



Diverse nutritional strategies mediate early life thermal responses in reef-building corals in Moorea

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Seasonal plasticity of symbiotic strategies clarifies coral holobiont resistance and resilience

 Ariana S. Huffmyer, Emma L. Strand, Serena Hackerott, Kevin H. Wong,  Danielle M. Becker,  Dennis Conetta,  Kristina X. Terpis,  Ferdinand Pfab,  Juliet M. Wong, Zoe Dellaert, Francis J. Oliaro, Ross Cunning, Jose M. Eirin-Lopez, Steven B. Roberts, Roger M. Nisbet, Hollie M Putnam

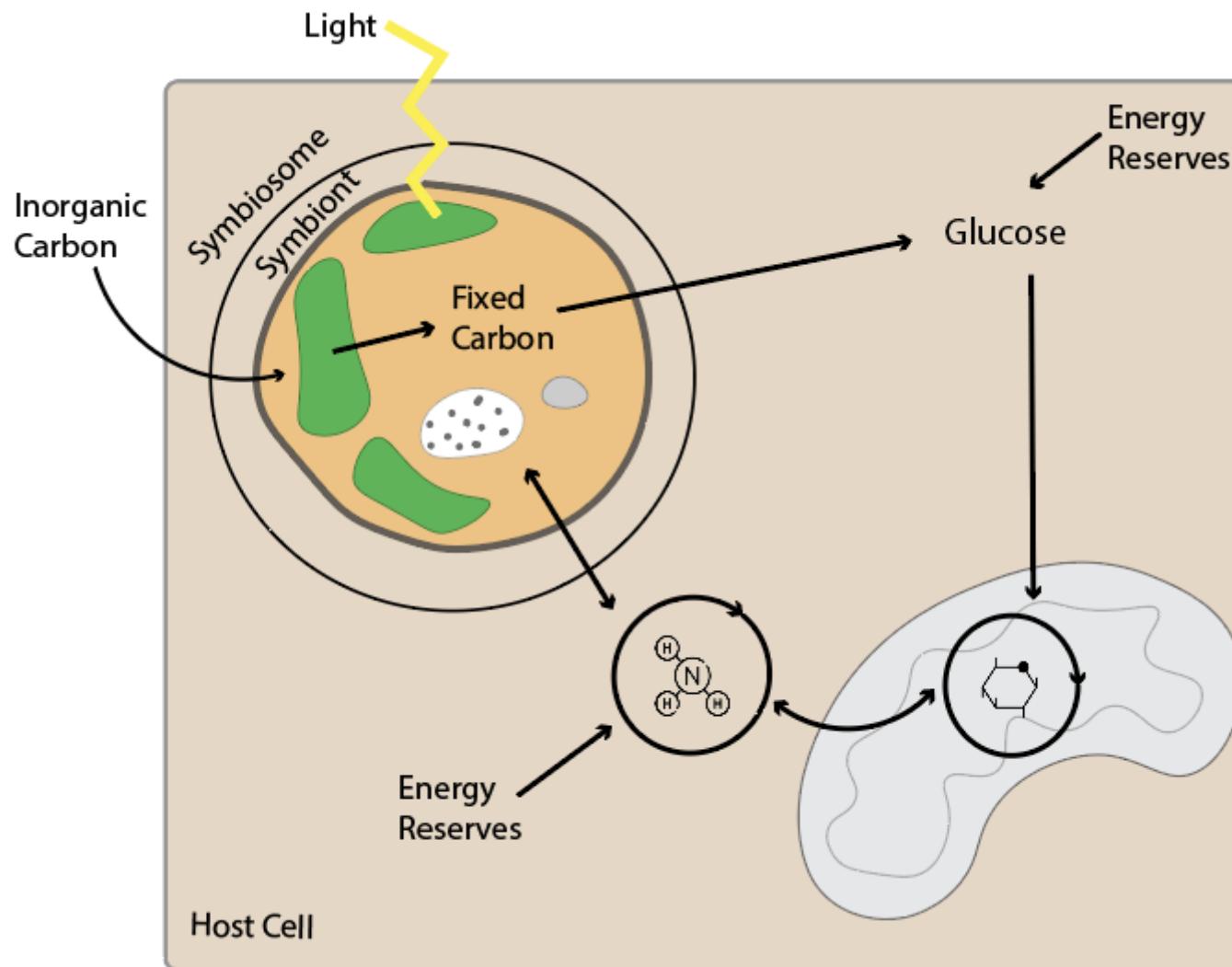
doi: <https://doi.org/10.1101/2025.11.20.689604>



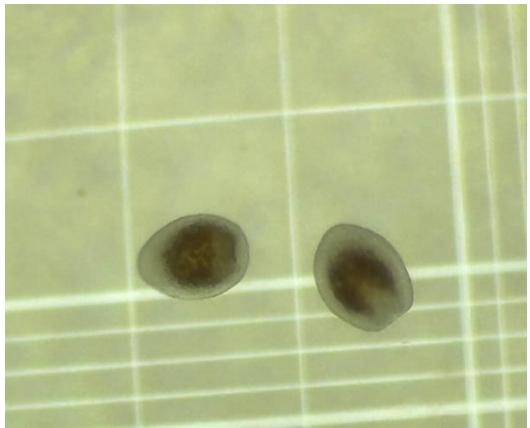
How does symbiotic nutritional strategy shift across life stages?

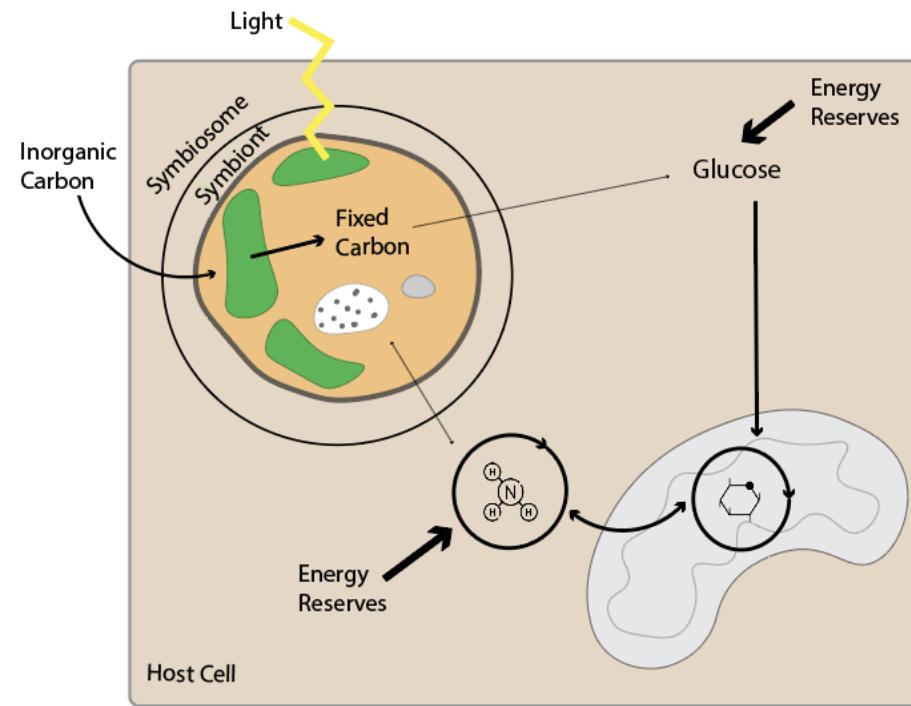


How does symbiotic nutritional strategy shift across life stages?



