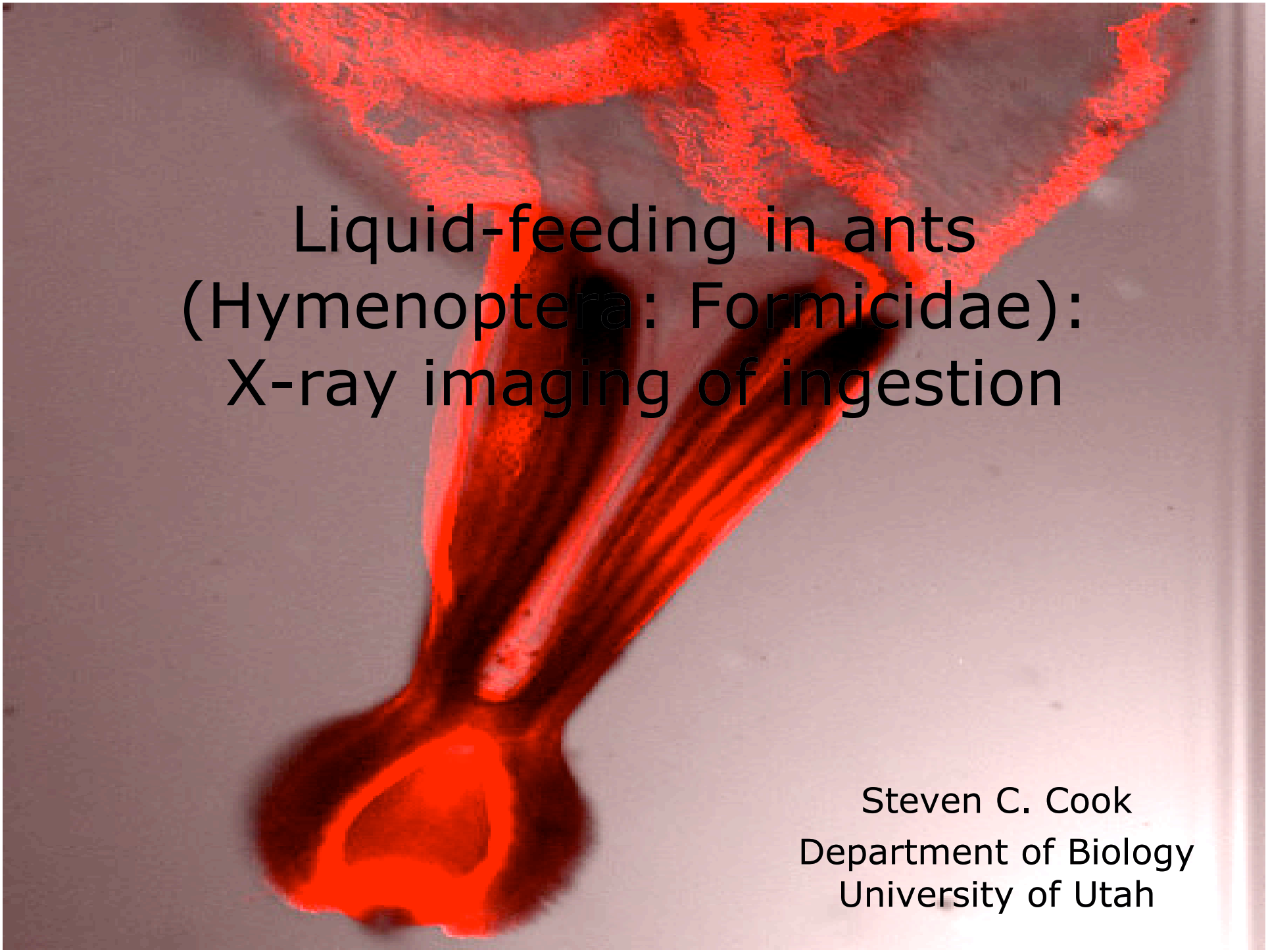
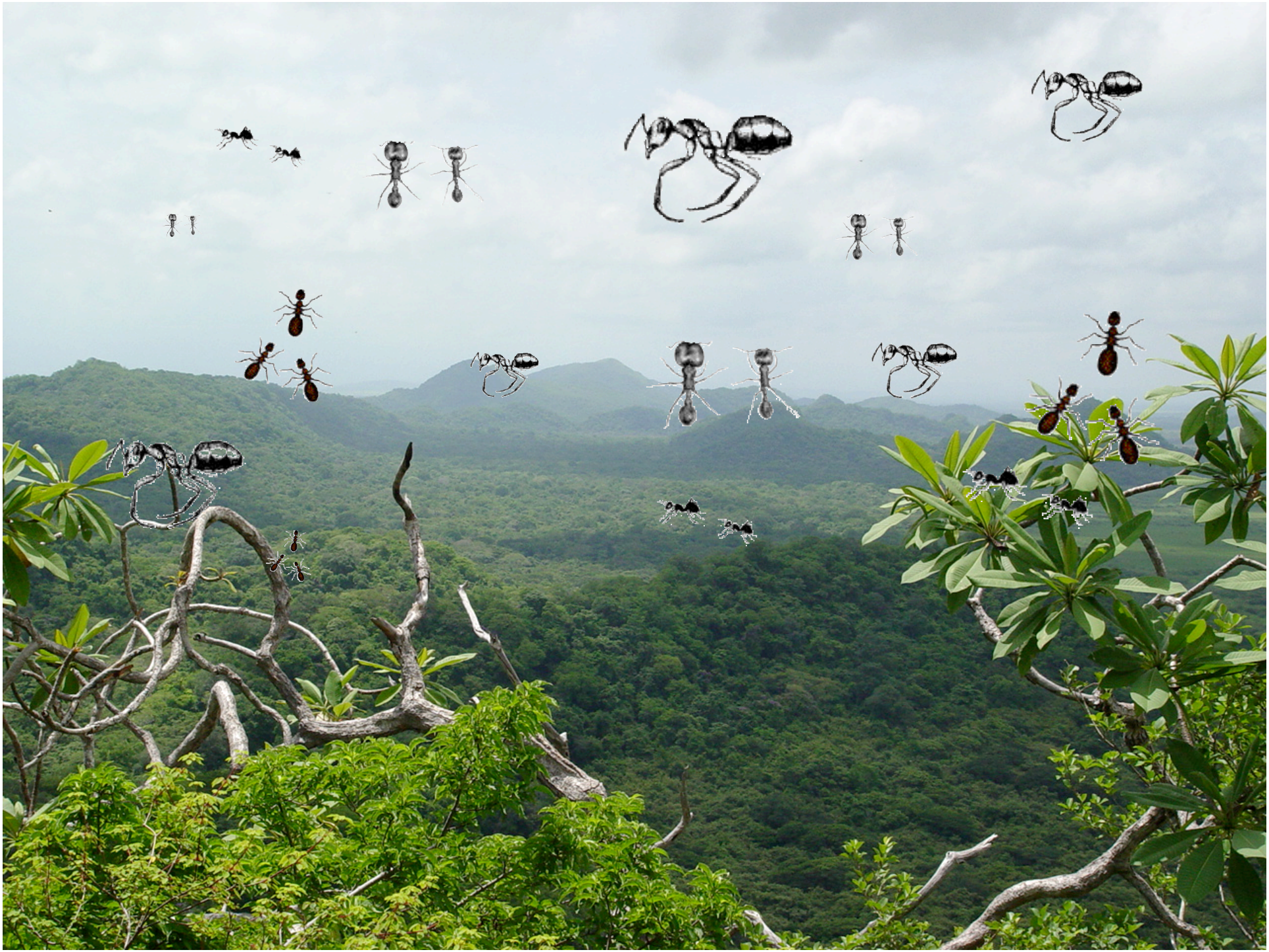


