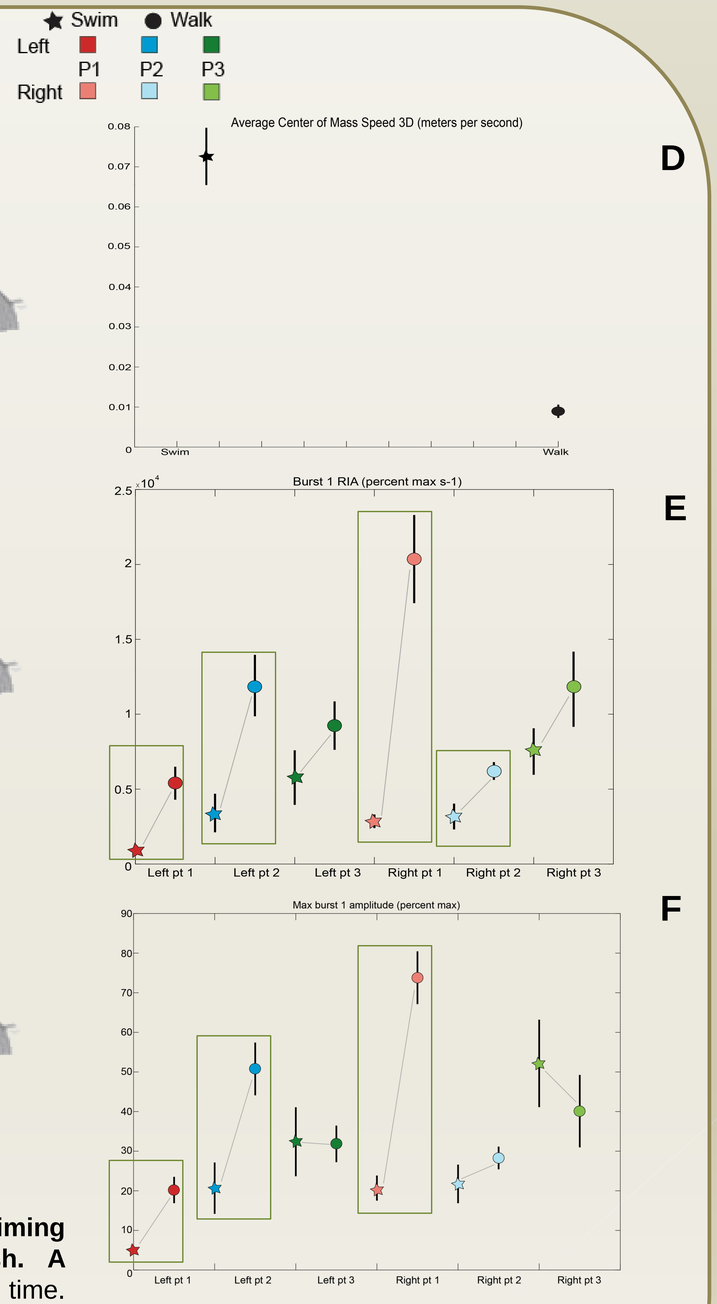


Figure DEF. D shows swimming speed is significantly faster than walking. **E** and **F** indicate that the same muscles are working harder in walking than during swimming (effort and max amplitude).

CONCLUSIONS

- There is a progression of activity from anterior to posterior on both sides of the fish both when swimming and walking.
- Contralateral matching pairs of points have their muscle activity happening on opposite sides of the polar plot (i.e. approx. 180° later in the stroke cycle).
- Muscle activity, including max activity happens later in the stroke cycle when walking than when swimming.
- Swimming speed is significantly faster than walking speed.
- Muscles are working harder (increased effort over a longer period of time and with greater electrical amplitude) during walking than in swimming in body points that are closer to the front of the body.

FUTURE DIRECTIONS

- Investigate muscle activation patterns in fish raised on land for an extended period of time.
- We predict that fish raised on land will have different body muscle activation patterns during walking compared with those raised in water.
- Explore the red and white muscle phenomenon observed during the study.
- Determine mechanical effectiveness of differences in muscle activation and muscle length change measurements (sonomicrometry) .

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2. Wilhelm, B. C., Du, T. Y., Standen, E. M. and Larsson, H. C. E. (2015), *Polypterus* and the evolution of fish pectoral musculature. J. Anat., 226: 511–522. doi:10.1111/joa.12302
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