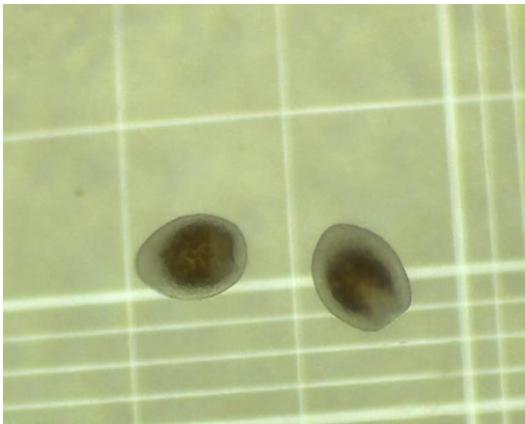
Development & Ontogeny

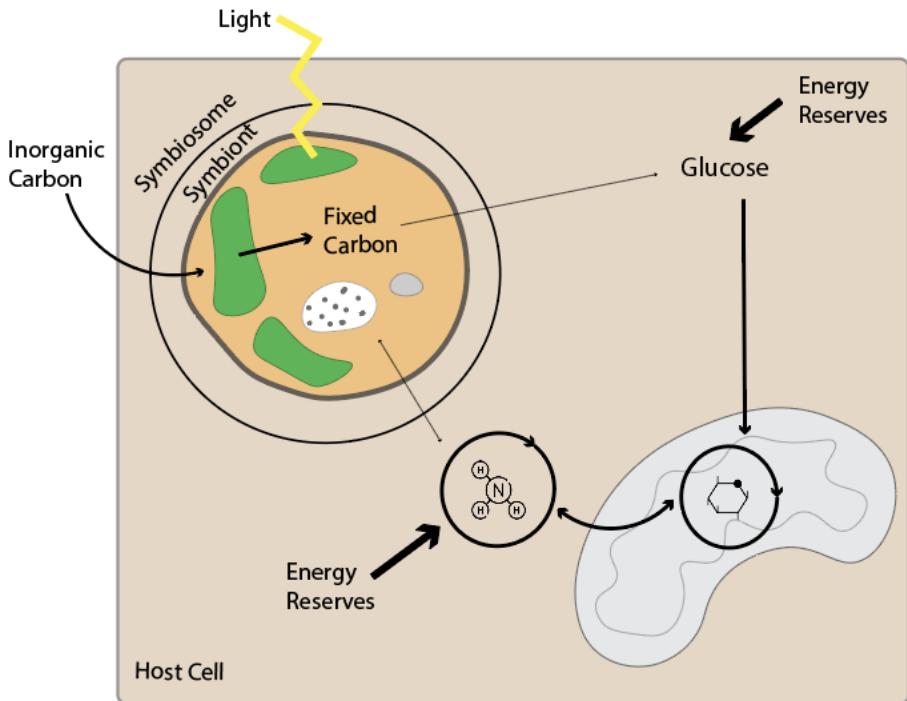




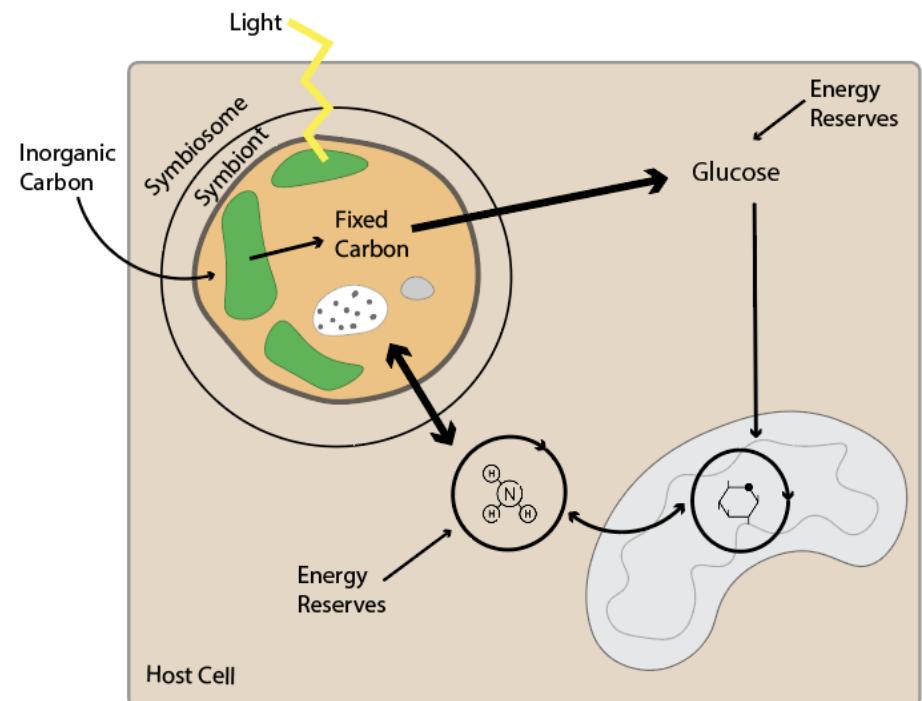
Reliance on reserves

Development & Ontogeny



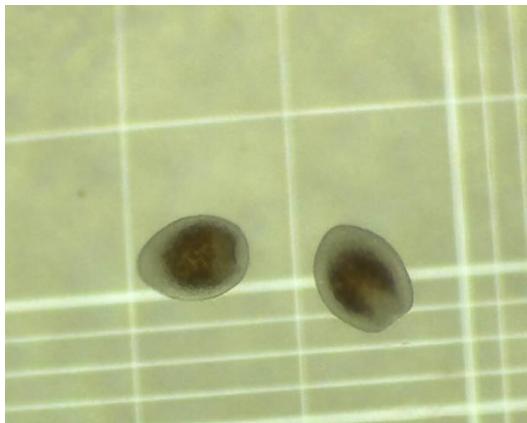


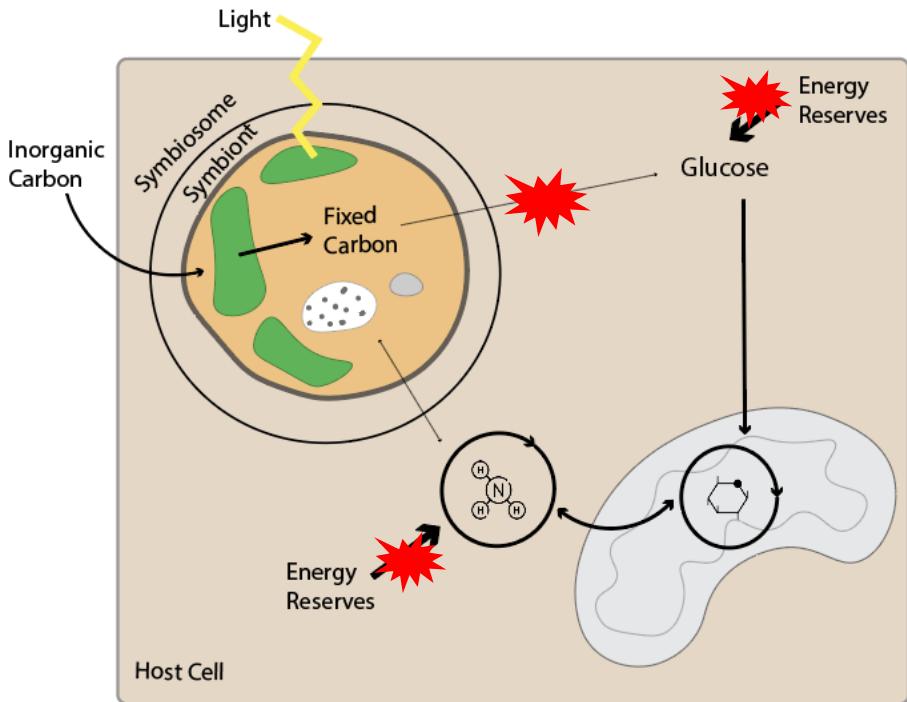
Reliance on reserves



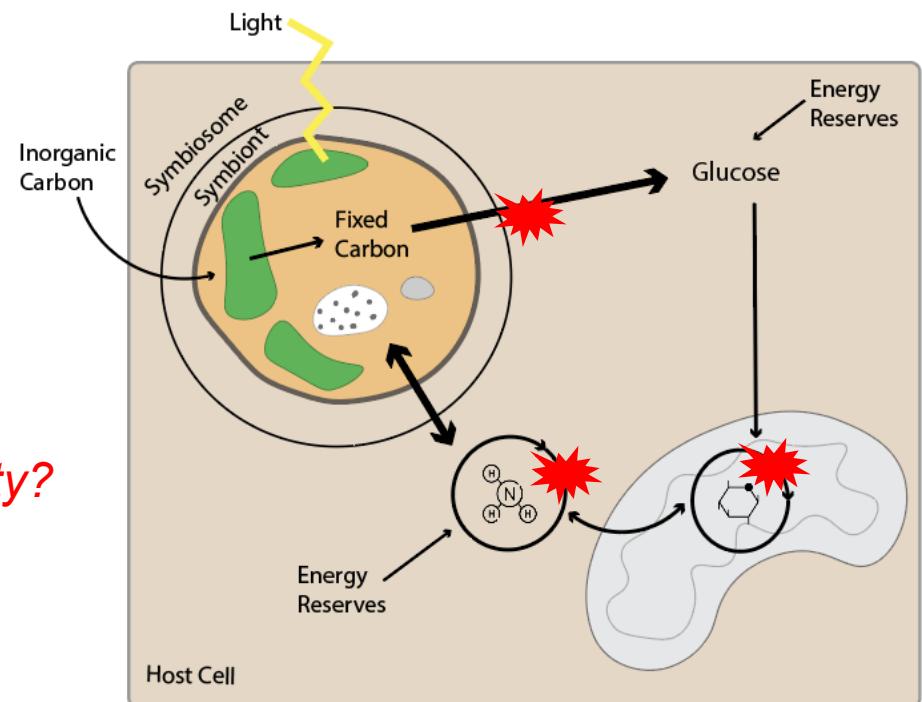
Established nutritional exchange

Development & Ontogeny



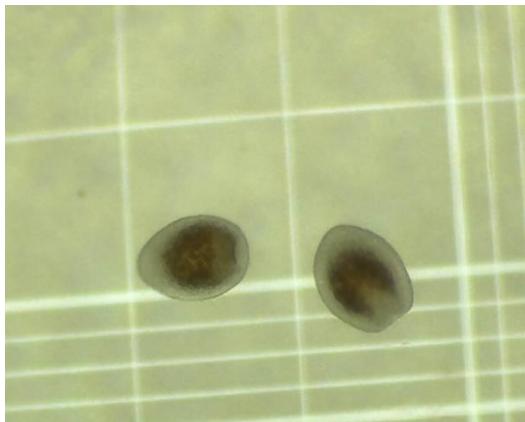


Reliance on reserves



Established nutritional exchange

Development & Ontogeny

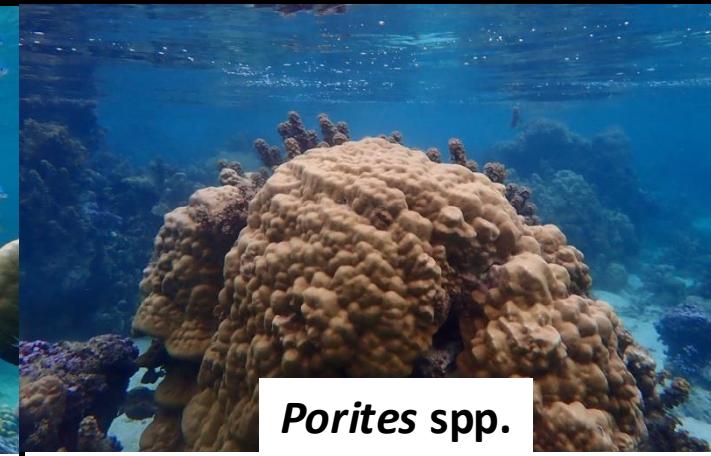




Acropora spp.



Pocillopora spp.



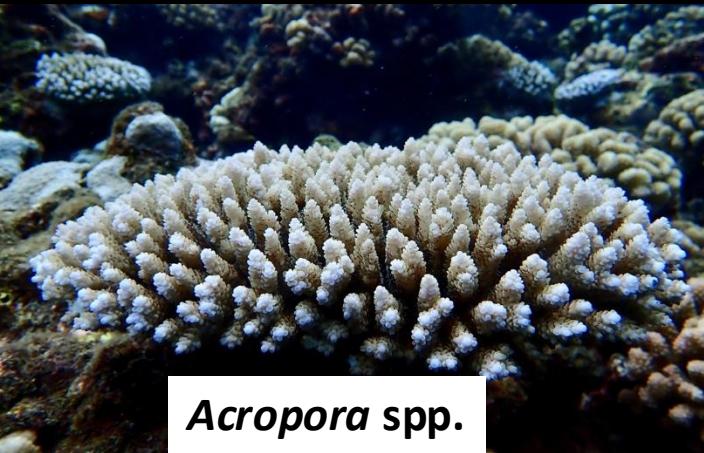
Porites spp.

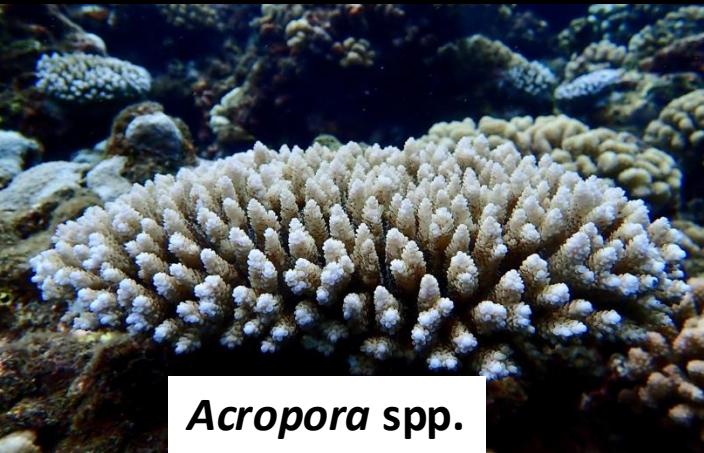
*Life stages
tested*

Adult, recruit, larvae

Adult, recruit, larvae

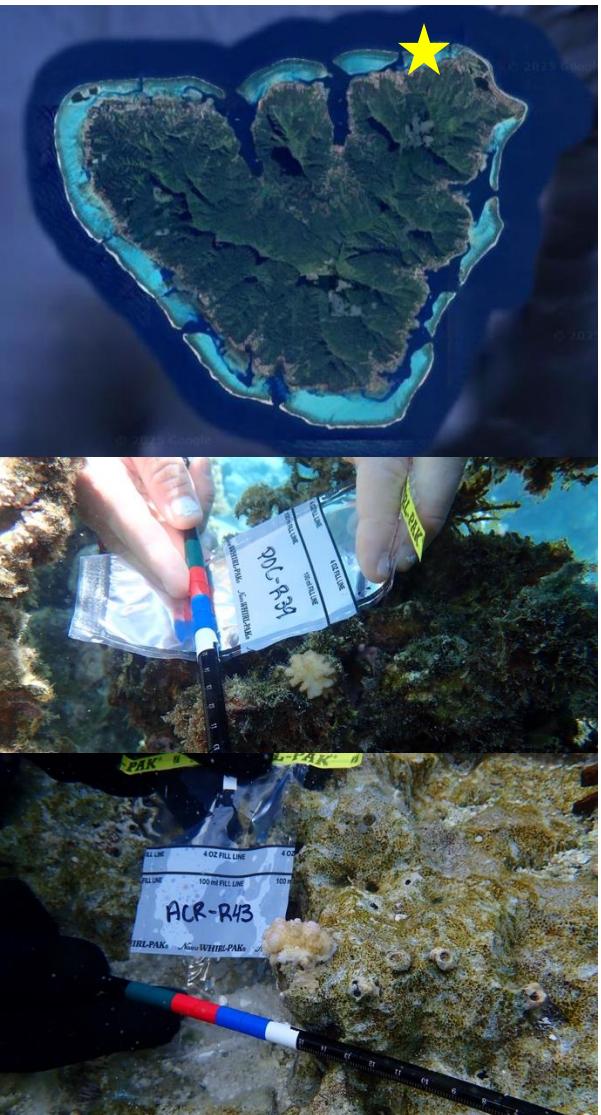
Adult, recruit

			
Life stages tested	Adult, recruit, larvae	Adult, recruit, larvae	Adult, recruit
Transmission	Horizontal	Vertical	Vertical
Symbionts	<i>Symbiodinium</i> & <i>Durusdinium</i>	<i>Cladocopium</i> & <i>Durusdinium</i>	High fidelity <i>Cladocopium</i> (C15)
Reproduction	<i>Broadcast spawning</i>	<i>Broadcast spawning</i>	<i>Broadcast spawning</i>

			
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How does nutritional strategy mediate thermal stress responses across life stages?

Adults & recruit
(< 5 cm) collections

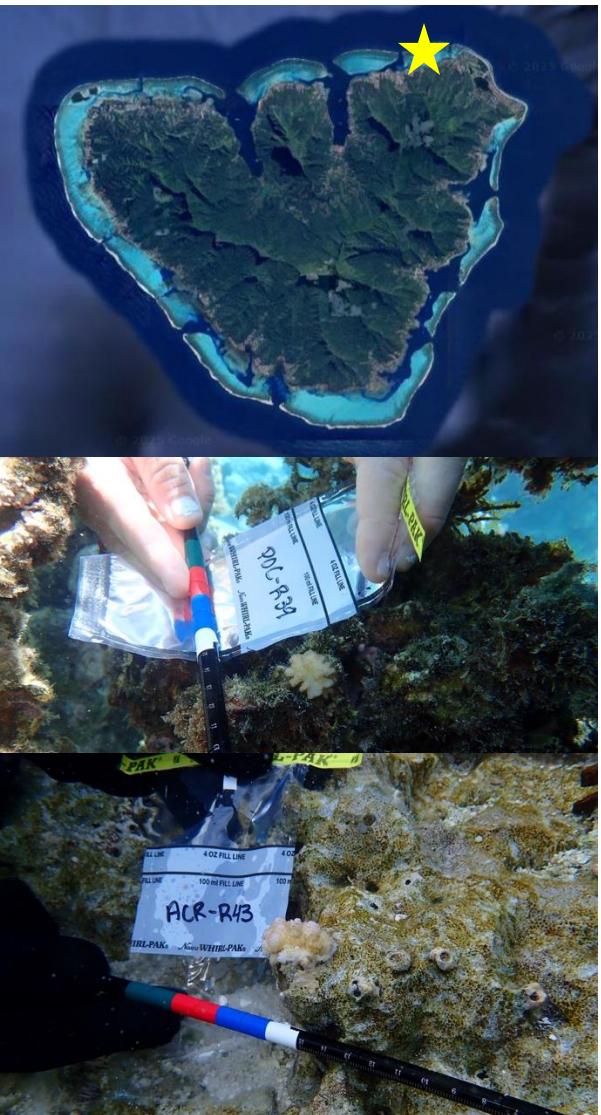


Spawning & larval
rearing

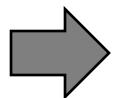


How does nutritional strategy mediate thermal stress responses across life stages?

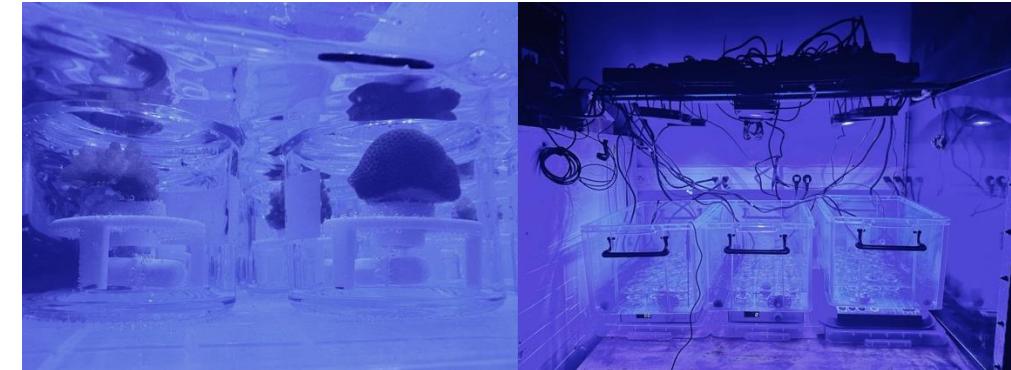
Adults & recruit
(< 5 cm) collections



Spawning & larval
rearing



Nutritional exchange under thermal stress
 27°C , 30°C , 33°C (4 h)



Stable isotope ^{13}C tracing metabolomics



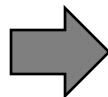
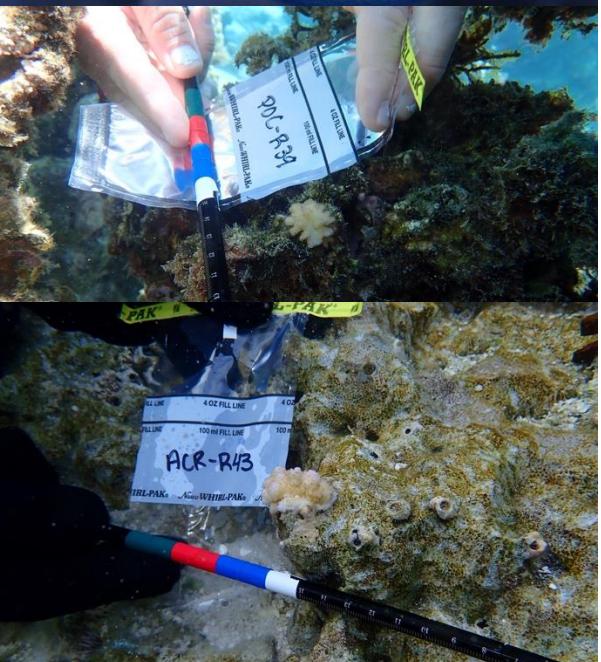
Acropora hyacinthus recruits
Pocillopora meandrina recruits
Pocillopora meandrina larvae

How does nutritional strategy mediate thermal stress responses across life stages?