Liquid-feeding in ants (Hymenoptera: Formicidae): X-ray imaging of ingestion

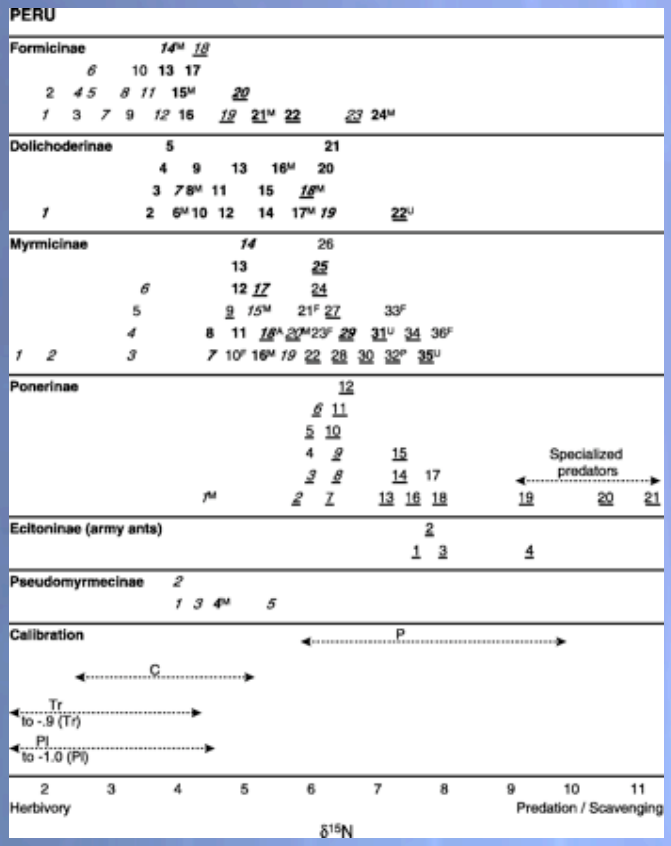
Steven C. Cook
Department of Biology
University of Utah

OUTLINE

- Background
  - Ants as 'cryptic herbivores'
  - Liquid-feeding performances
    - Ant digestive anatomy--hypothesis
- X-ray imaging
  - Methodology
  - Results
- Future Studies



Ants as Herbivores

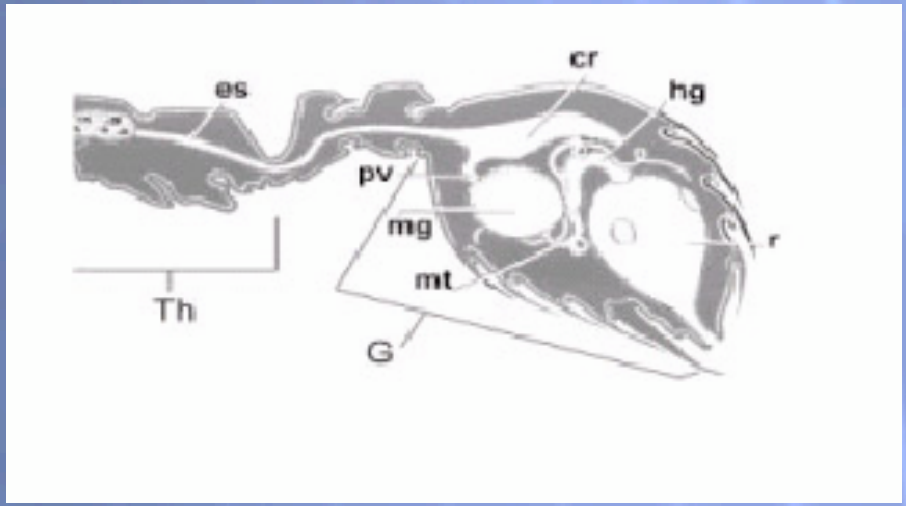


Davidson *et al.*, 2003

Hunt, 2003

$\delta^{15}N$ ($^{15}N/^{14}N$) as indicator of trophic level in ants. Predatory ants have high $\delta^{15}N$ values relative to more 'herbivorous' ants.

Ant Digestive Anatomy



Th= Thorax, G= Gaster, cr= crop, pv= proventriculus, mg= midgut, mt= malpighian tubules, hg= hindgut, r= rectum

- Petiole (=constriction at 'waist') restricts workers to feeding mostly on liquids
- Crop='social stomach'- contents regurgitated to fellow workers and developing larvae
- Digestion occurs in midgut

Liquid Resources

- Extra-floral nectar (EFN)
  - CHO-rich, N-poor
  - Mostly non-essential AAs
  - Simple CHOs
  - Ephemeral
  - Copiously produced
- Hemipteran 'honeydew'
  - CHO-rich, N-poor
  - Some essential AAs
  - Complex CHOs (e.g., melezitose)
  - Predictable
  - Produced gradually

