Feeding and filtration rates in juvenile freshwater mussels

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Freshwater mussels: Search for resettlement habitats and evaluation of protection measures
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Missouri State University

Fulbright Commission

fba

What we're going to cover

- Previous filtration rate studies
- Research:
  - Mass-specific clearance rates
  - Gape limitation of particle ingestion
- Conclusions and future work

https://www.youtube.com/watch?v=1sidnCHMUoA

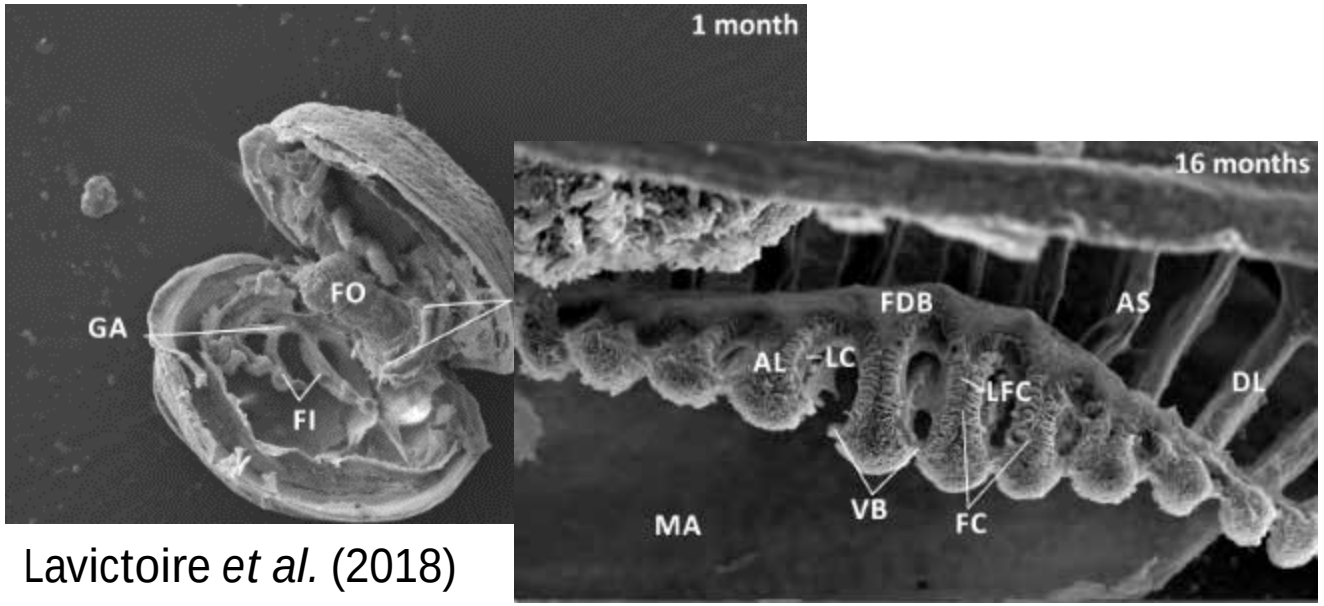
Context and previous filtration rate studies