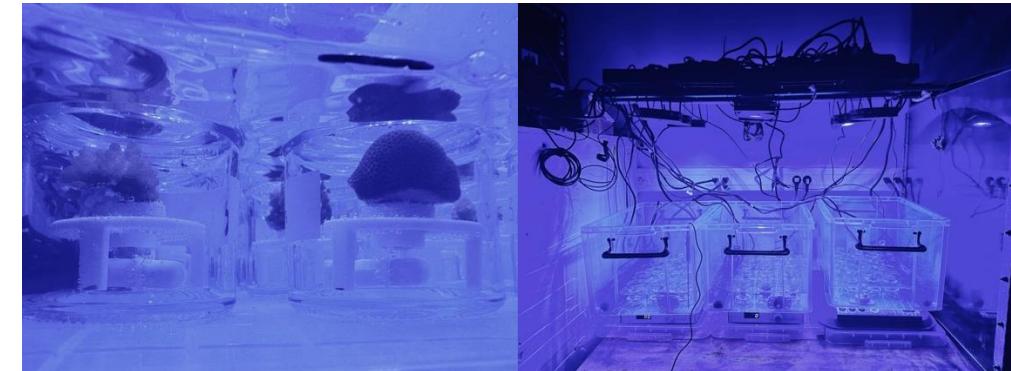
Adults & recruit
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Spawning & larval
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Nutritional exchange under thermal stress
 27°C , 30°C , 33°C (4 h)

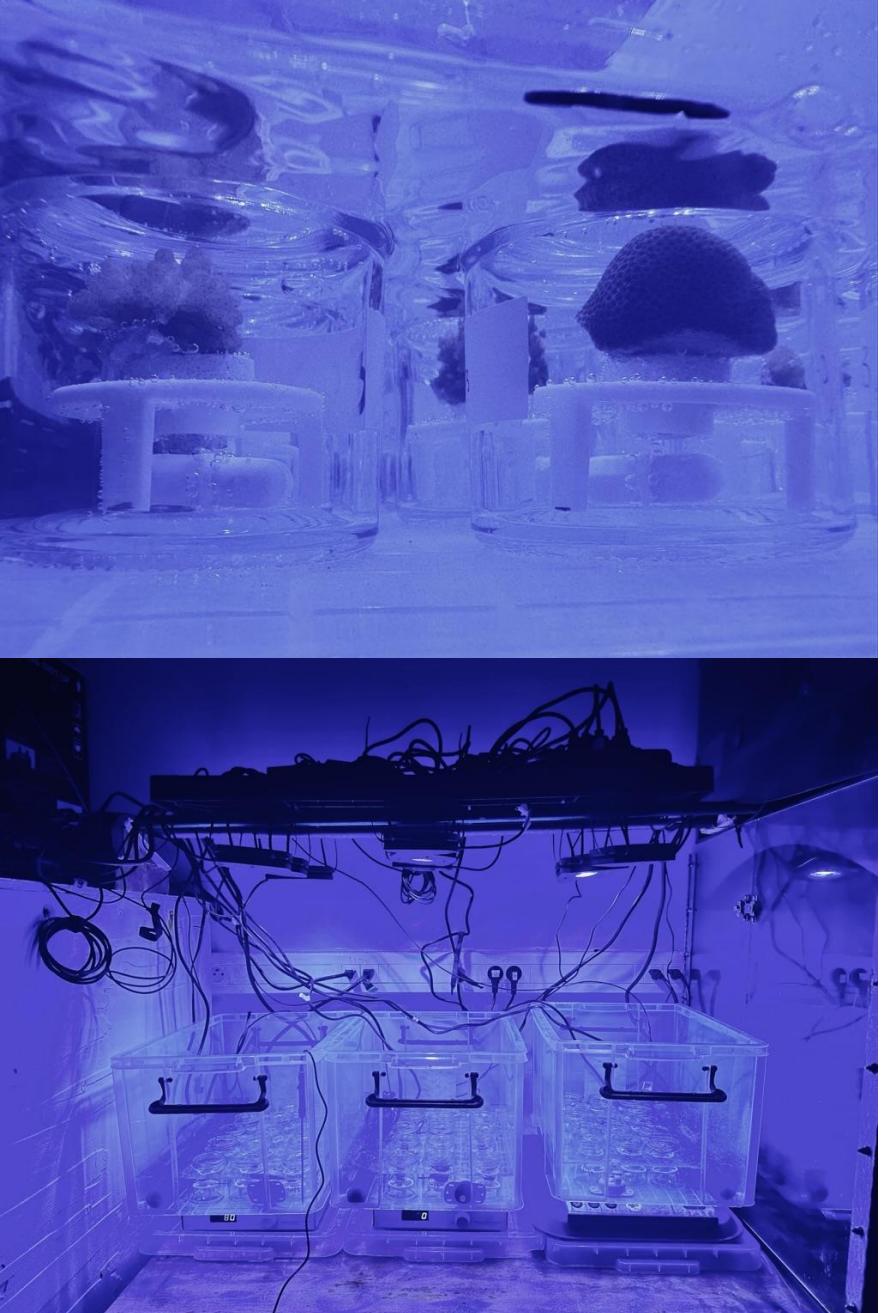


Stable isotope ^{13}C tracing metabolomics

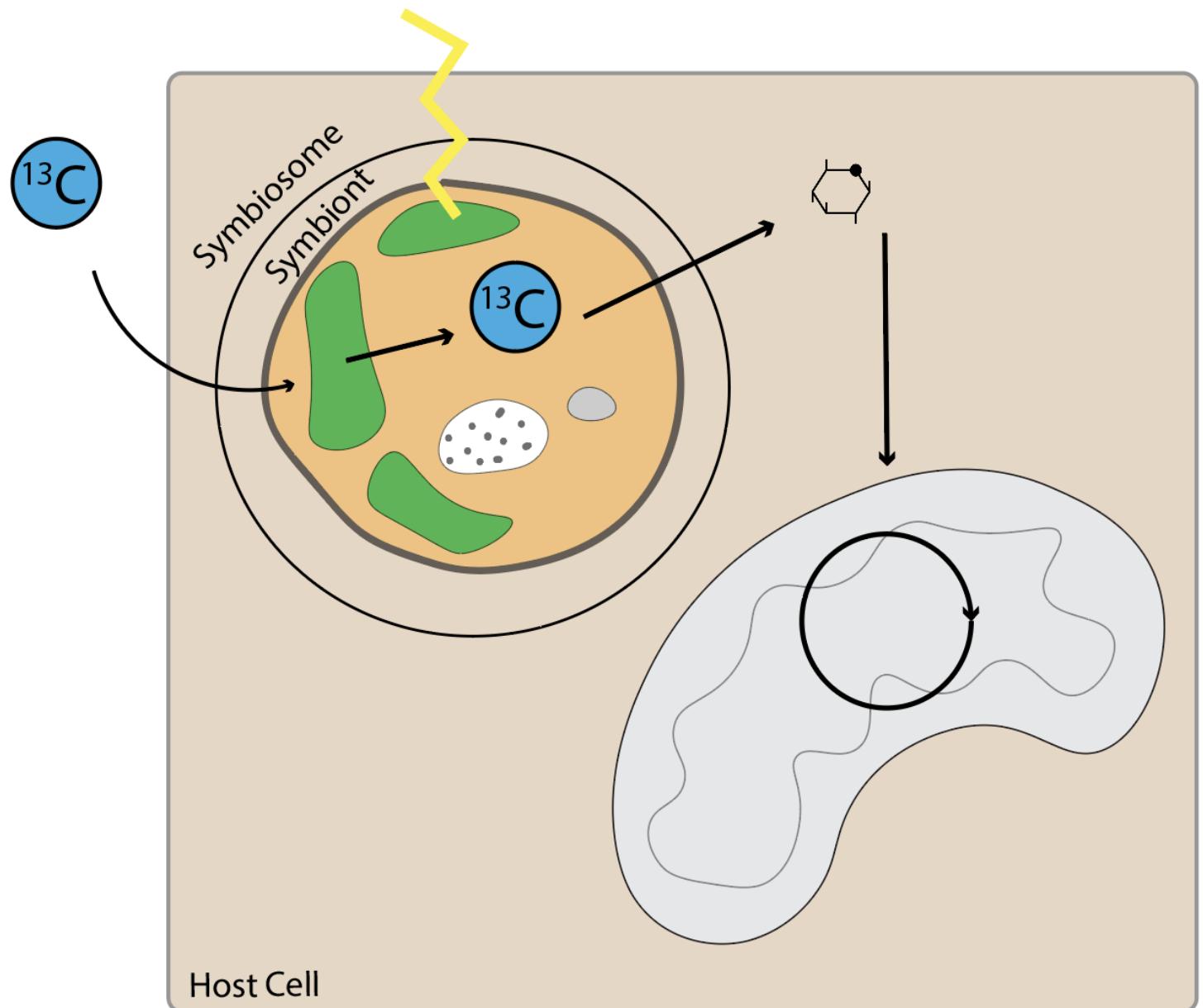


Acropora hyacinthus recruits
Pocillopora meandrina recruits
Pocillopora meandrina larvae

Additional datasets
DNA species identification
Symbiont ITS2 profiling
RNAseq
Respirometry
Physiology

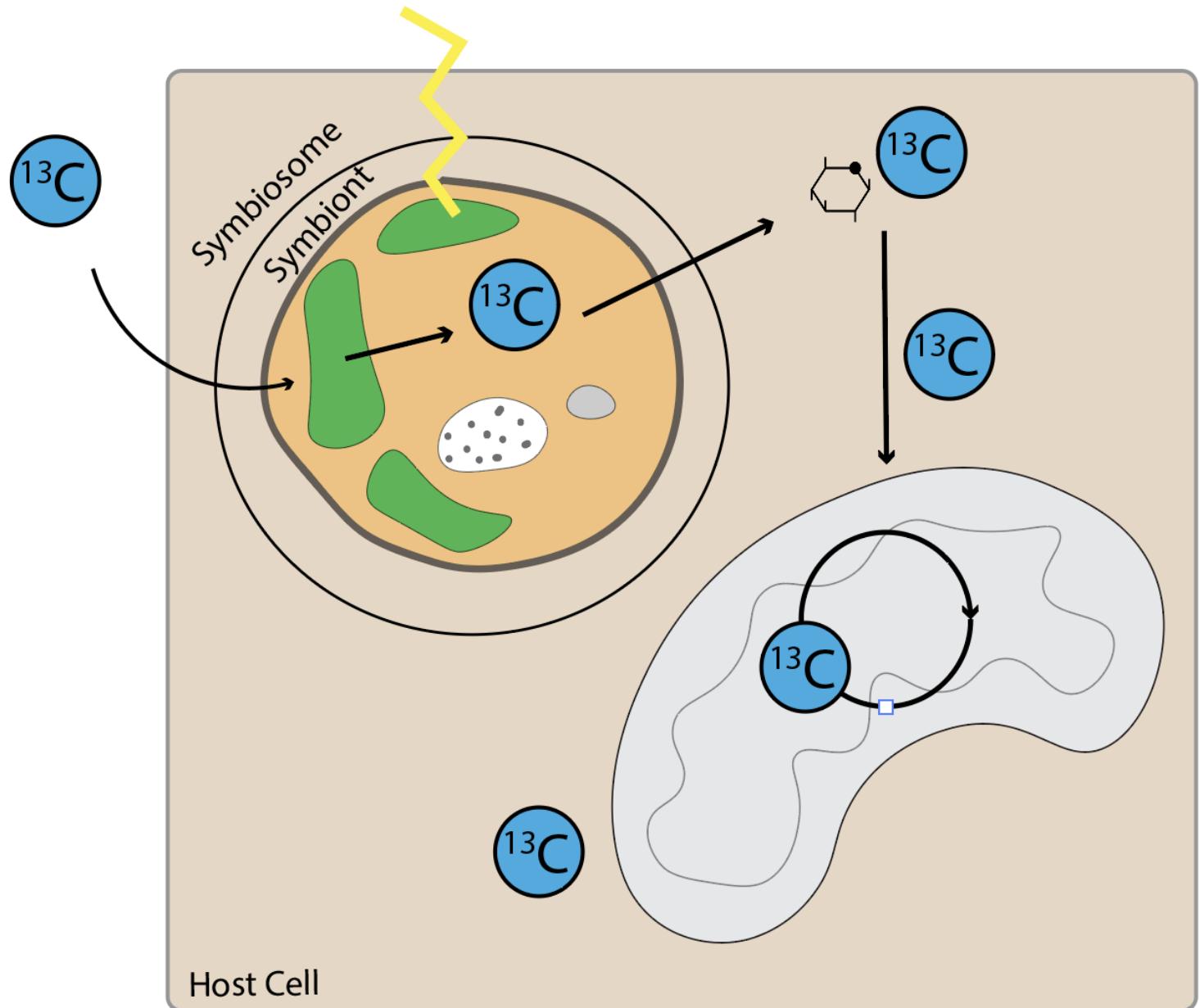


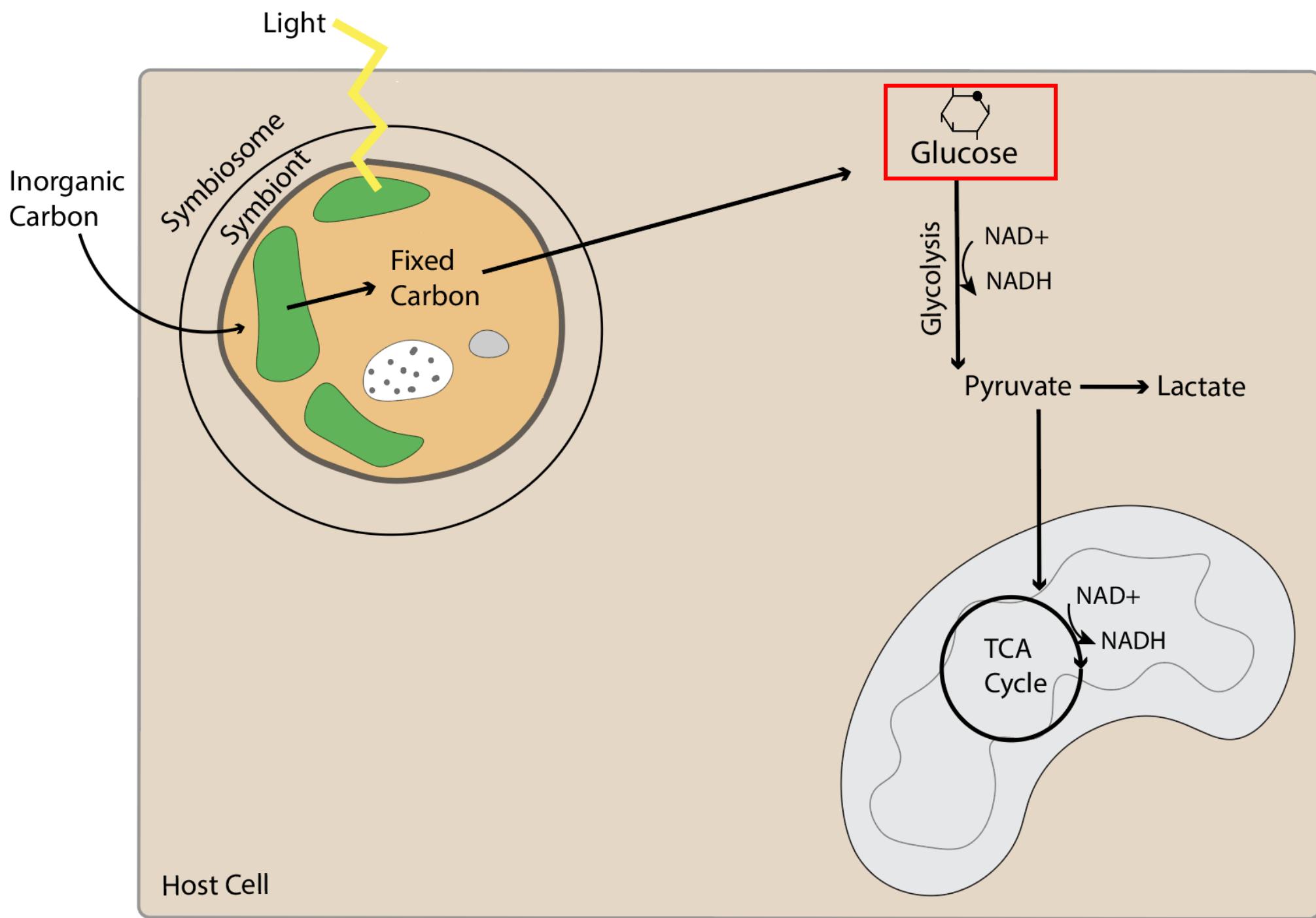
4 mM ^{13}C bicarbonate
27, 30, 33°C (4 h)