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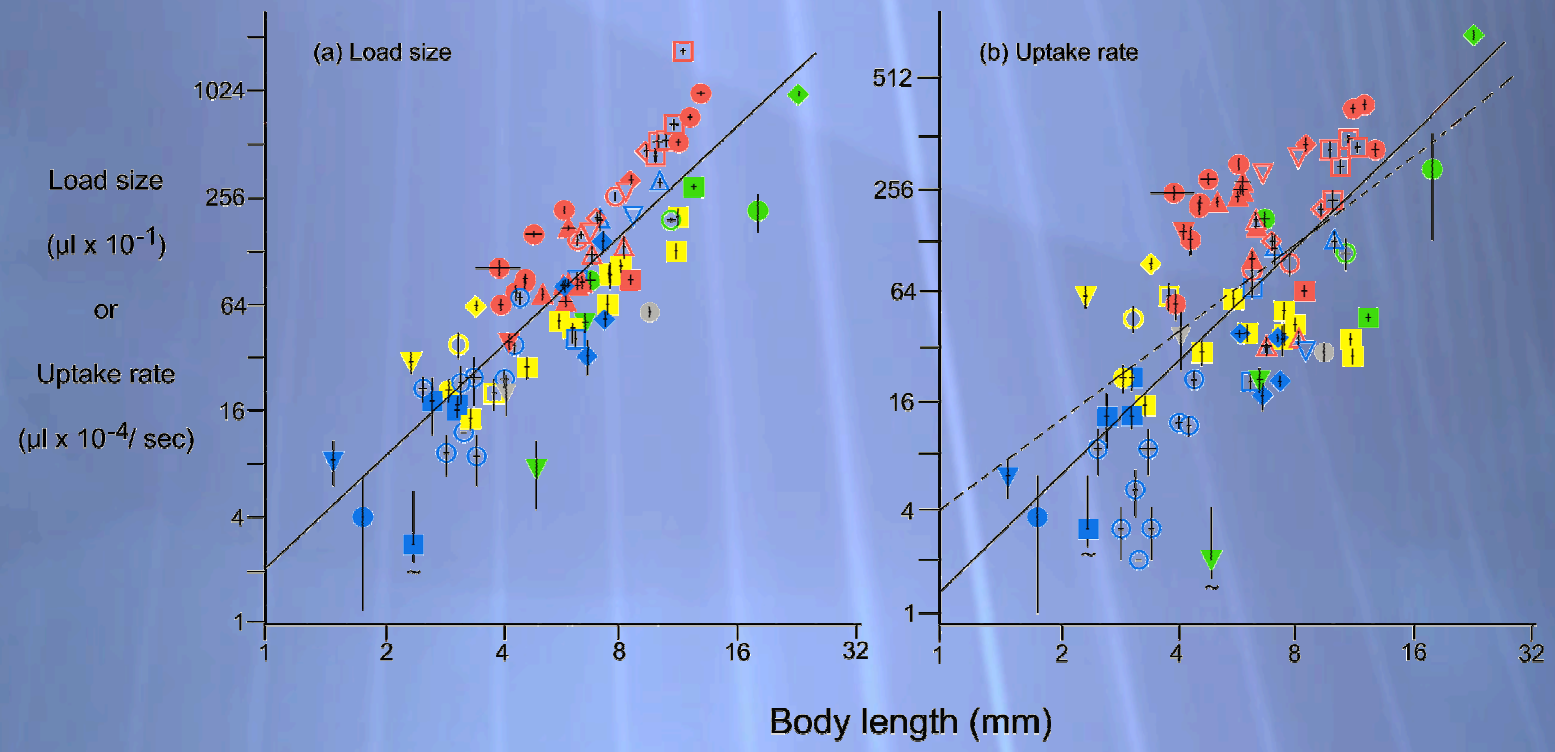
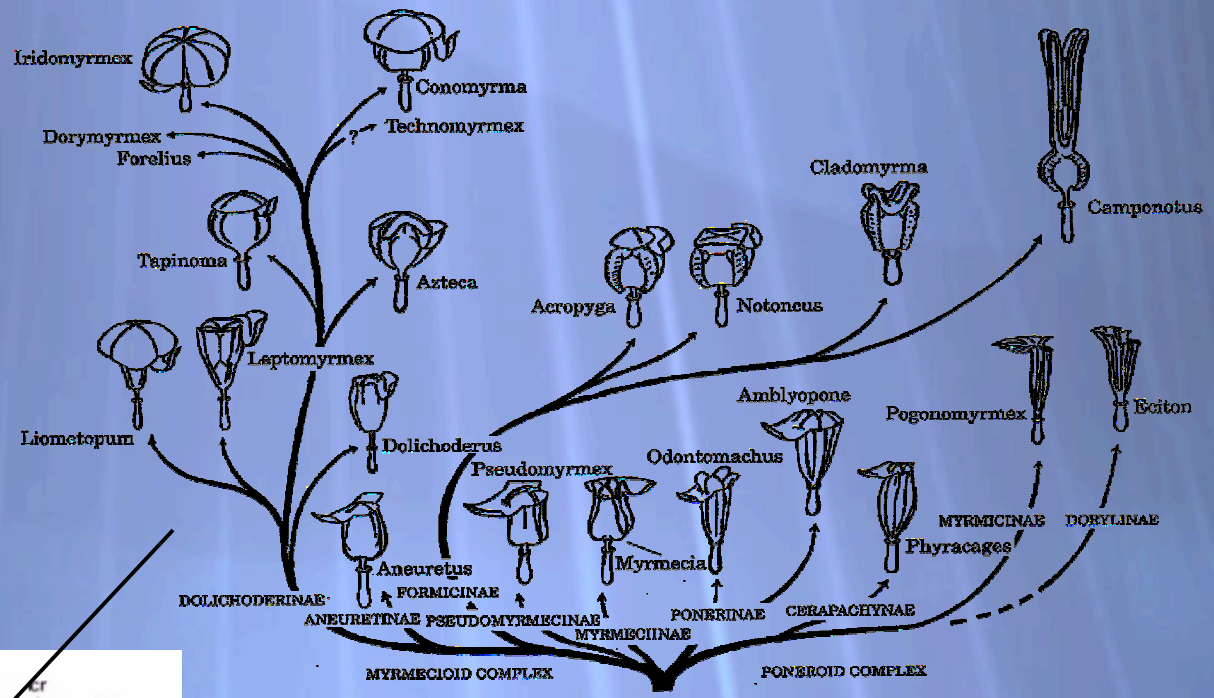
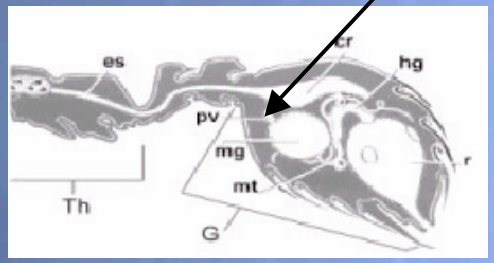
Liquid-Feeding Performances



