Electrosensory Behavior of C. elegans Induced by Ionic Current and Electric Field

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Introduction

Previously claimed, Caenorhabditis elegans are sensitive to electric field and crawl towards the negative pole in an apparatus similar to electrophoresis chamber. However, C. elegans do not appear to gain advantages from sensitivity to electric field, therefore we are skeptical that C. elegans are expressing electrosensory behavior. Since C. elegans are also sensitive to ion concentration gradients as well as electrical current stimulations, we hypothesize that C. elegans are not sensitive to a static electric field and that previous electrotaxis claims are caused by ion sensitivity from the electrophoresis solutions.

To test our hypothesis, we replicated Gabel's electrophoresis chamber assay and also created an electric field with parallel-plate capacitor.

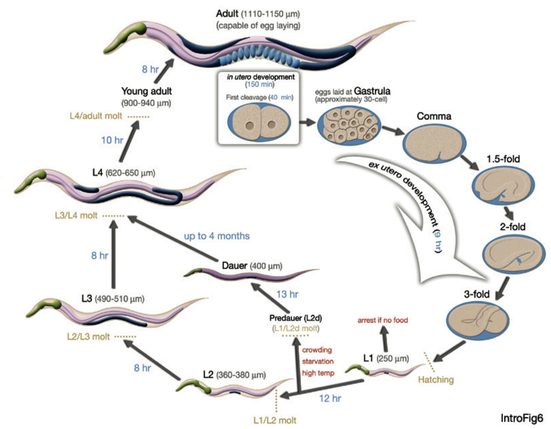

Fig 1. Life cycle of C. elegans. To ensure results are unaffected by incomplete development and different age groups, young adult worms are used.

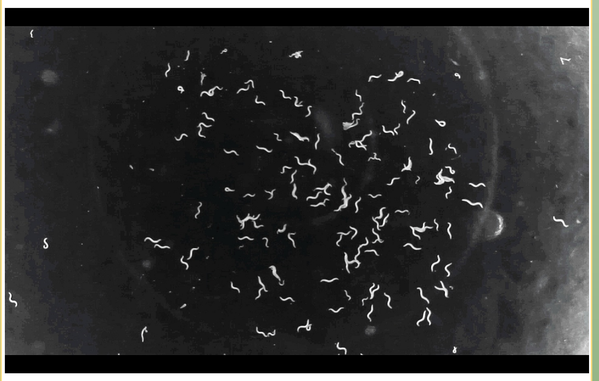

Fig 2. Dark field illumination of worms lit by red-filtered ring of LED. Field of view is 3.5 x 2.4 cm.

Material and Methods

Sample Preparation

N2 young adult worms are cultivated on NGM plates with E. coli OP50 and washed with M9 buffer using standard procedures. Animals are then transferred to assay plates.

Electrophoresis Chamber

Assay plates and solutions are made using the same concentration of NaCl and glycerol. Assay plates are placed in the chamber in a water bath. Solution is poured into the chamber, immersing all but the top surface of the agar.

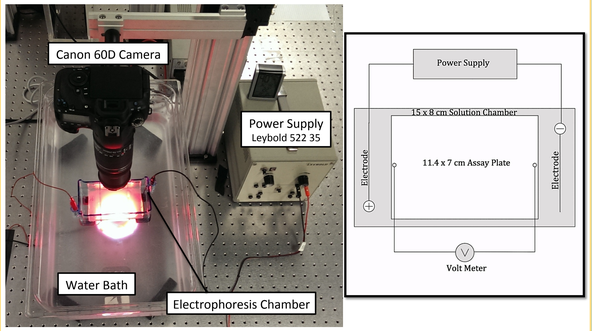

Fig 3. Assay plate is placed in the center of the chamber. Water bath reduces resistive heating of the agar. A volt meter measures the potential difference across each end of assay plate. Platinum wire electrodes line the sides to supply current through the chamber.

Parallel-Plate Capacitor

Assay plates are placed in the middle of the capacitor for uniform electric field stimulation.