Definitions

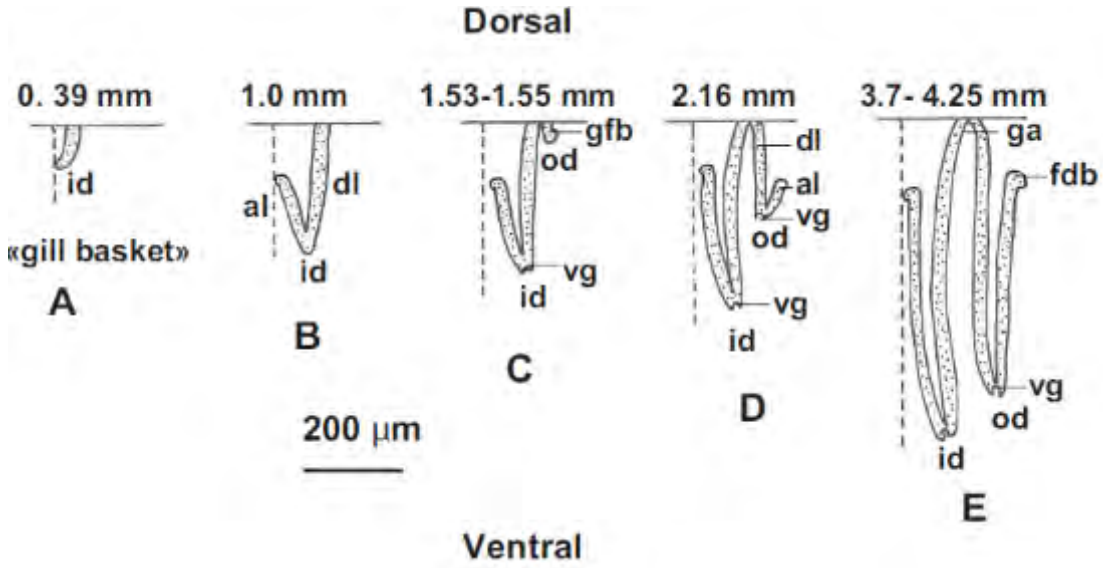
- Filtration rate = Particulate matter removed per unit time. FR = ingestion rate when all filtered material is ingested and no pseudofaeces are produced (Iglesias et al., 1998).
- Clearance rate = Volume of water filtered completely free of particles per unit time (e.g. cm^{-3} s^{-1}).
- Direct (difference between particle conc. water in ‘vs’ water out) or indirect (disappearance of particles from the surrounding water) methods of determining pumping rates (Famme, Riisgård, & Jørgensen, 1986).

Context and previous filtration rate studies

- Most previous studies measured CR/FR in either larger adult mussels or in groups (Barnes, 2006).
- From previous work on *M. margaritifera* we know that juveniles begin to undego major gill transformation at ~1.1 mm (Lavictoire et al., 2018).



Lavictoire *et al.* (2018)



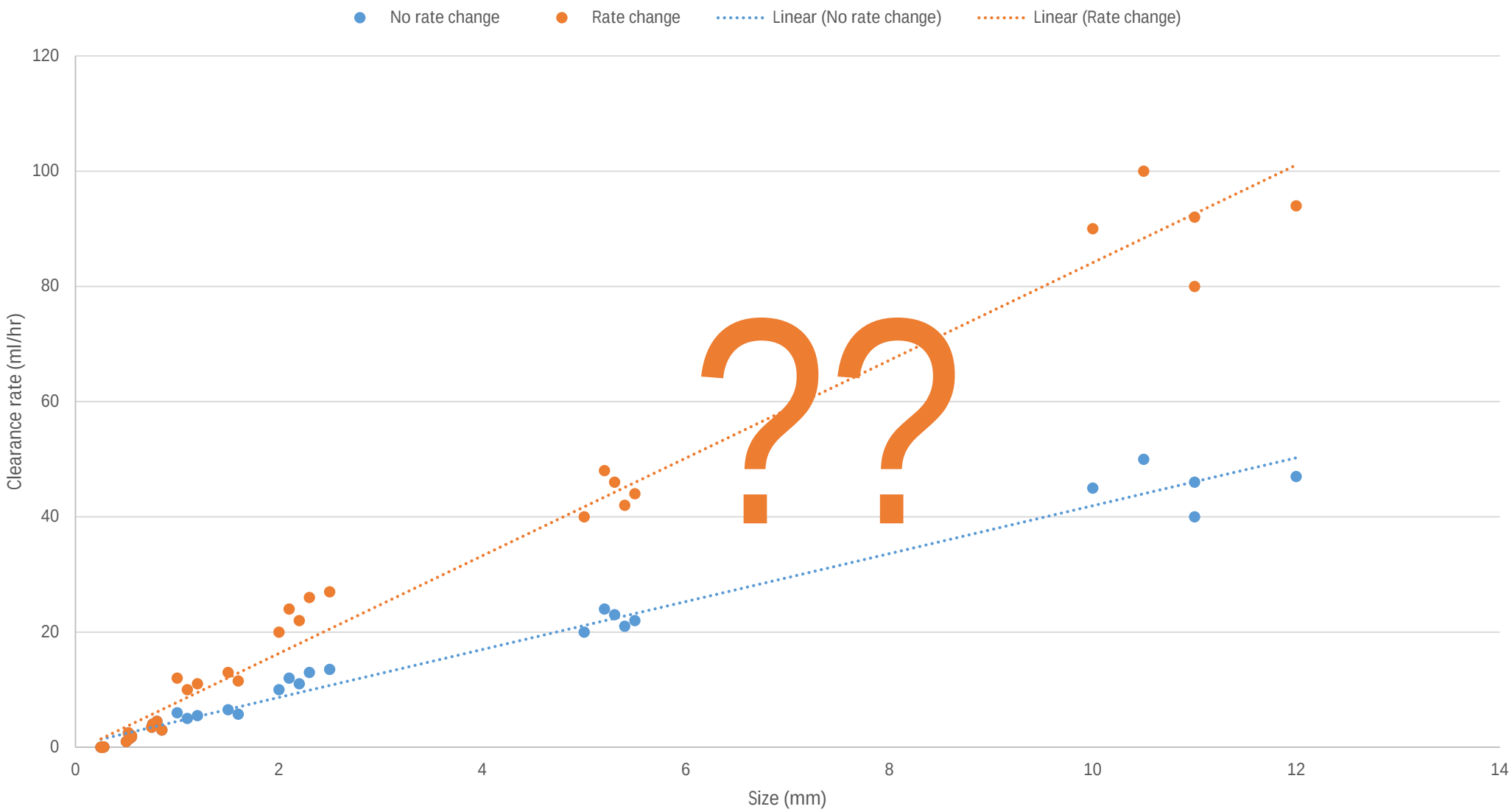
Cannuel *et al.* (2009)