Davidson, Cook & Snelling, 2004

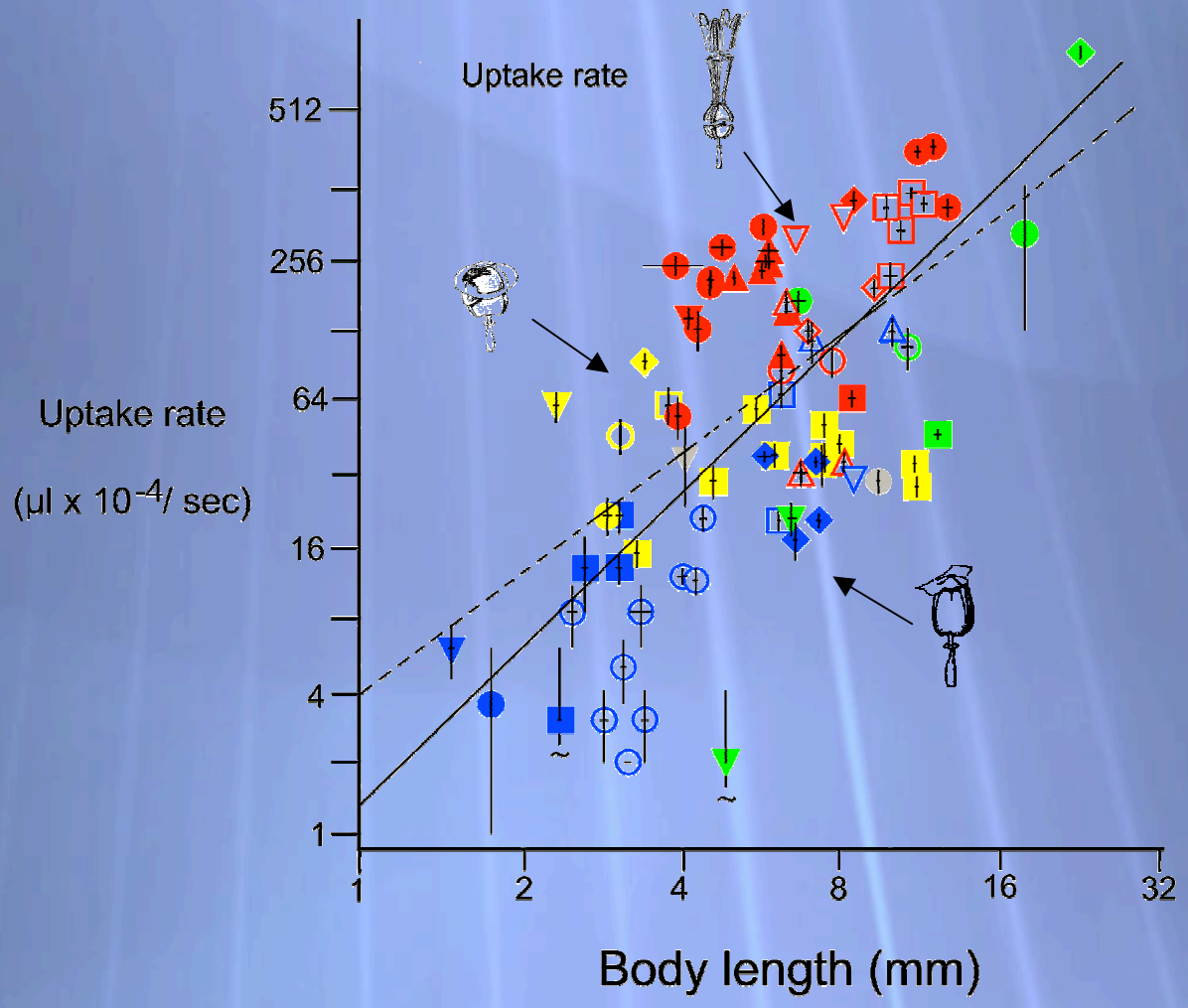
Diversity of Formicid Proventricular Forms