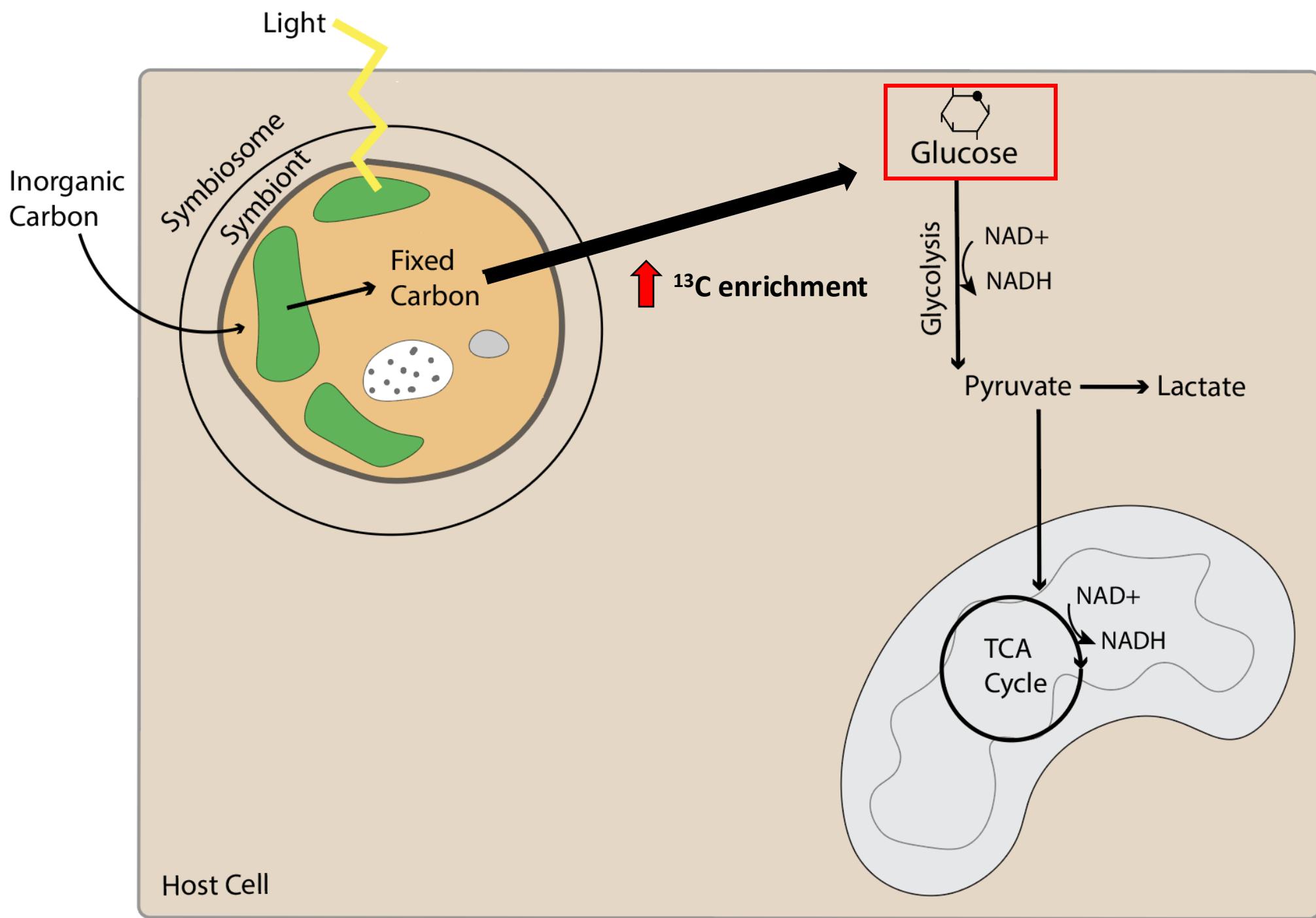


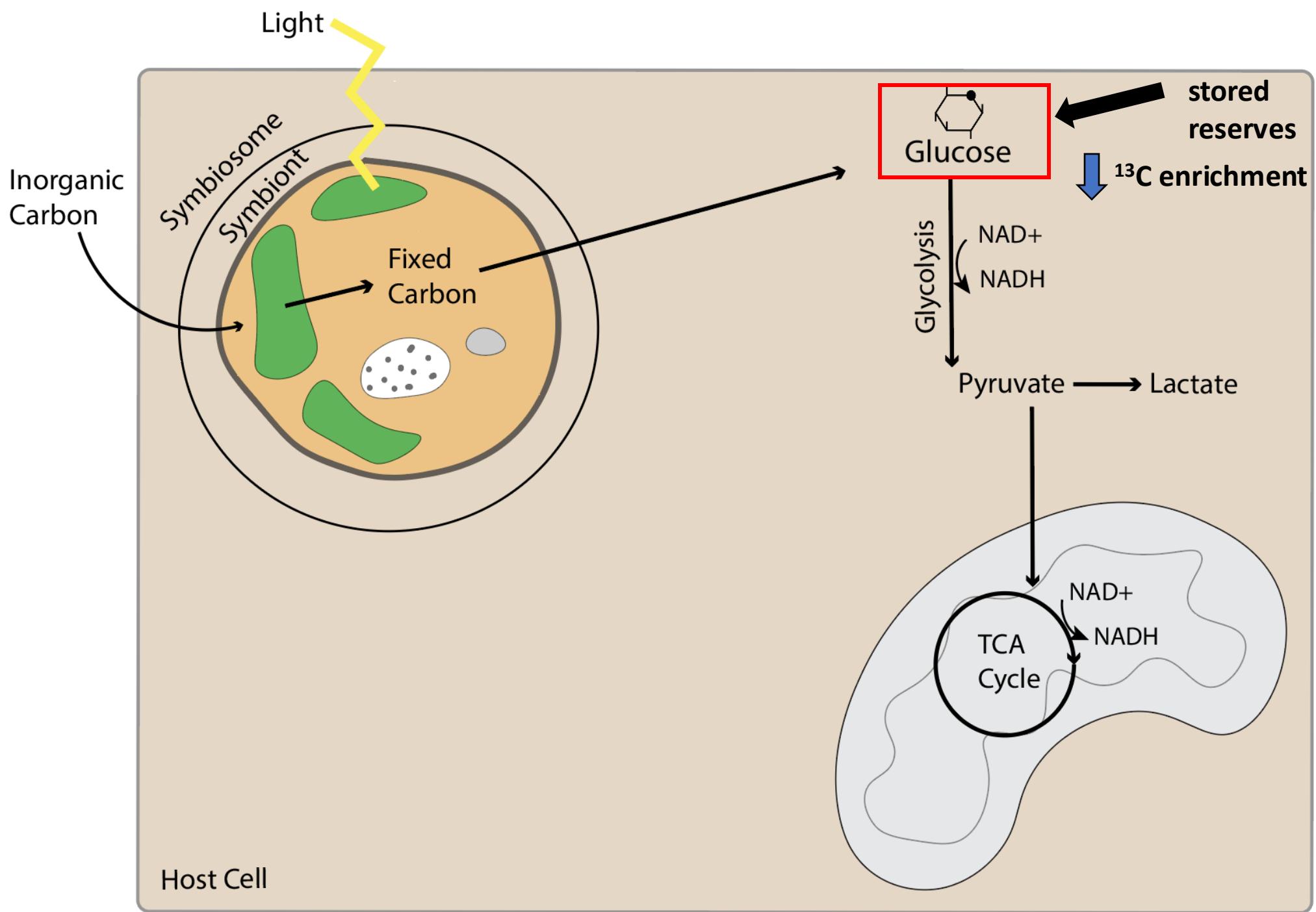


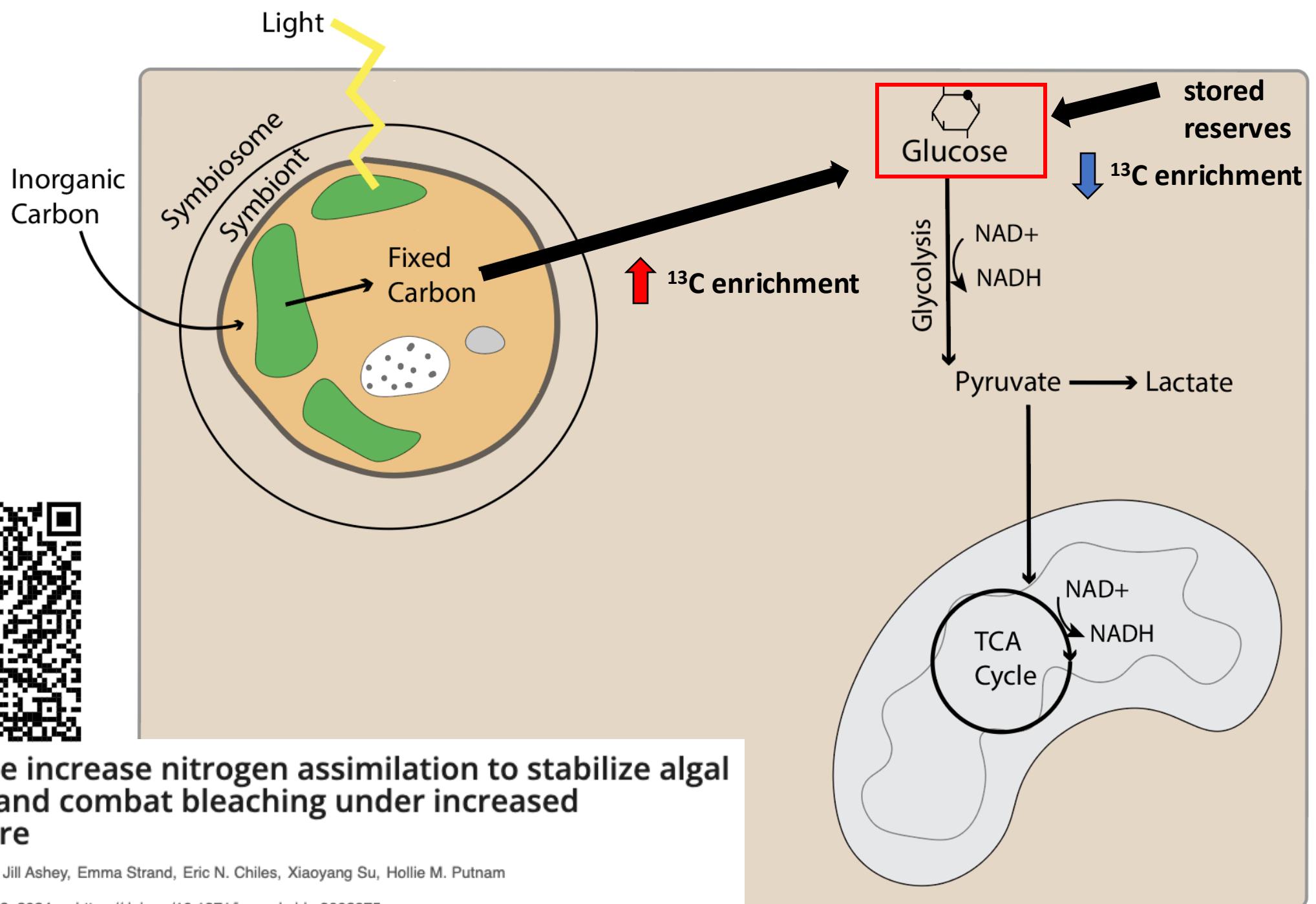
4 mM ^{13}C bicarbonate
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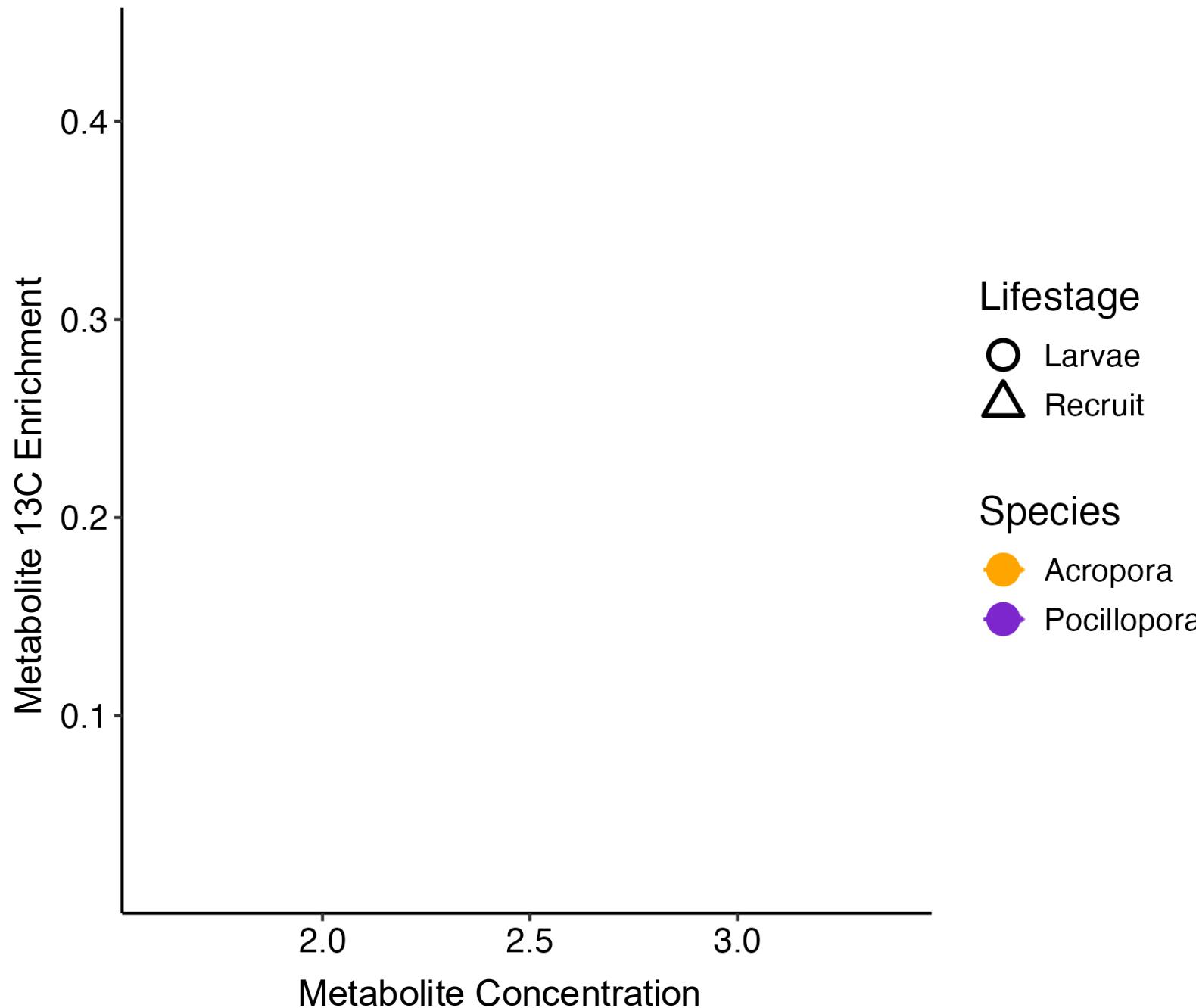