Research questions

1. **Is there is a difference in standardised (per g dry mass) feeding rate in pedal feeding ‘vs’ filter feeding juveniles? Do filter-feeding juveniles have the advantage of faster growth? Is this why we see such a large size range within cohorts?**

- Allometry (or scaling) is a general observation in biology where the mass-specific metabolic rate scales with $mass^{-0.25}$
- Metabolism requires food so we observe feeding rates scale with metabolism
- Smaller juveniles have a higher metabolism and so have exponentially higher rate processes.
- Does this rate change when juveniles are undergoing gill transformation?

Research questions





Research questions

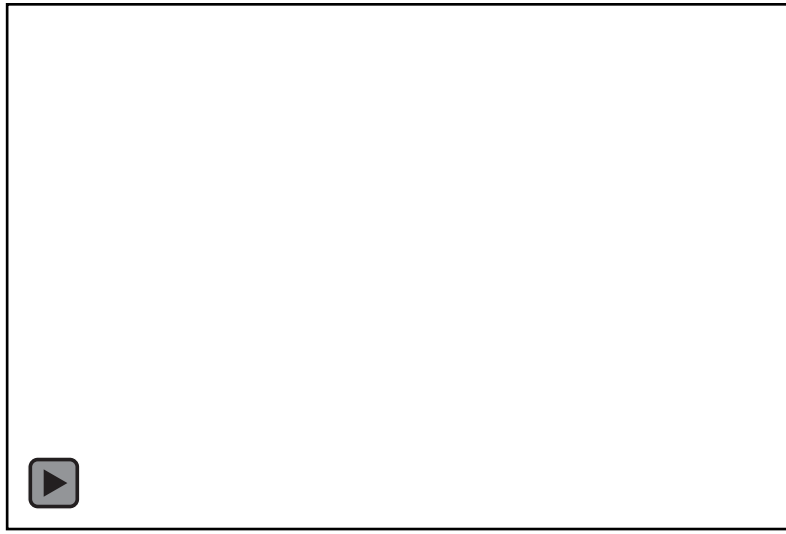
2. **What size particles can the smallest juvenile mussels consume (i.e. what is their gape limitation?). Four species:**
   - *Lampsilis siliquoidea*
   - *Anodonta californiensis*
   - *Alasmidonta viridis*
   - *Margaritifera marrianae*