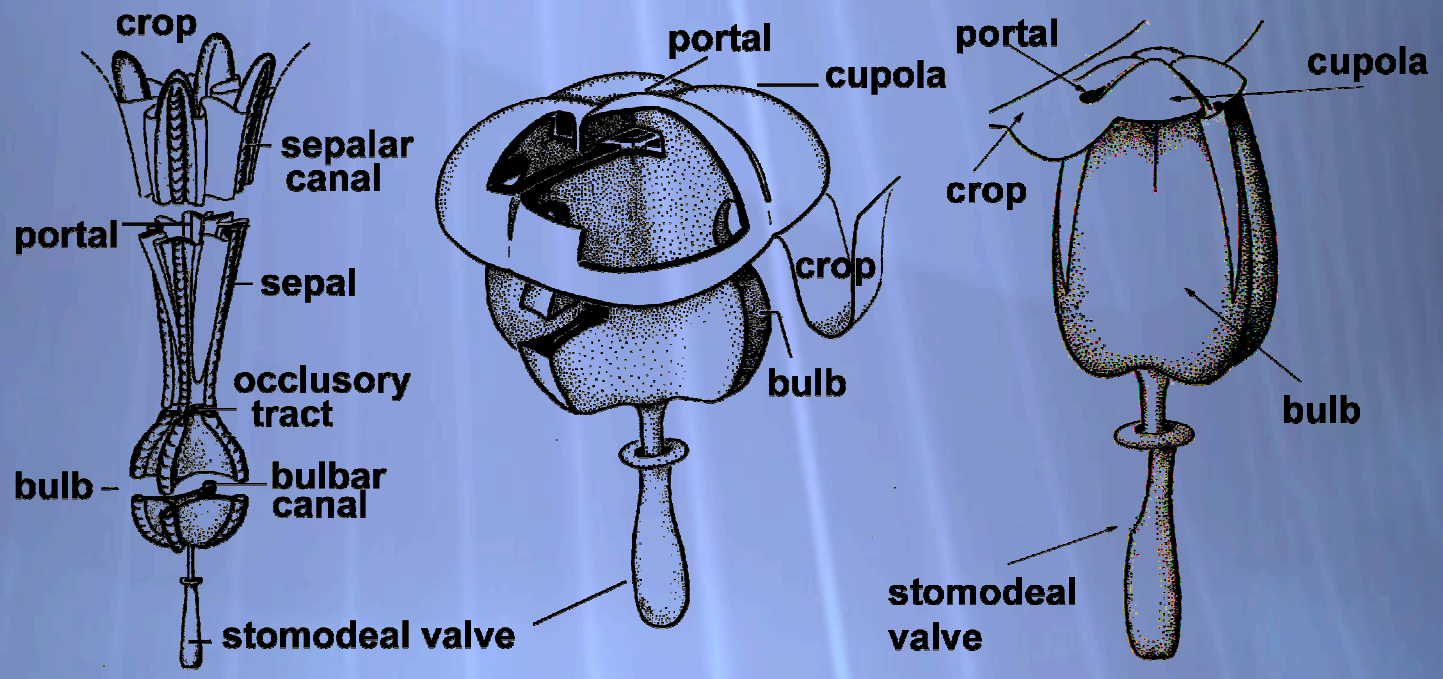
Eisner, 1957

Liquid-Uptake Rates



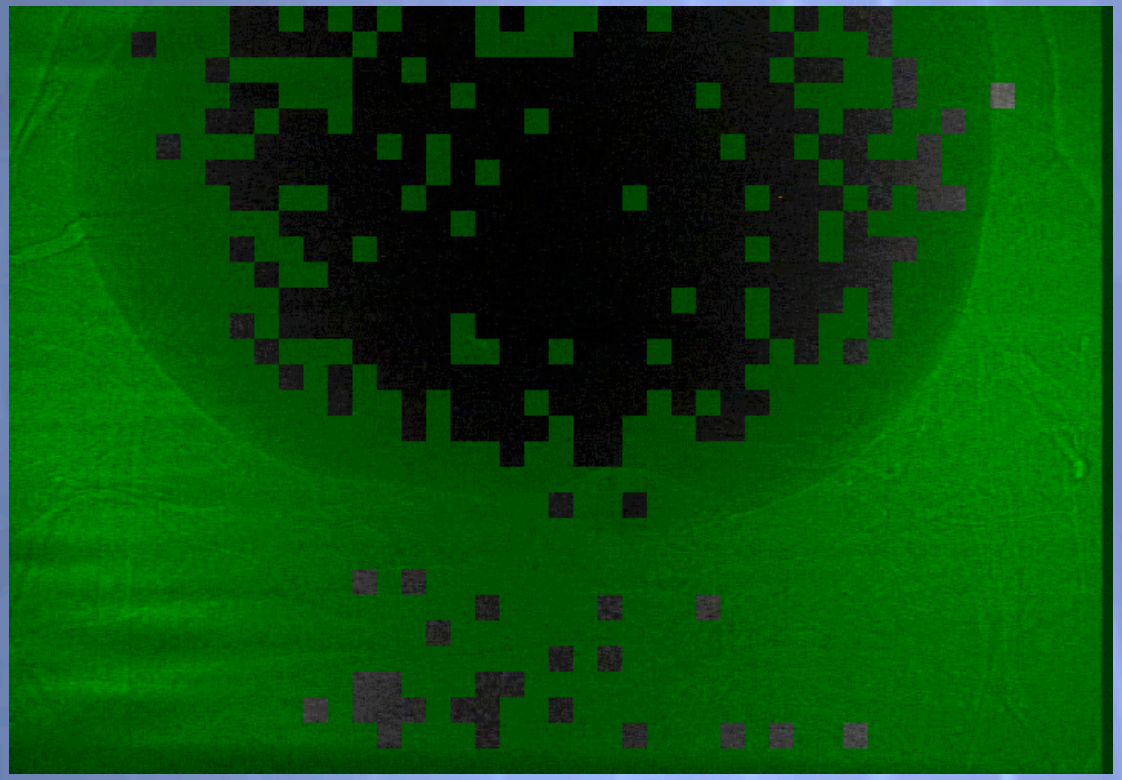
Davidson, Cook & Snelling, 2004

Formicid Proventriculi



Eisner, 1957

Proventriculus



Function of sepalous proventriculus during liquid feeding

Sepalous proventriculus (*Camponotus* sp.)

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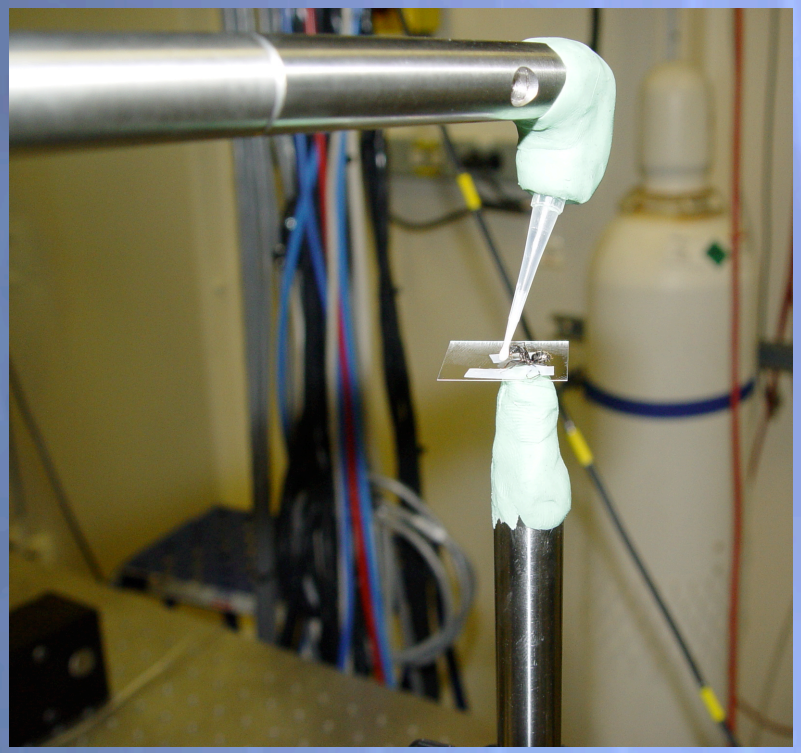
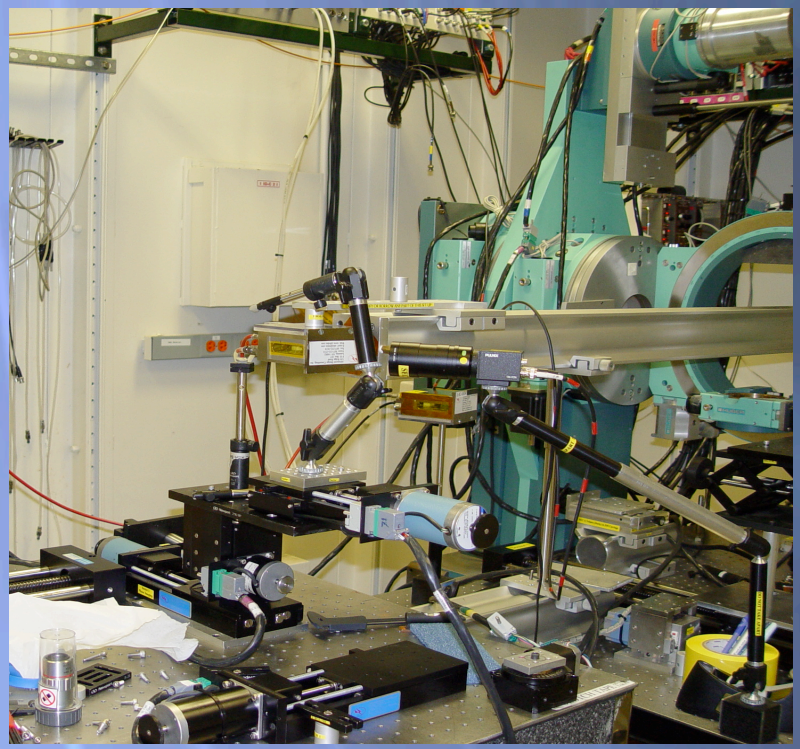
Methodology

- Setup
  - XOR-CAT 1-ID beamline
    - 20-30 KeV
    - High gain on camera
    - $CdWO_4$ scintillator
  - Contrasting agent
    - IsoVue® with honey
  - Remote controlled specimen-grip

Methodology



Specimen mounted on grip



XOR-1-ID beamline--motorized grip

Methodology

- Data Analysis
  - DVD conversion
    - DVDxDV software
  - Digitizing
    - NIH Image (Quickview [J. Walker])
  - Data
    - Bolus velocities
    - Pharyngeal pump frequencies
    - Crop contractile wave frequencies
    - Correlation of crop contractions and bolus ingress