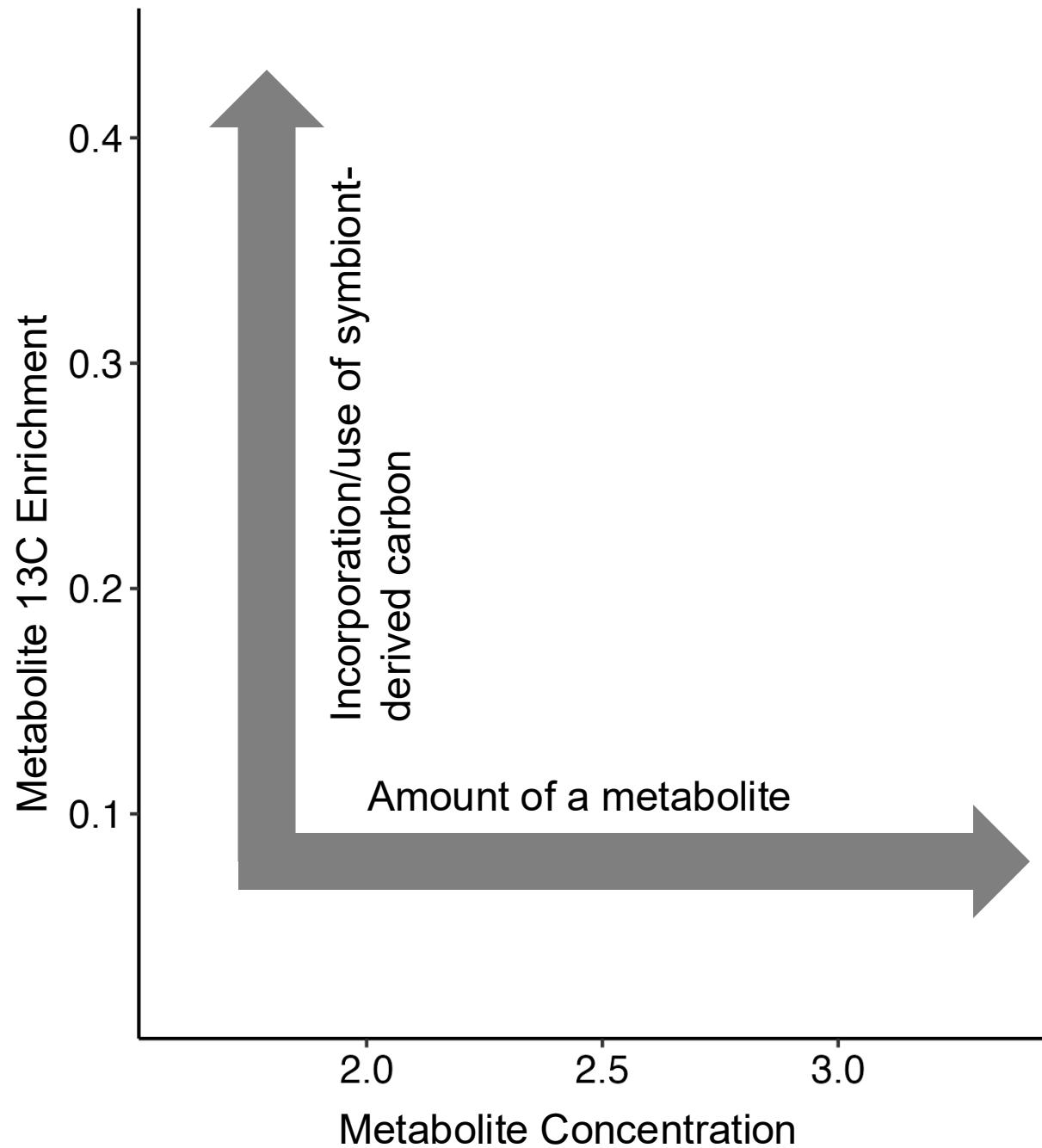


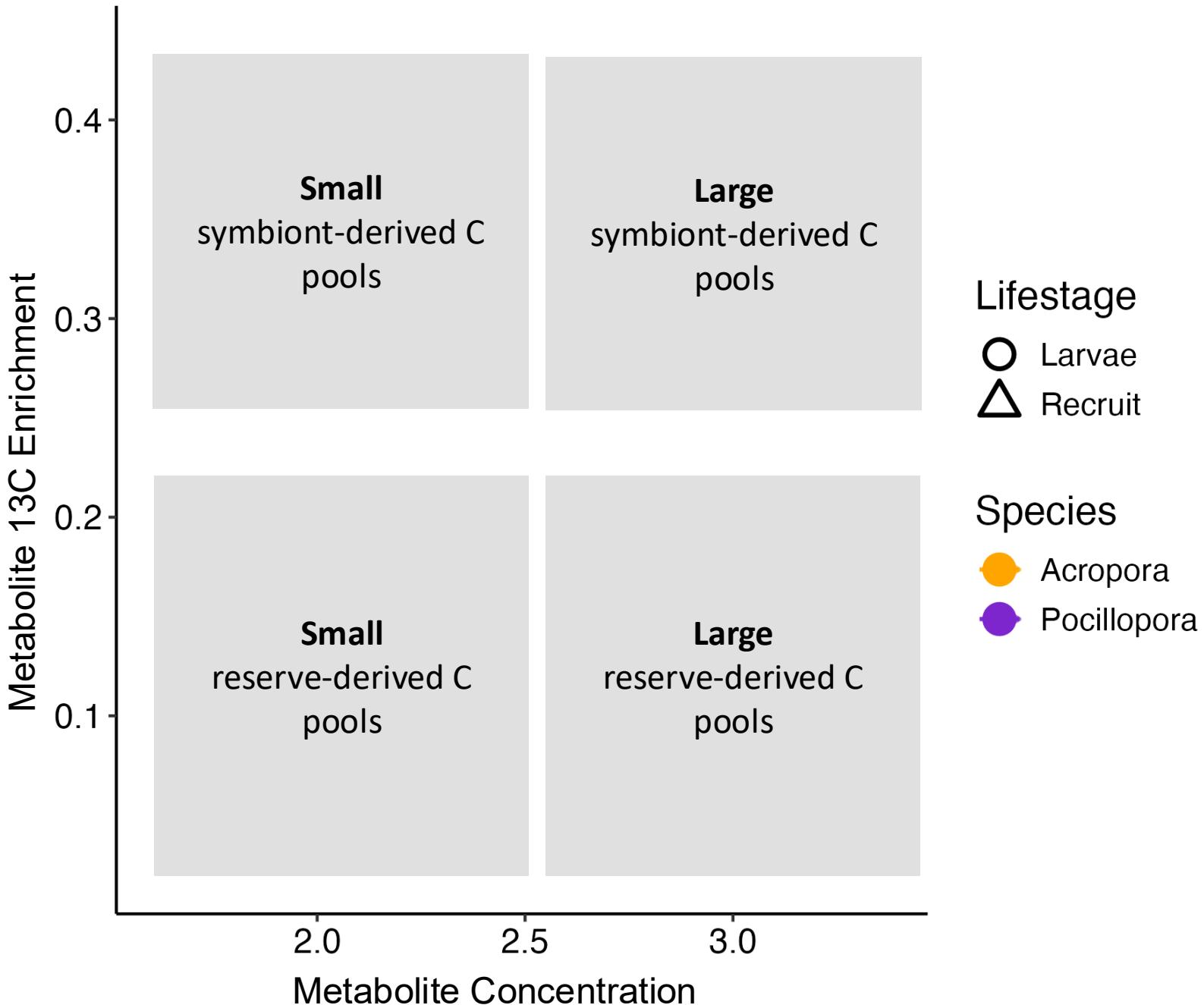


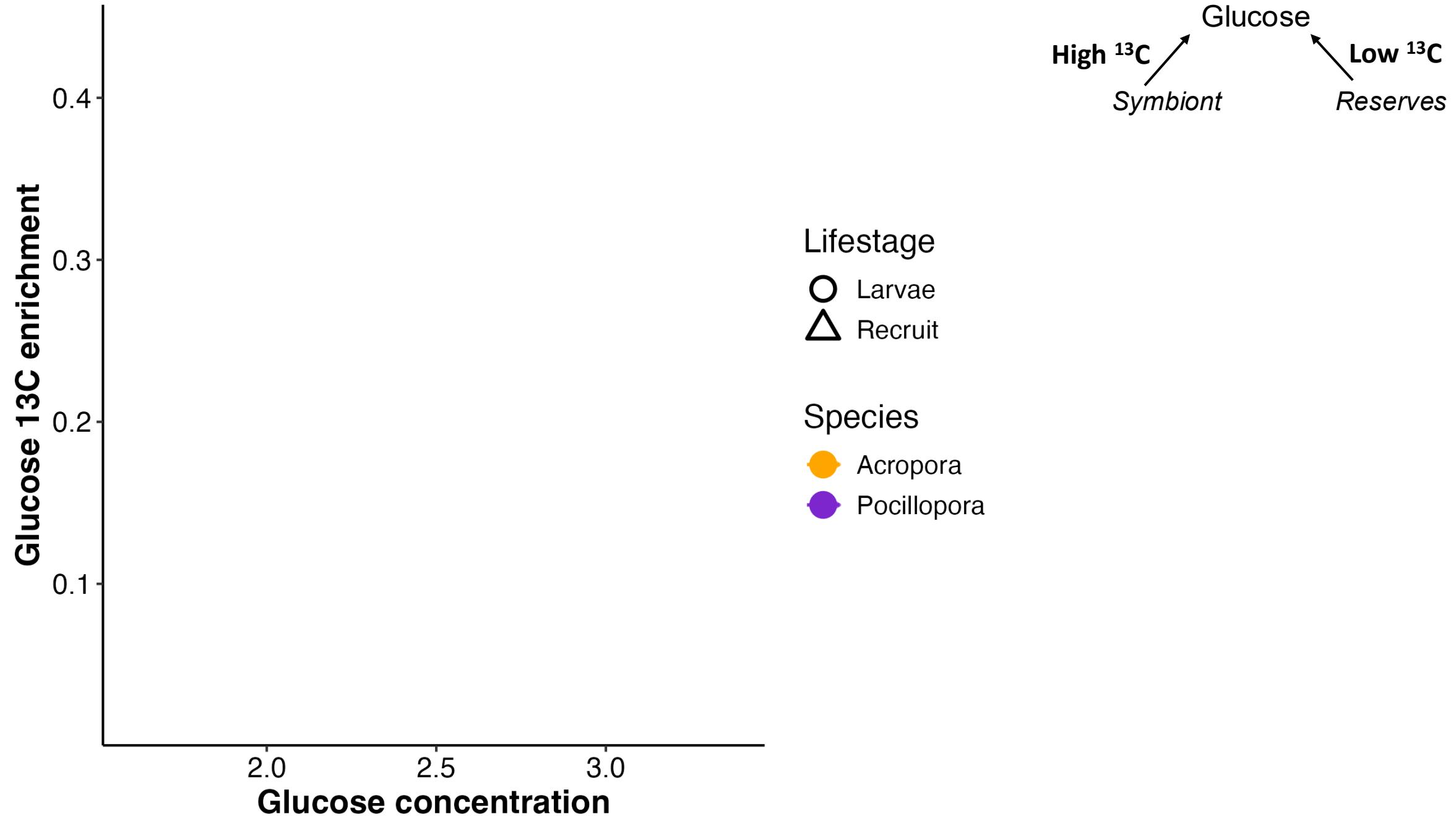


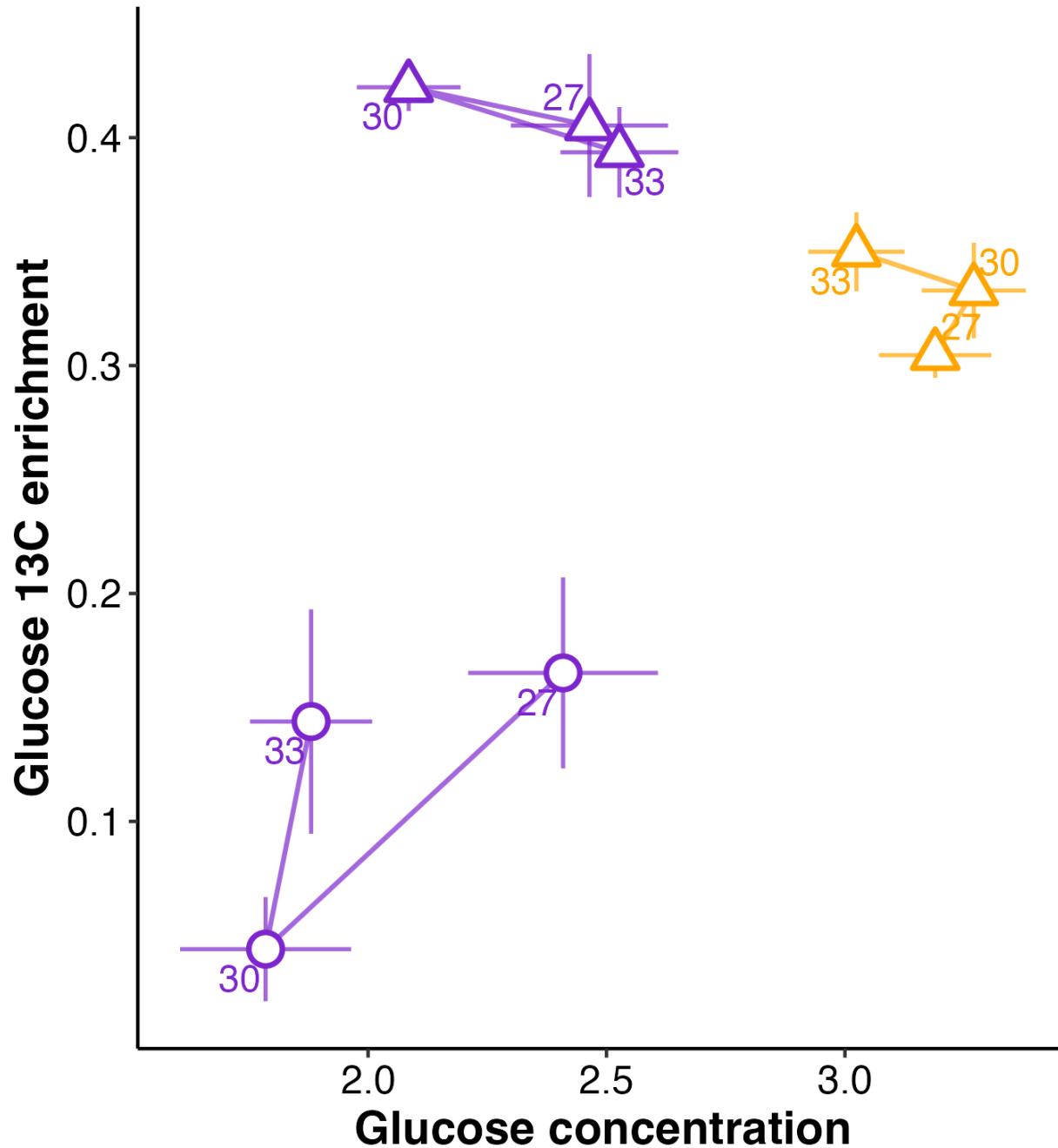










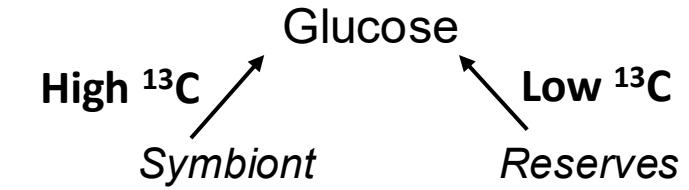


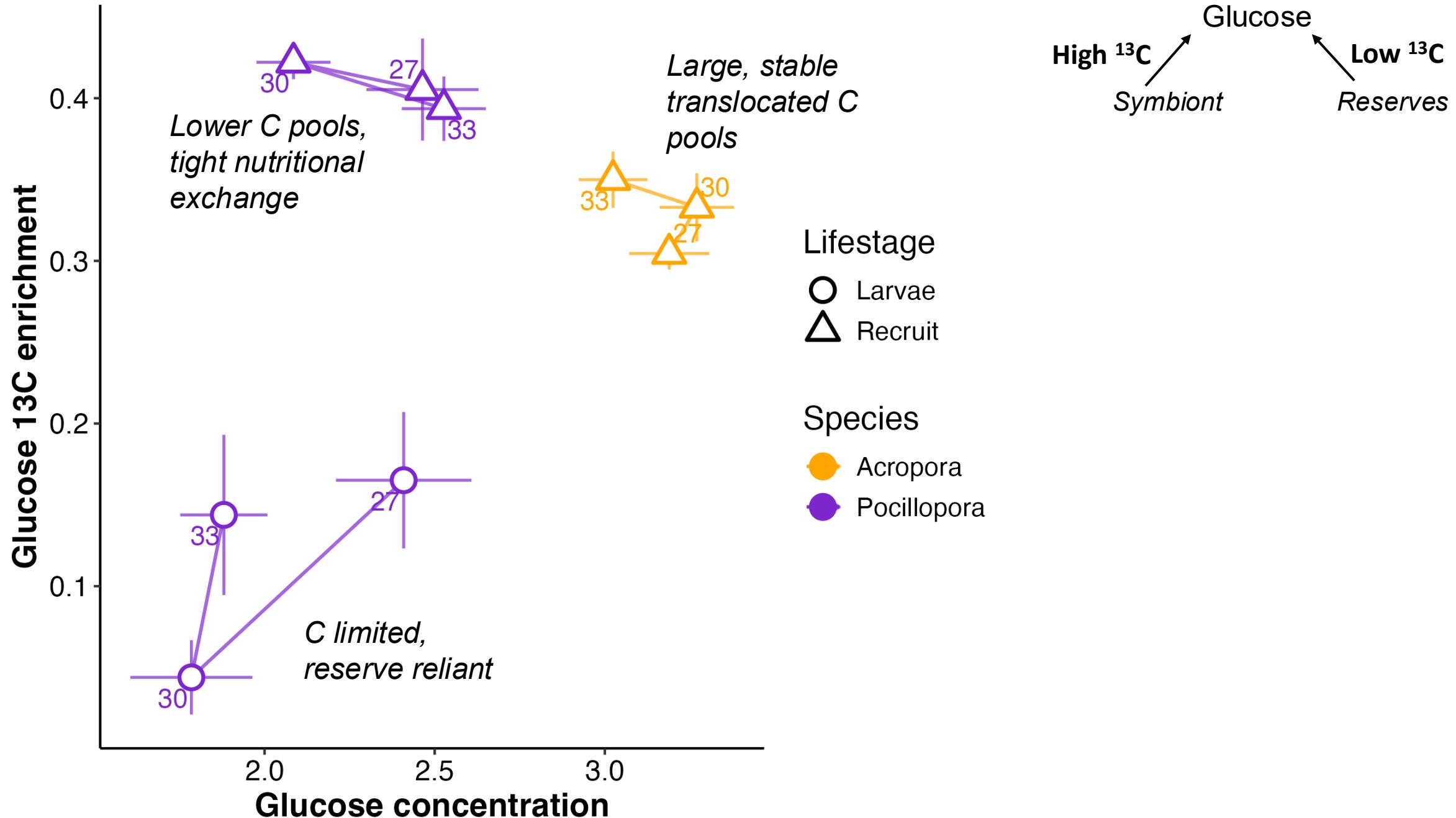
Lifestage