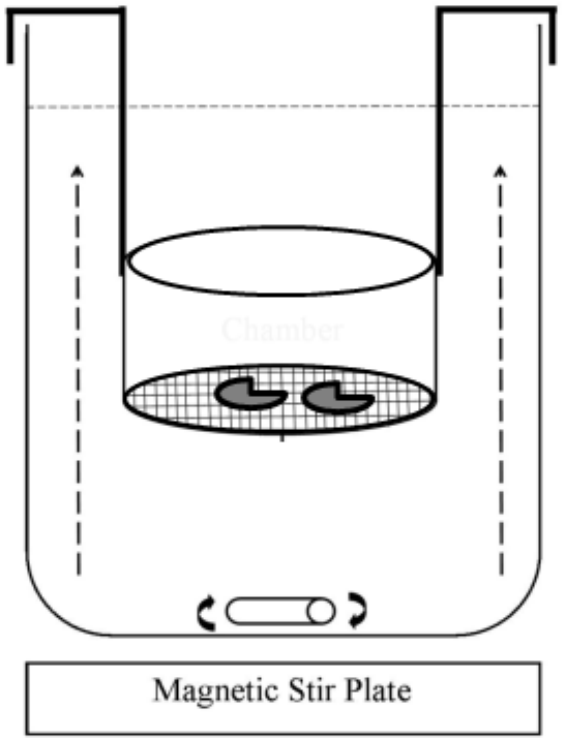
Method

- Measuring CR is difficult for small juvenile mussels:
  - Use very small feeding volumes (attempted),
  - Use groups of individuals in slightly larger feeding volumes (deriving mean rates, not individual)
  - Measure ingestion rate rather than CR, of individuals

- Developed a method for measuring feeding rates of individual juveniles (*Lampsilis siliquoidea*, fatmucket) from excystment (250 µm) using fluorescent microbeads



Method



- Mussels rest on screen, while water with algae and beads is circulated by stir bar
- 6 µm fluorescent microbeads (green)
- 10 µm fluorescent microbeads for gape limitation experiment (red)