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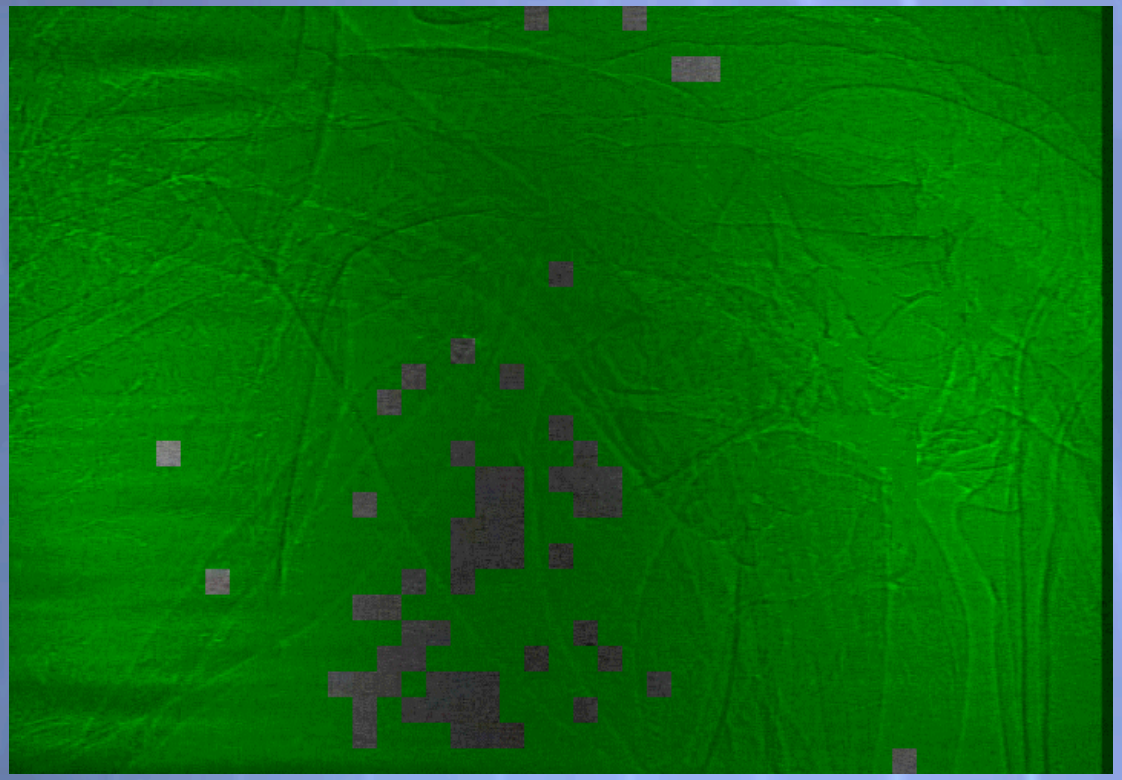
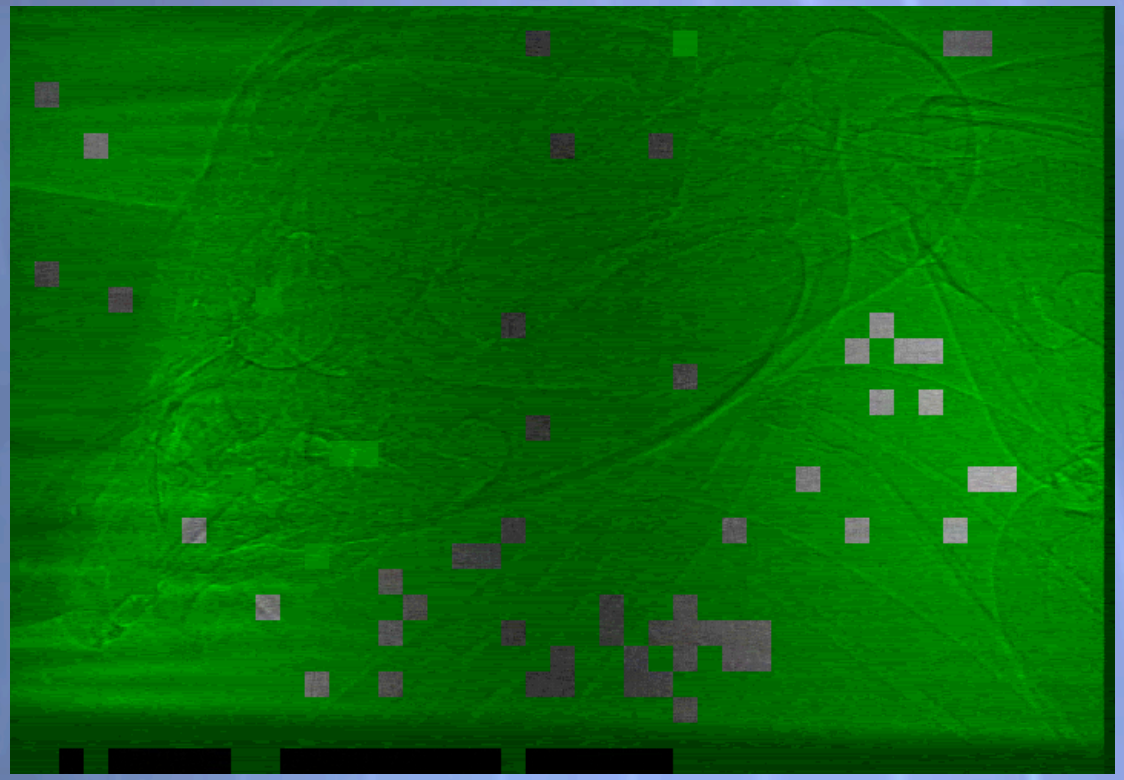
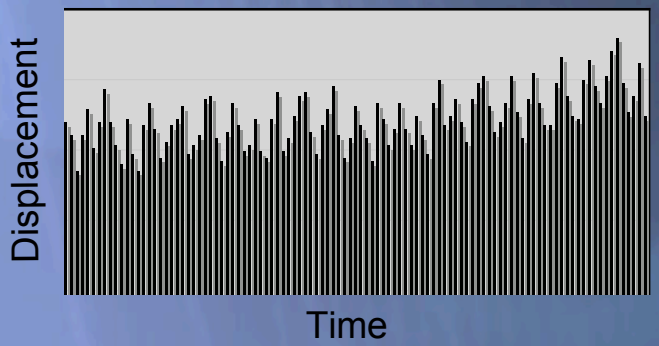
Bolus Velocities