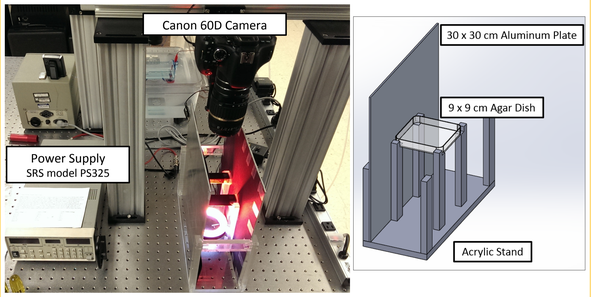

Fig 4. Capacitor apparatus made of 30 × 30 cm aluminum supported by acrylic stands.

Analysis

Canon 60D cameras are set up above each plate illuminated by a red-filtered ring of LED. Videos are analyzed by MatLab Worm Tracker.

Results

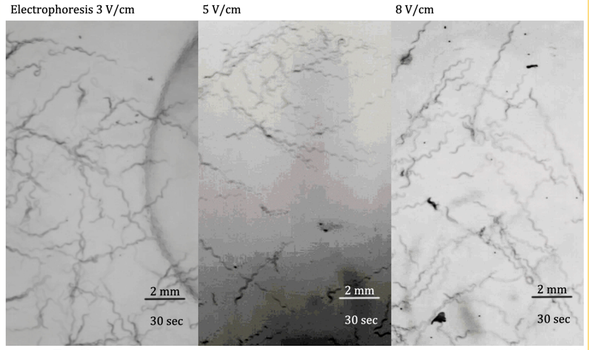

Fig 5. Superimposed images of the worms' tracks for 30 sec.

- Worms do not respond to E-field in the capacitor. Worms in the electrophoresis chamber show obvious attraction to the negative pole.
- Worms travel with an angle relative to the electric pole. Stronger field strengths causes higher speed and larger angles relative to the field direction.
- The worms gradually reduce their angles and crawl more parallel to the field direction.
- When stimulation is turned off, worms performs reversal and omega turns.

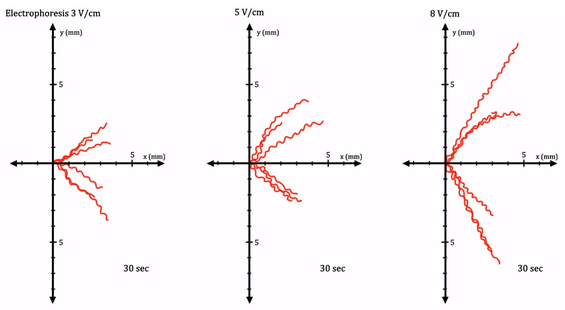

Fig 6. Electrophosesis tracks for 30 sec. Negative pole on the right. Higher field strength displays higher angles.

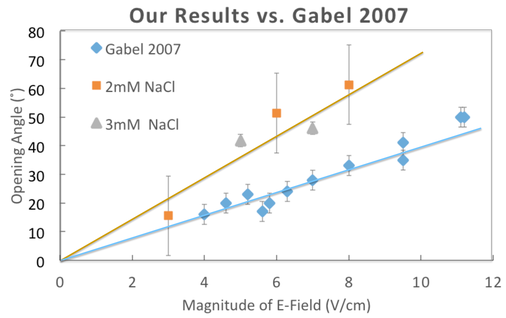

Fig 7. Comparison between published results by Gabel and our plotted data points with two different concentrations of NaCl plates.

Conclusions

- Worms crawl towards the negative pole of electric field in electrophoresis assay.
- C. elegans move at specific angles relative to the field direction that is directly proportional to the electric field strength.
- C. elegans are unresponsive in the parallel-plate capacitor, suggesting that the worms are affected by a stimuli specifically present in the electrophoresis chamber.
- The observed movements may be driven by the ions in solution and not by the E-field.
- Our data shows greater approach angle under same field strength stimuli compared to Gabel's results. The reason may be different data collection methods.

Future

- Find out what drives the worms to crawl toward one end with specific angle
- Incorporate associative learning in C. elegans to desensitize the worms to sodium.
- Separate effects of electric field from current and temperature.

References

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