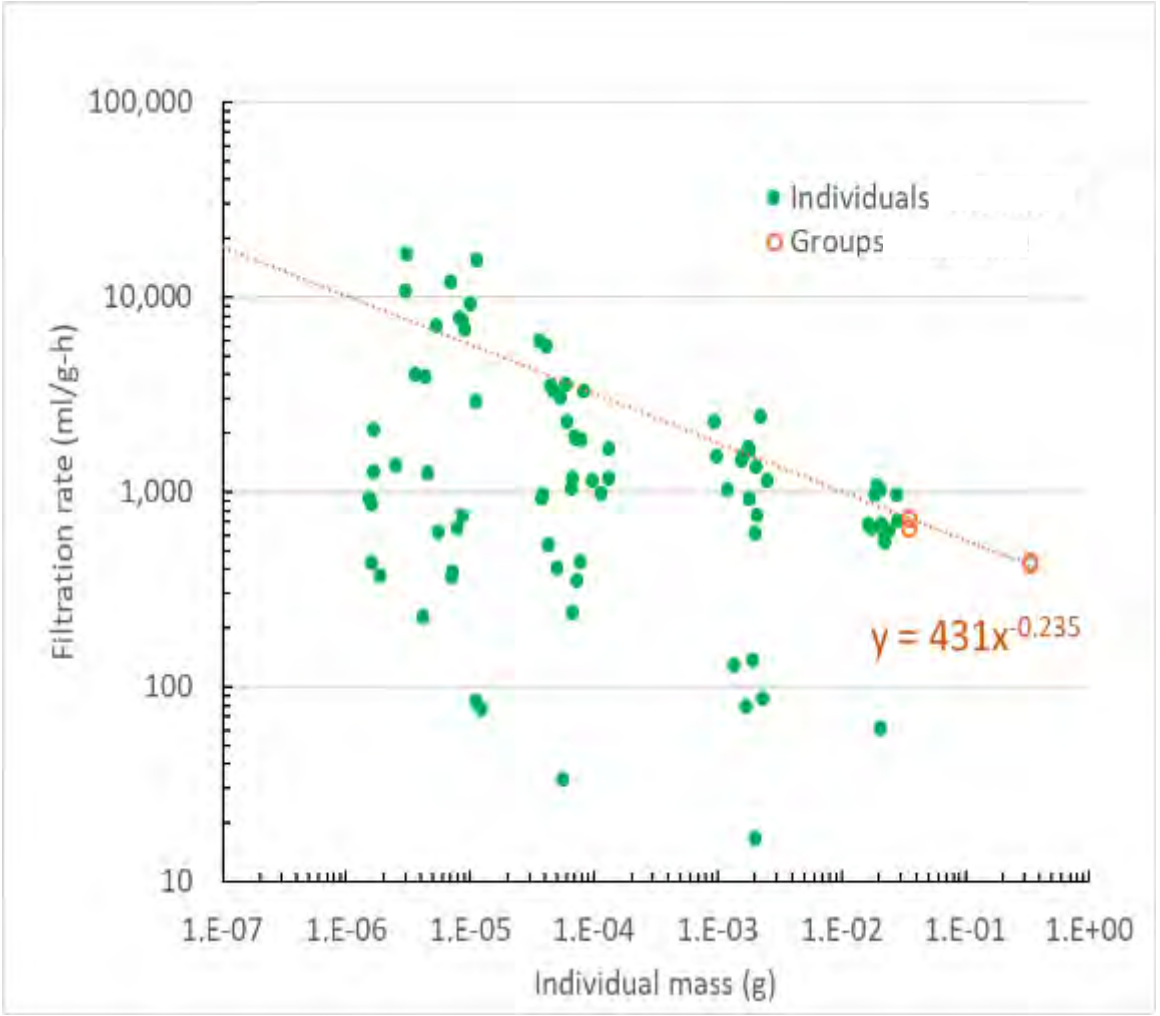


Method

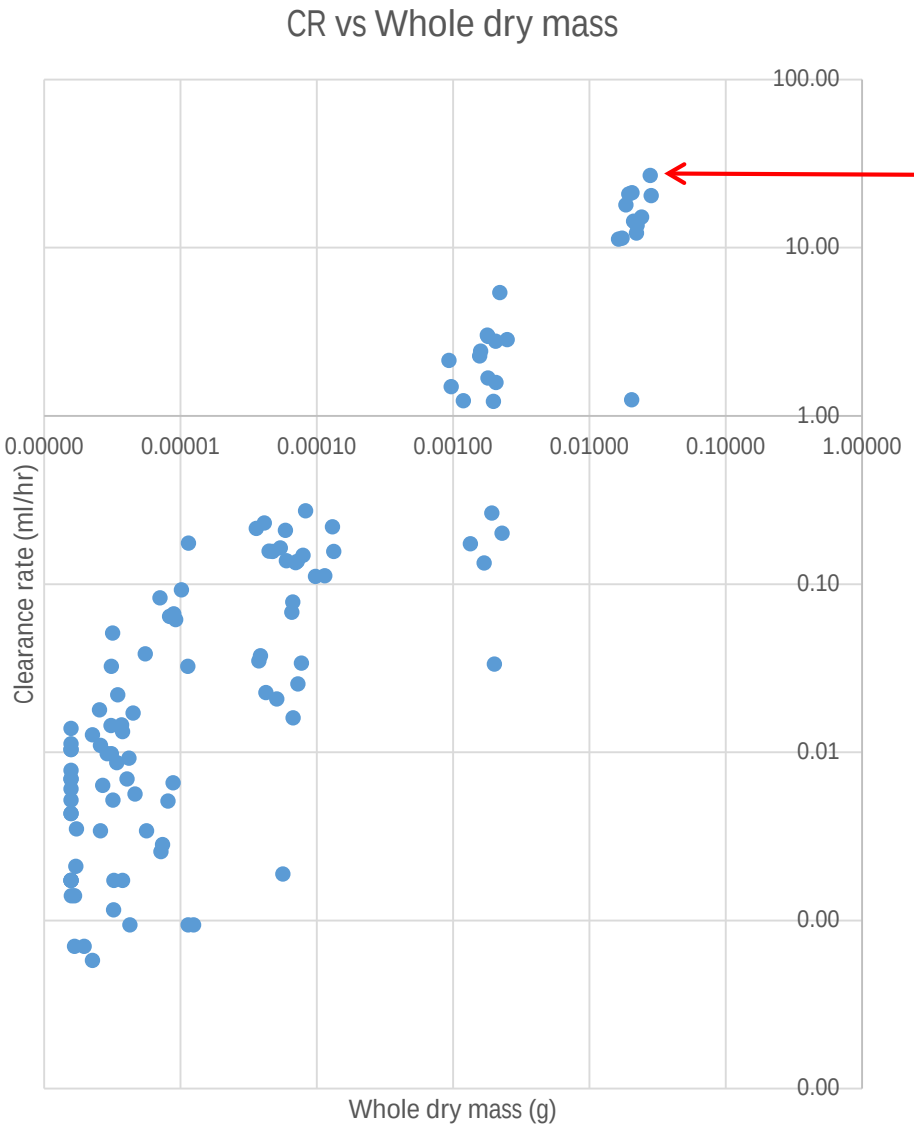
- Juveniles added to system the afternoon before the experiment
- Test period (15-60 minutes) began when fluorescent beads were added to the beaker, and ended when the mussels were removed from the system and rinsed.
- Mussels were placed into digestion media (Alka Det-2) to dissolve tissues and recover any captured beads.
- Counted the captured beads, converted to particles ingested/hr and equivalent filtration rate
- Water samples were also taken at t = 3 mins and t = end for particle analysis – if we know the bead concentration we can calculate CR