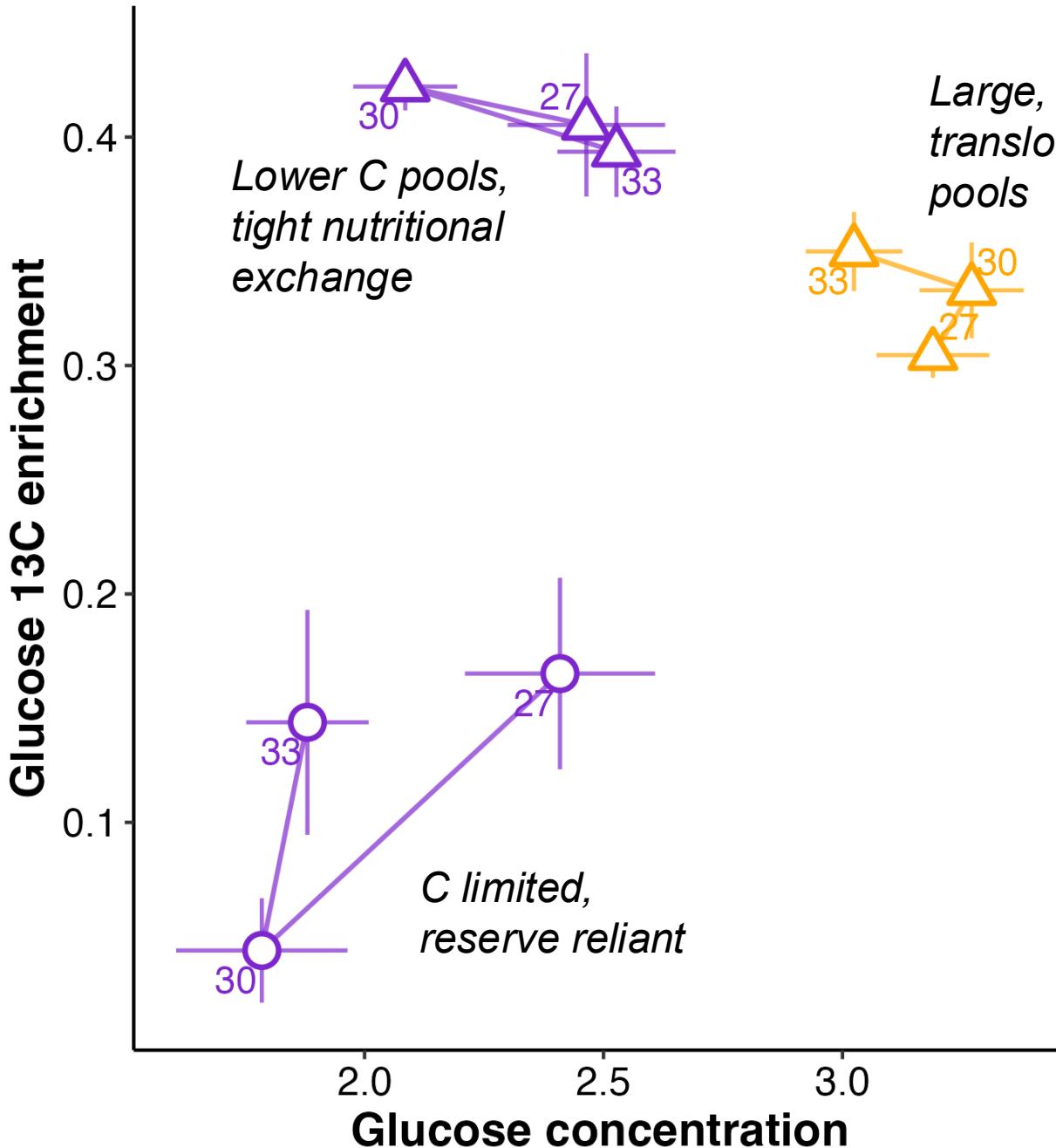
- Larvae
- Recruit

Species

- Acropora
- Pocillopora







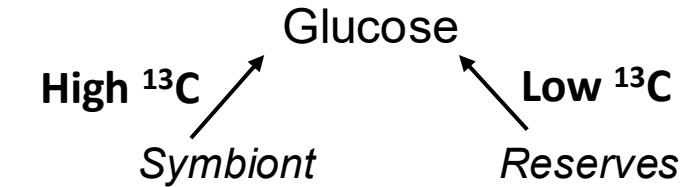
Large, stable
translocated C
pools

Lifestage

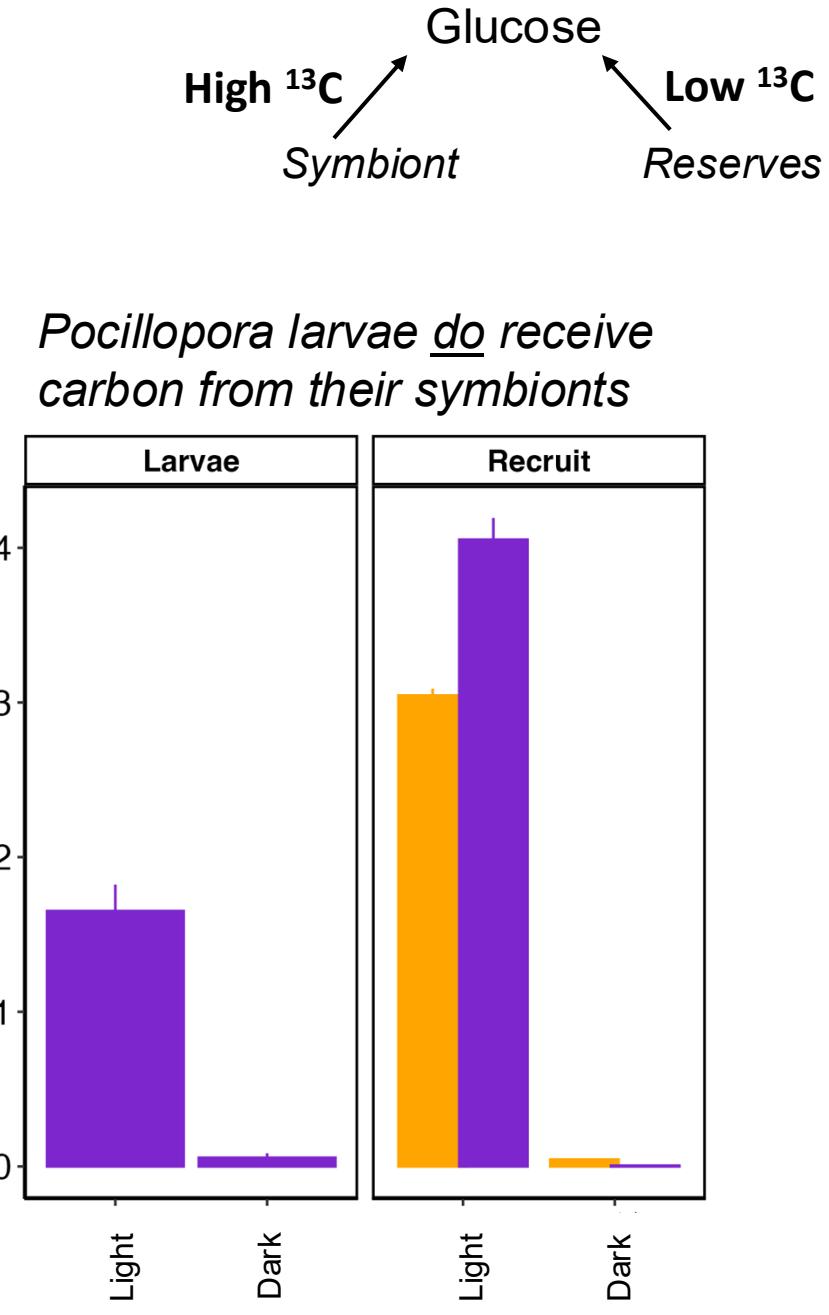
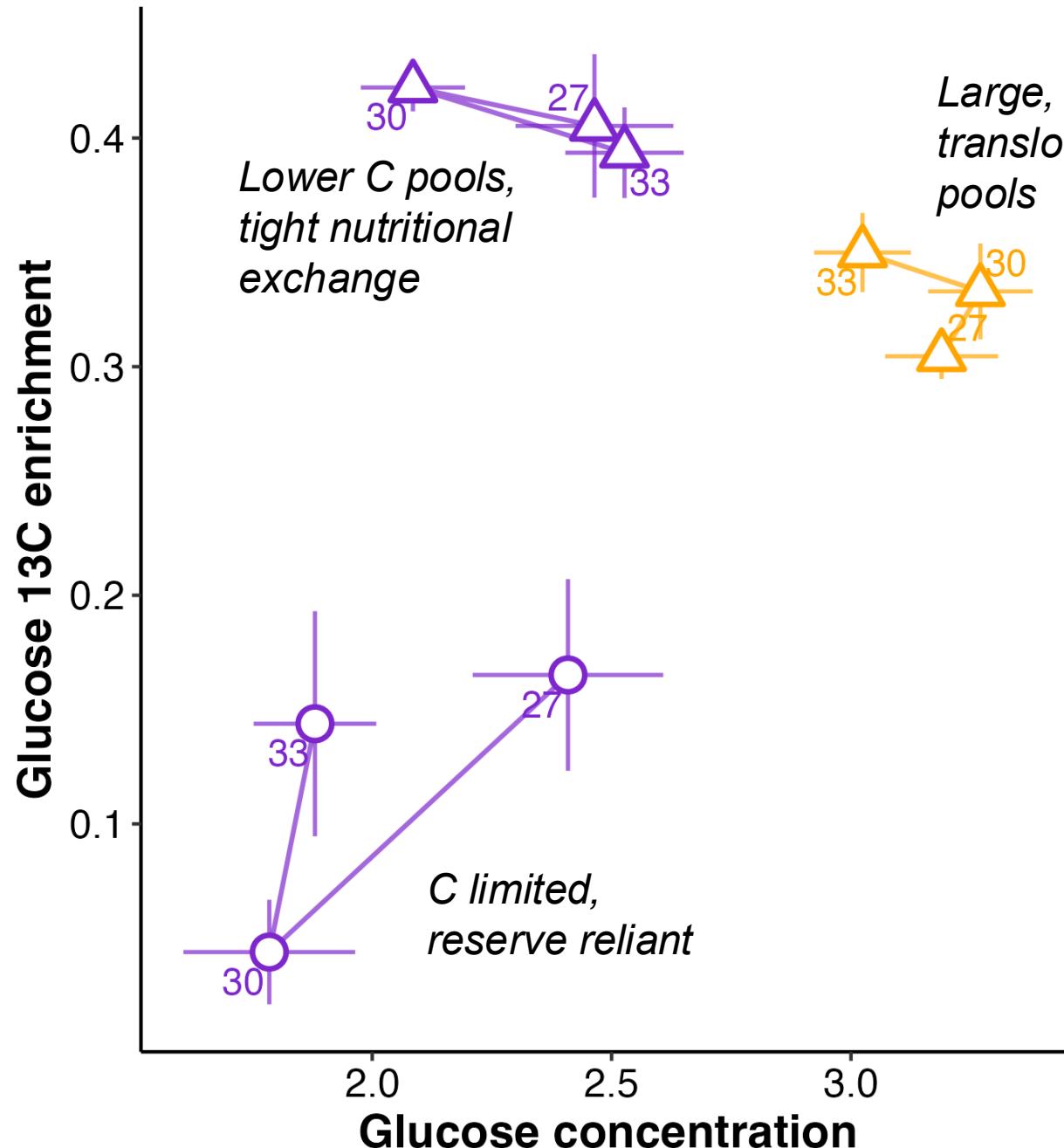
○ Larvae
△ Recruit