Average Bolus Velocity
(N=10)= 5.014 mm/s
st. dev.= 0.579

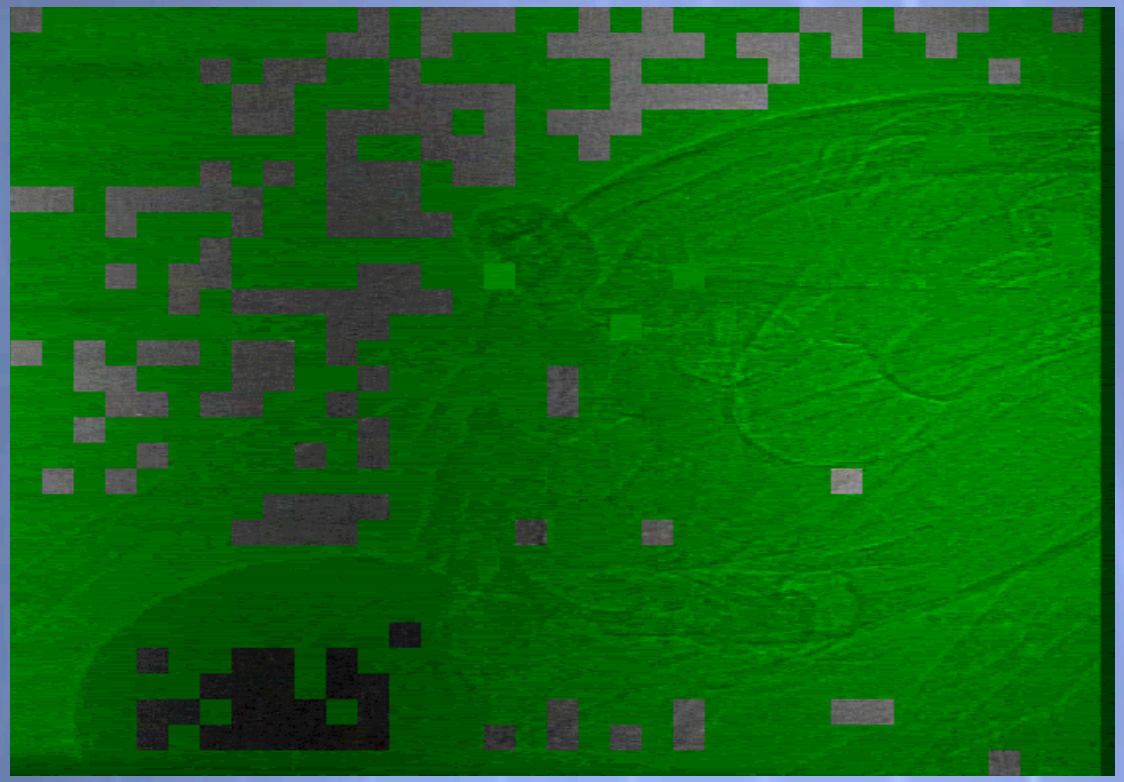
Glossal Frequency

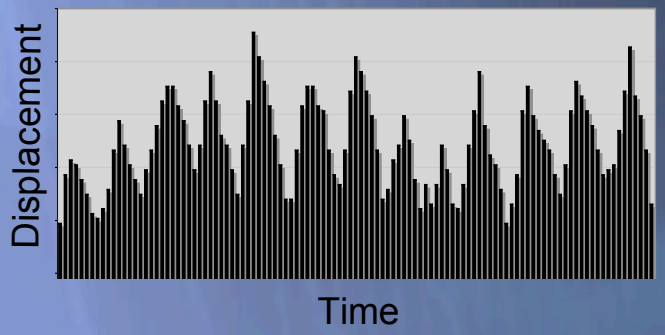




Average Frequency (N=3)= 3.61 ‘laps’/s

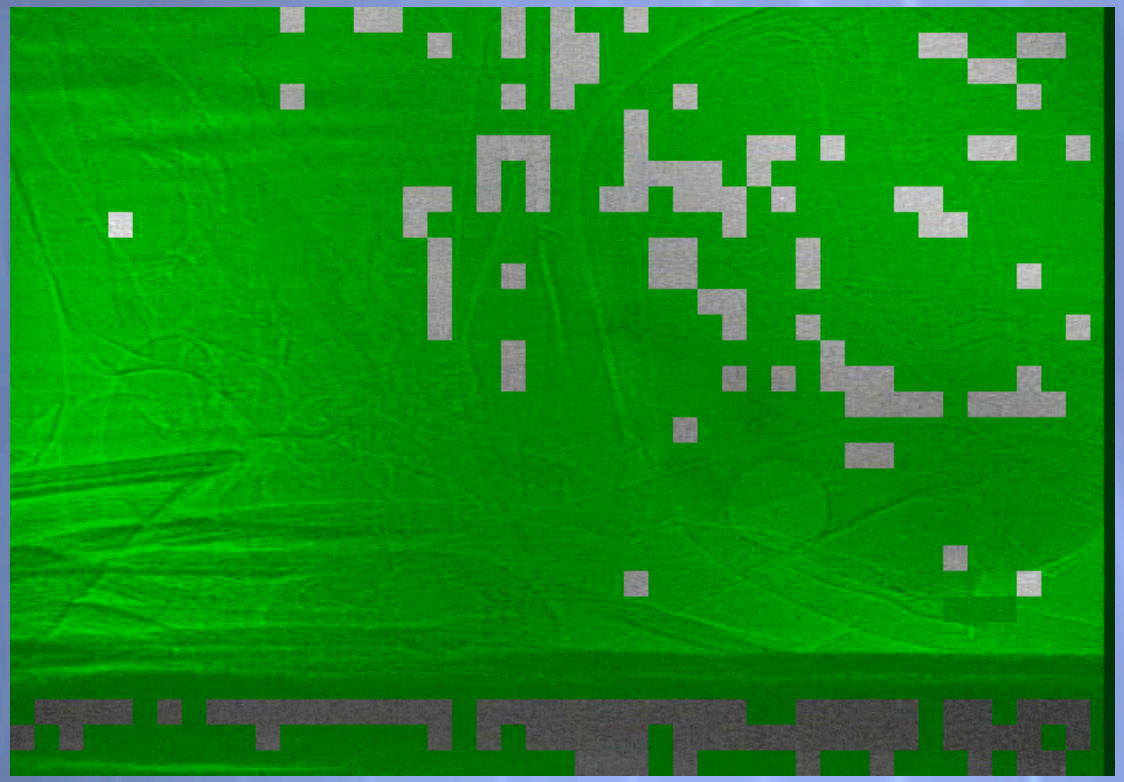
Pharyngeal Pump Frequency

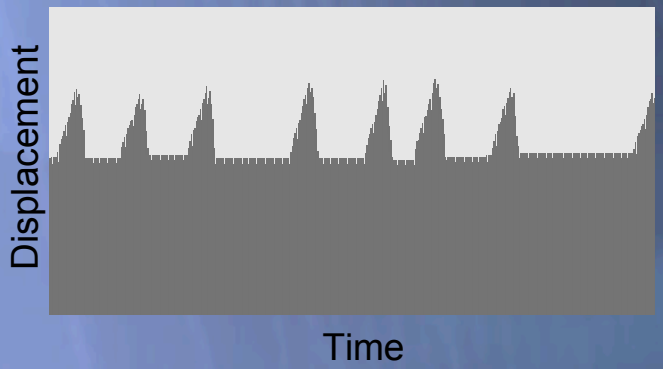




Average (N=3) Frequency= 1.90 pumps/s

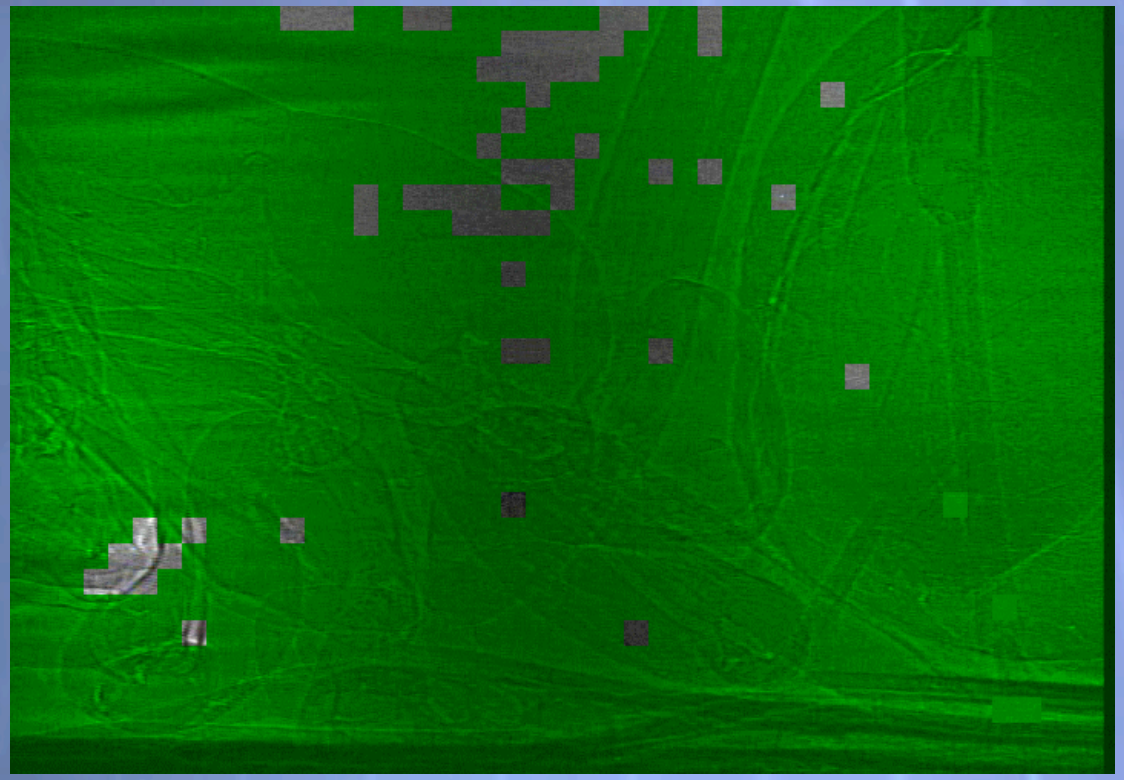
Crop Contractile Wave Frequency

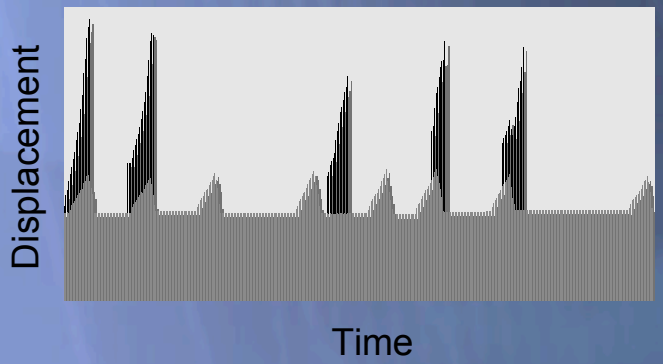




Frequency (N=8) = 0.532 waves/s
st. dev. = 0.101