Results – mass-specific FR/CR

- **Is there is a difference in standardised (per g dry mass) filtration rate in pedal feeding 'vs' filter feeding juveniles?**
- Allometry predicts exponentially higher rate processes in smaller individuals.
- Mass-specific metabolic rates of organisms are typically proportional to mass$^{-0.25}$.
- Filtration rate of juvenile mussels scaled with mass$^{-0.235}$.
- Clearance rates of smallest juveniles were approximately 8 litres per gram whole dry mass per hour



Results



Highest CR = 27 ml hr^{-1}
FR = 33,800 beads hr^{-1}
(7.8 mm juvenile)

Results – proportion of juveniles feeding

- Juveniles were classed as having fed, if CR was > 0.01 ml/hr (~20 particles/hr)

Shell length	% fed	Min CR (ml/hr)	Max CR (ml/hr)
<1mm	33	0.00058	0.136
1 – 7.8 mm	100	0.11101	26.80

- Two thirds of smaller juveniles didn't feed at all during the measurement periods. Is this intermittent feeding or a reason for high post-excystment mortality?
- Highlights importance of doing individual measurements vs means

Results – gape limitation

- All species of newly excysted juveniles ingested both 6 and 10 µm particles
- Previous work with 1 cm juvenile *L. siliquoidea* found that they were unable to ingest 20 µm beads (J. Duzan, unpublished)
- Knowledge of size-limitation of particle ingestion is important for culture programmes using ‘natural’ or commercial diets



Conclusions and future work

- Working with individuals provides the best data resolution.
- So far it appears that a similar relationship of size and filtration rate is maintained over the whole range of body size, despite morphological transitions in the gills.
- These observations suggest that juveniles are able to suspension-feed throughout development; ‘Interstitial suspension feeding’ may be more descriptive than pedal feeding
- High clearance rates might allow intermittent feeding.
- All mussel species could consume 10 µm beads but may not be able to consume 20 µm beads – further work.

Acknowledgements and references

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Reintroductions review

- Call for information
- Sign- up sheet next to Lavictoire *et al*. poster

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Call for Information – Mussel Reintroduction, Augmentation, and Translocation Techniques

The FMCS Propagation and Restoration Committee is completing an updated review of mussel reintroduction/translocation techniques, including techniques associated with post-release monitoring. The last large-scale review of these techniques was carried out in 1995 by Greg Cope and Diane Waller, so it's time for an update! We would like YOUR help to make sure this review is as comprehensive as possible. We are interested in any results, reports, papers, observations, or protocols -- including negative results -- that describe how releases have been made. We are also interested in reviewing which techniques are currently in use and their relative success or failure, post-release monitoring evaluation, and any other related information.

In order to standardize responses and aid in the analysis, we have produced a spreadsheet to facilitate data collection. Please email Louise Lavictoire (llavictoire@fba.org.uk) to receive the spreadsheet and to share any electronic reports and papers. We look forward to hearing from you!



Margaritifera margaritifera released in the River Irt in Cumbria, United Kingdom.

Any questions?