Correlation of Crop Contractions and Bolus Ingress





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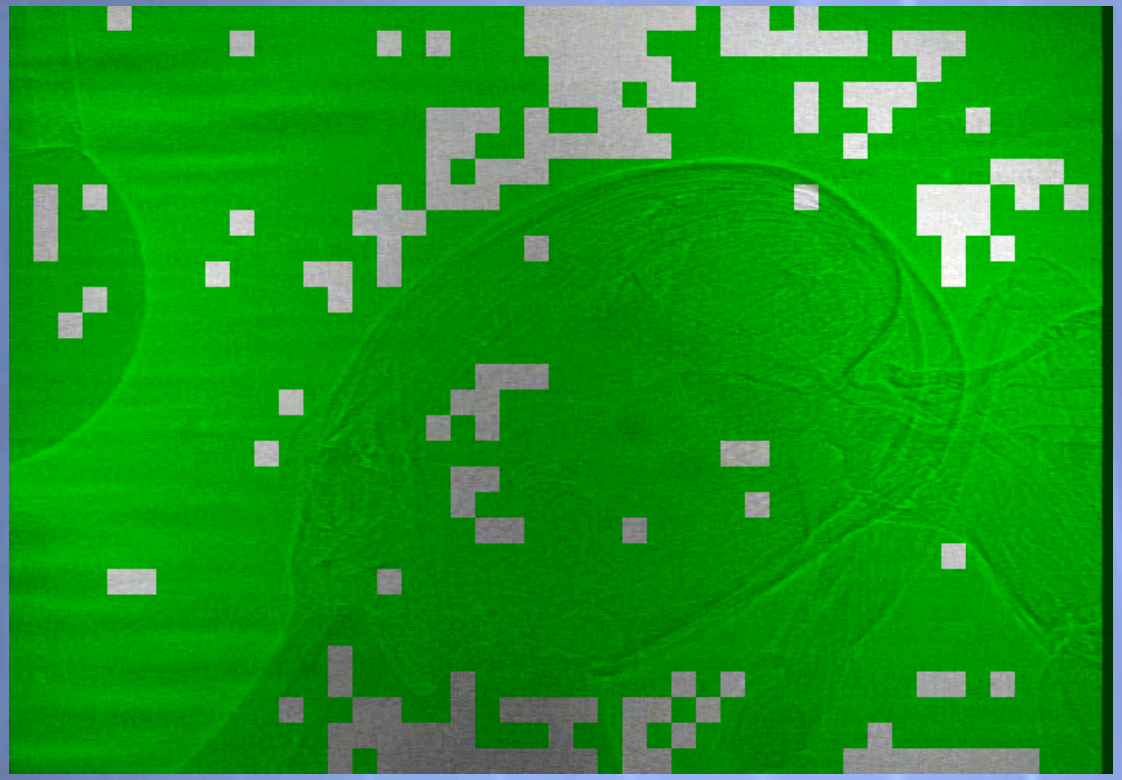
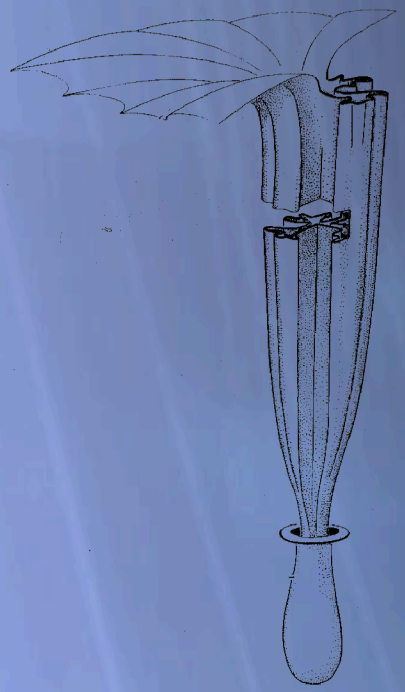
Pogonomyrmex





Additional Taxa

<u>Apomorphic</u>

Notoncus

Iridomyrmex

<u>Plesiomorphic</u>

Dolichoderus

Myrmicaria

Acknowledgements

- Chicago
  - APS/ANL
  - Kamel Fezzaa, Wah-Keat Lee, Jake Socha, Mark Westneat
  - Lis Nelis
- Utah
  - Denis Bramble, Dave Carrier, Dinah Davidson, Franz Goller, Ed King
  - NSF
  - GRF