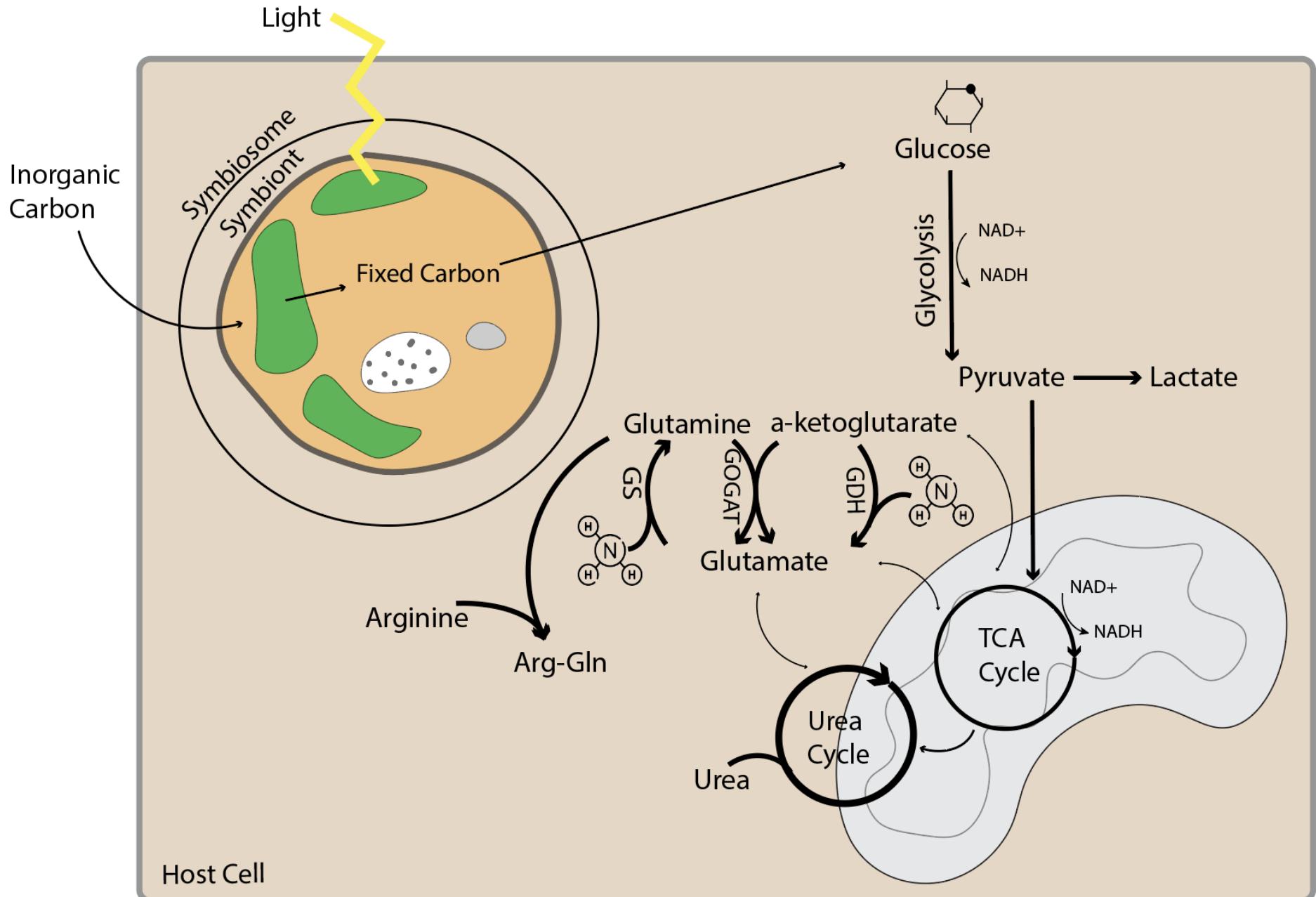
Species

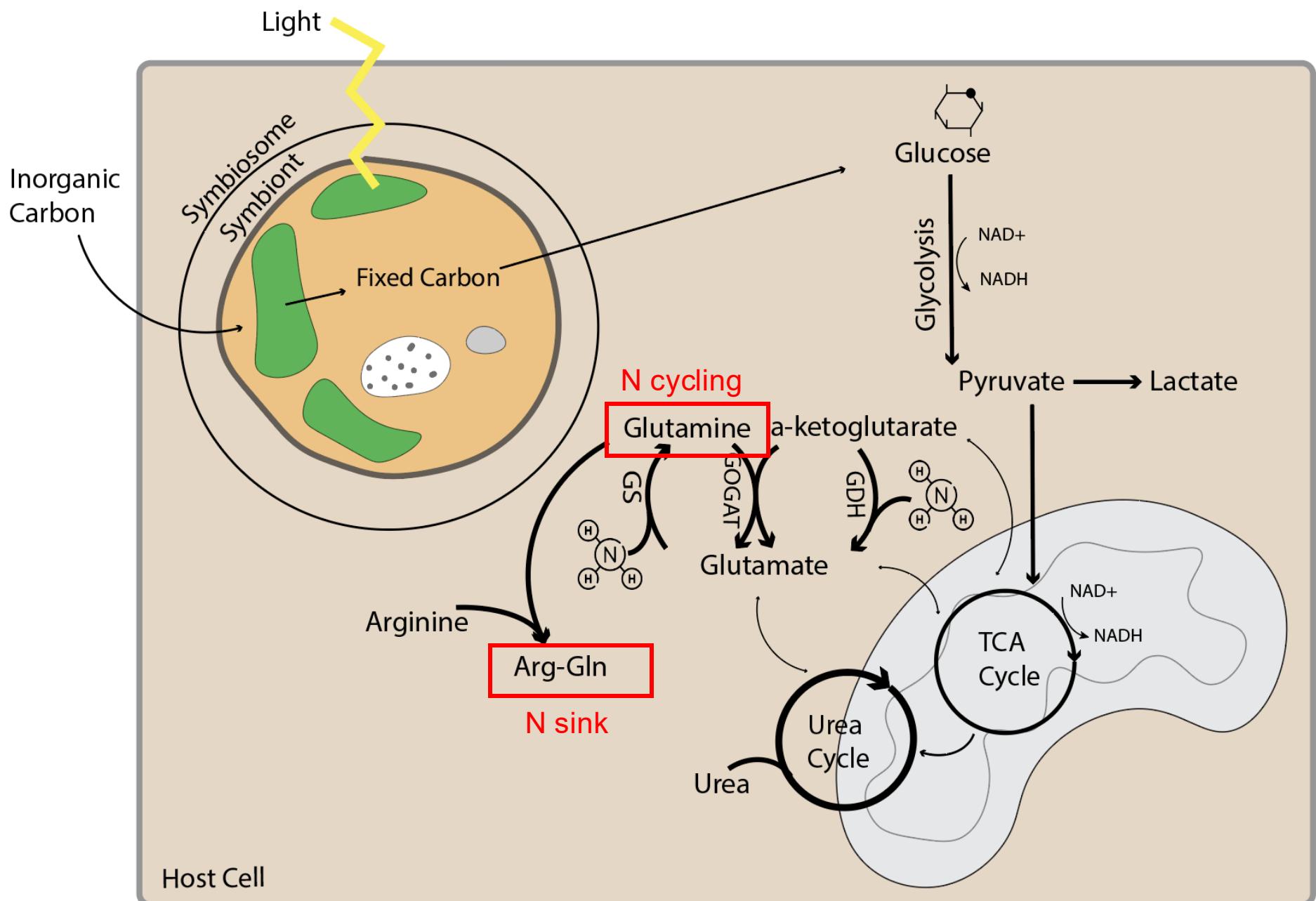
● Acropora
● Pocillopora



**Carbon translocation
is stronger in the
recruit life stage and
is stable across
temperatures**







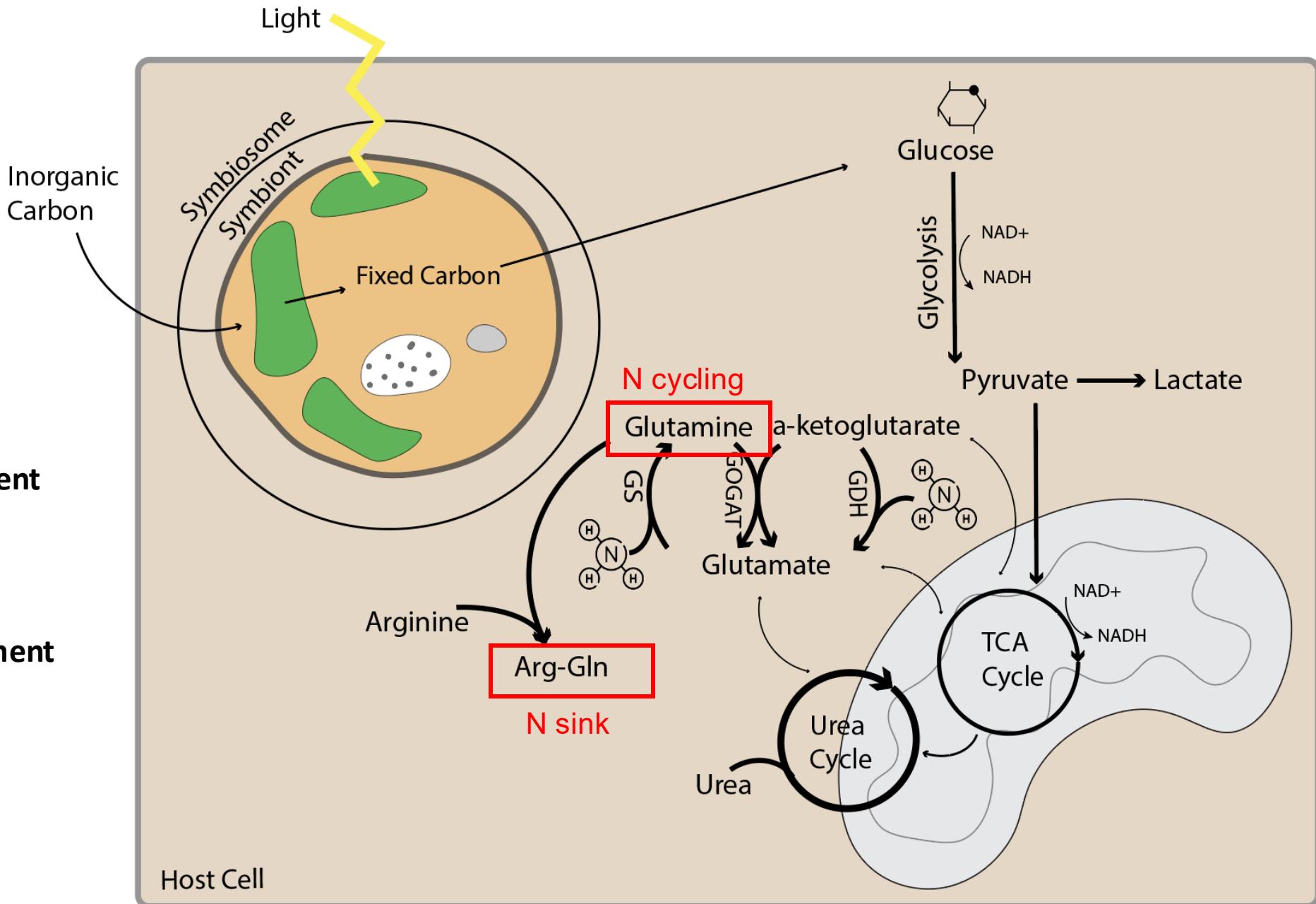
N-cycling fueled by:

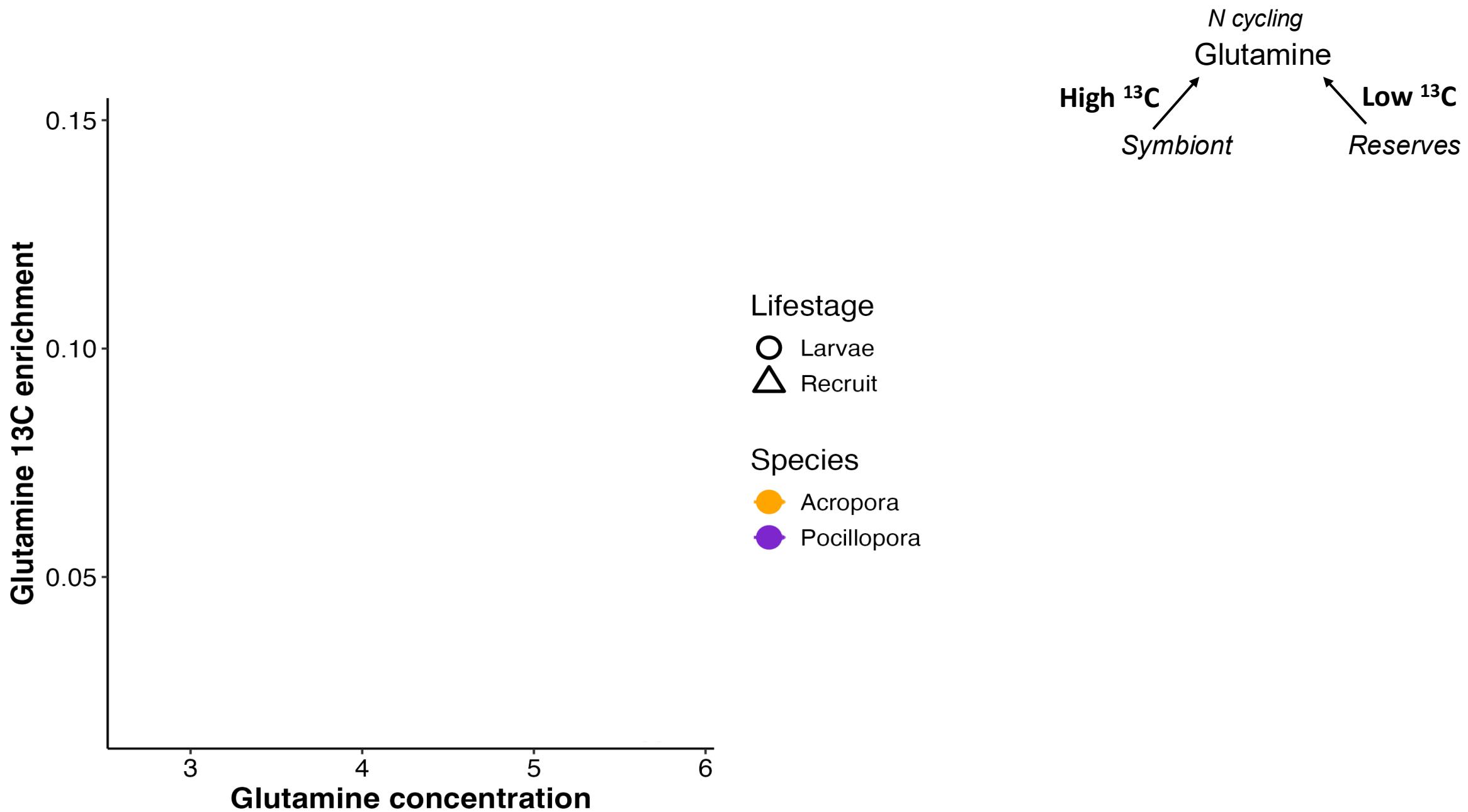
stored reserves

↓ ^{13}C enrichment

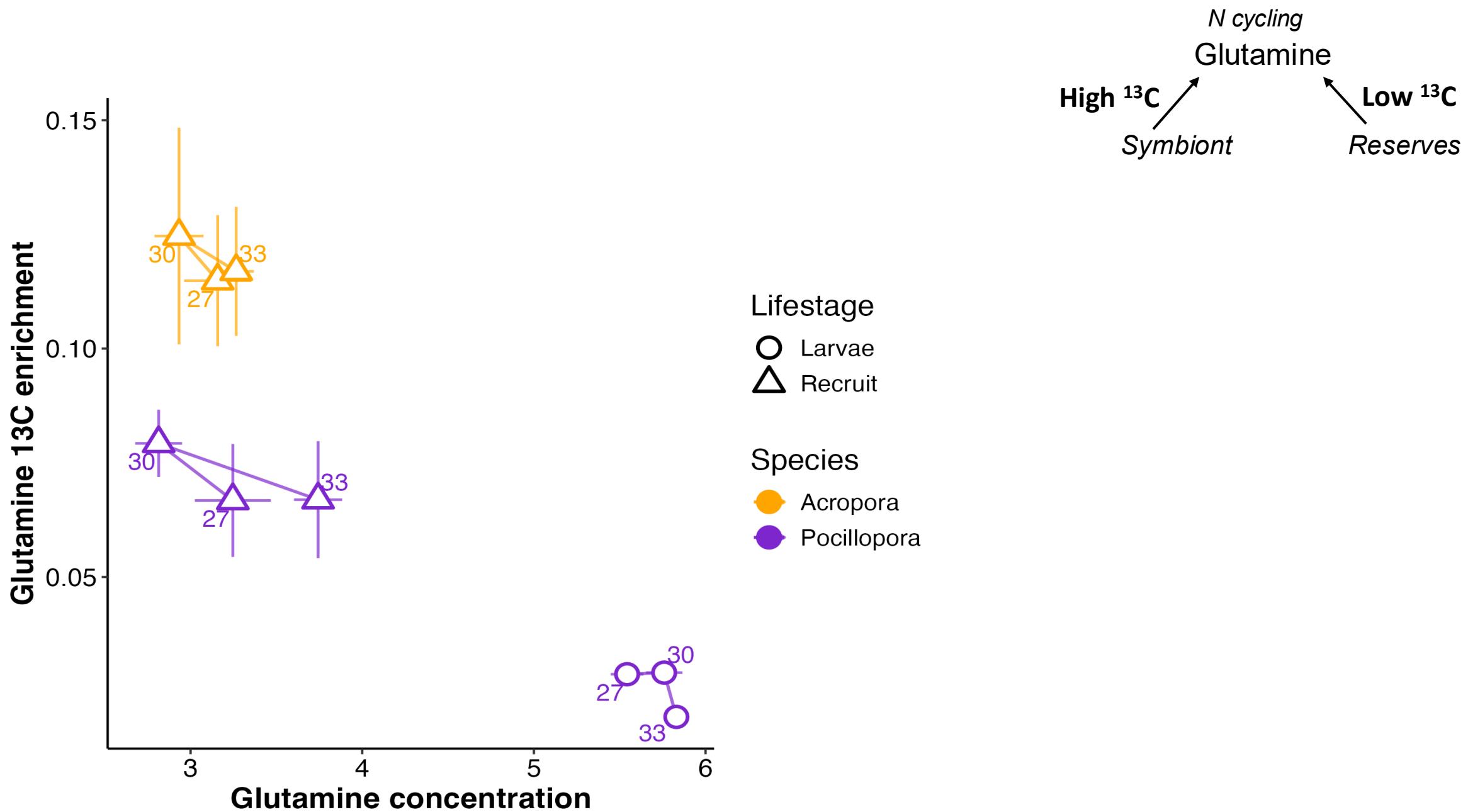
symbiont-derived carbon

↑ ^{13}C enrichment

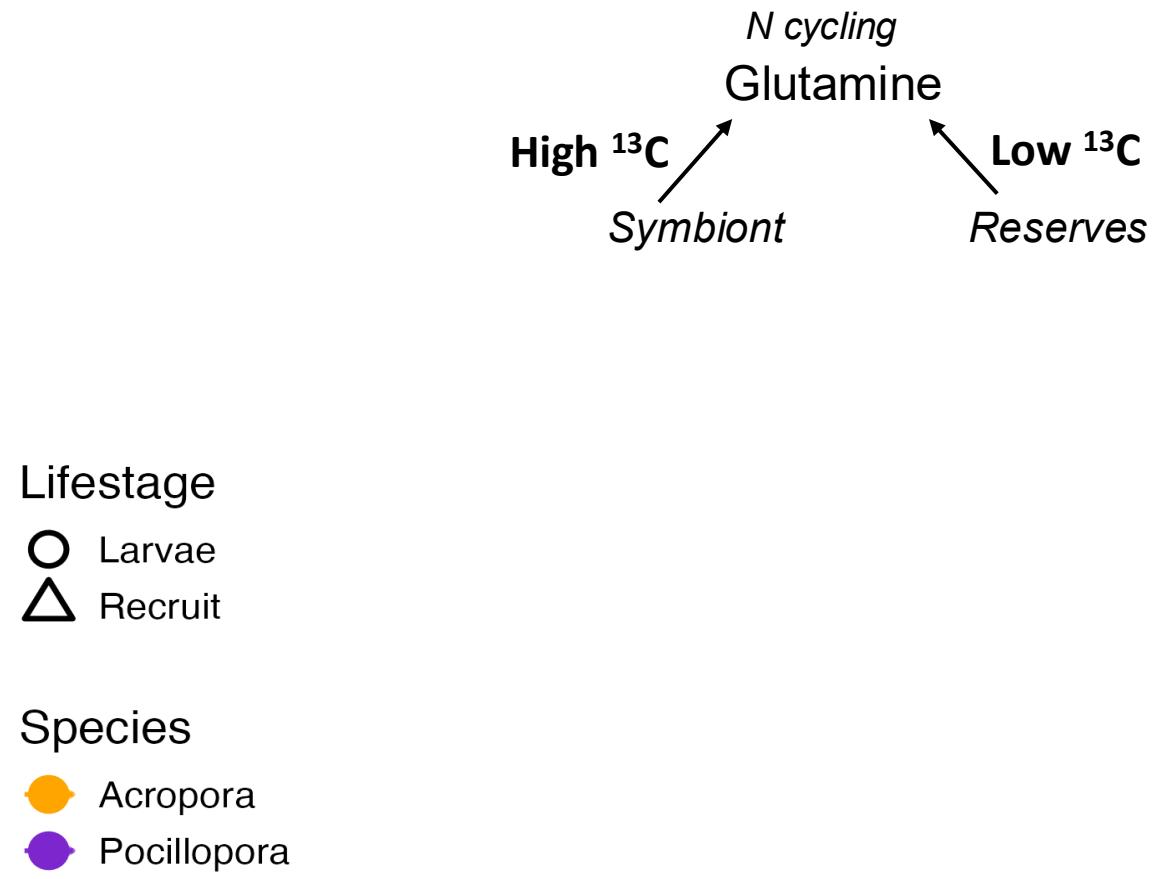
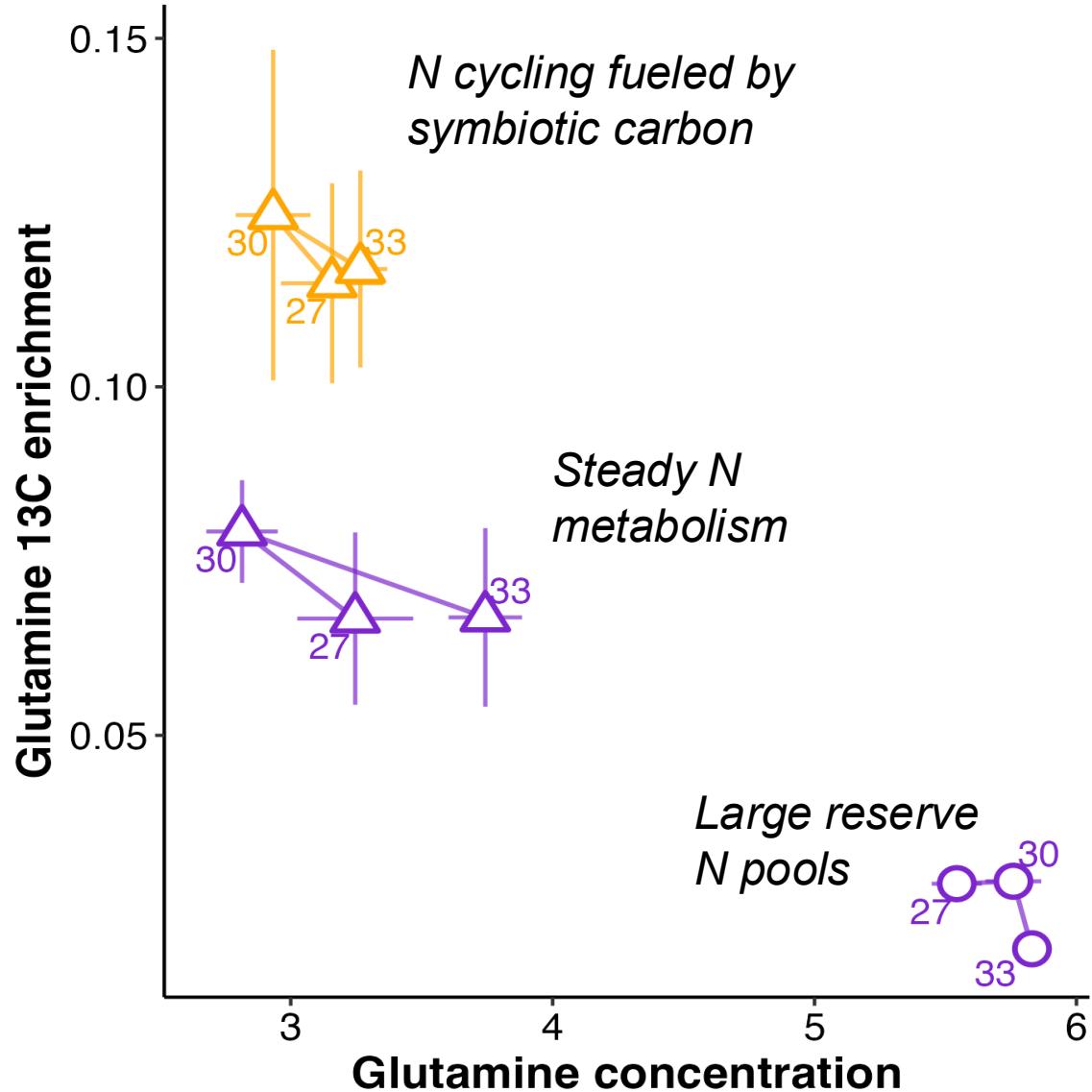




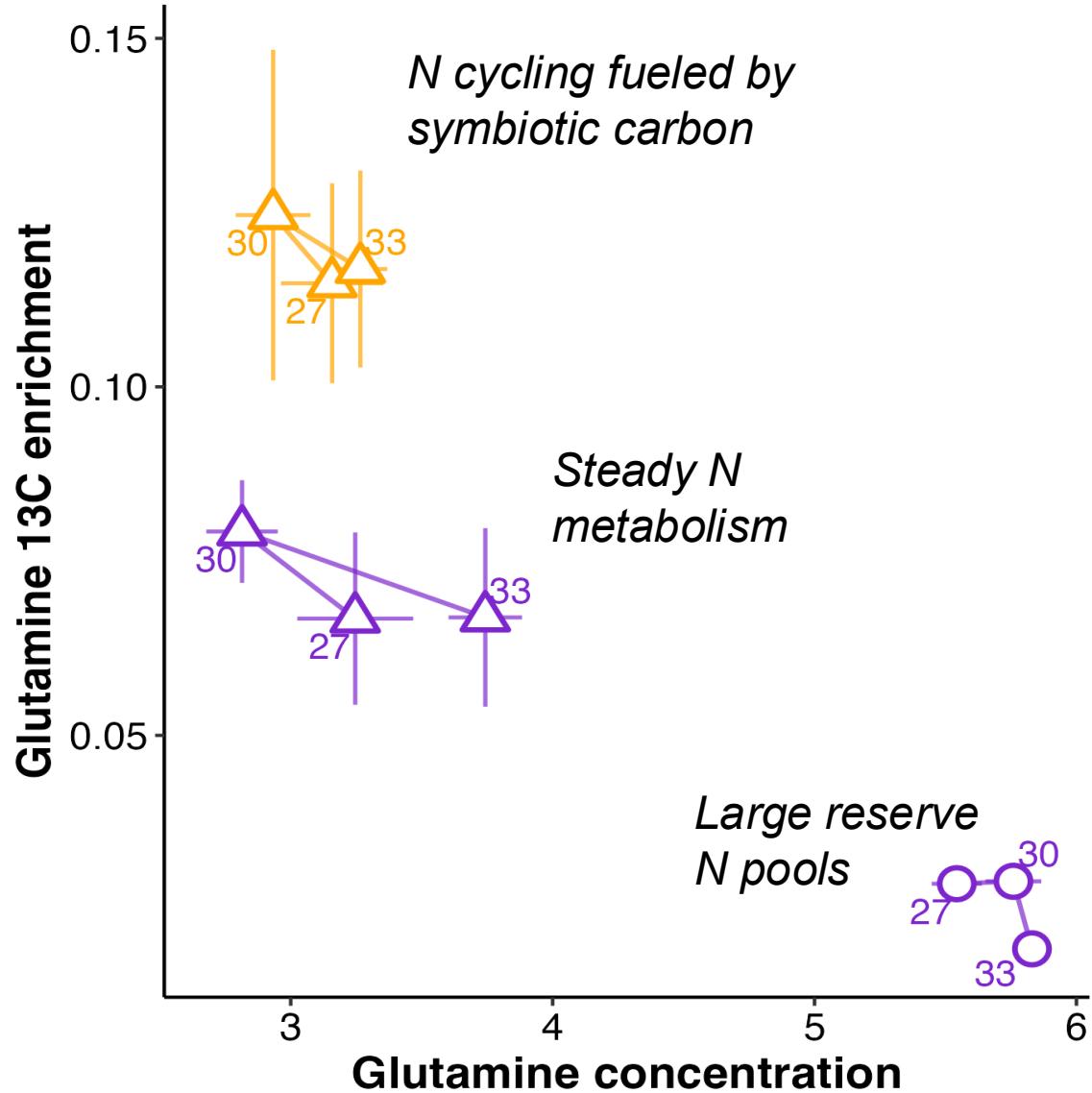
P[group]<0.001



P[group]<0.001

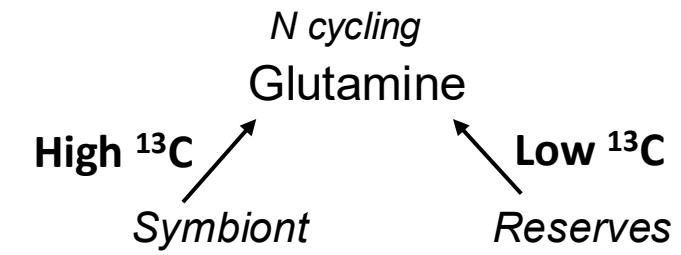


$P[\text{group}] < 0.001$

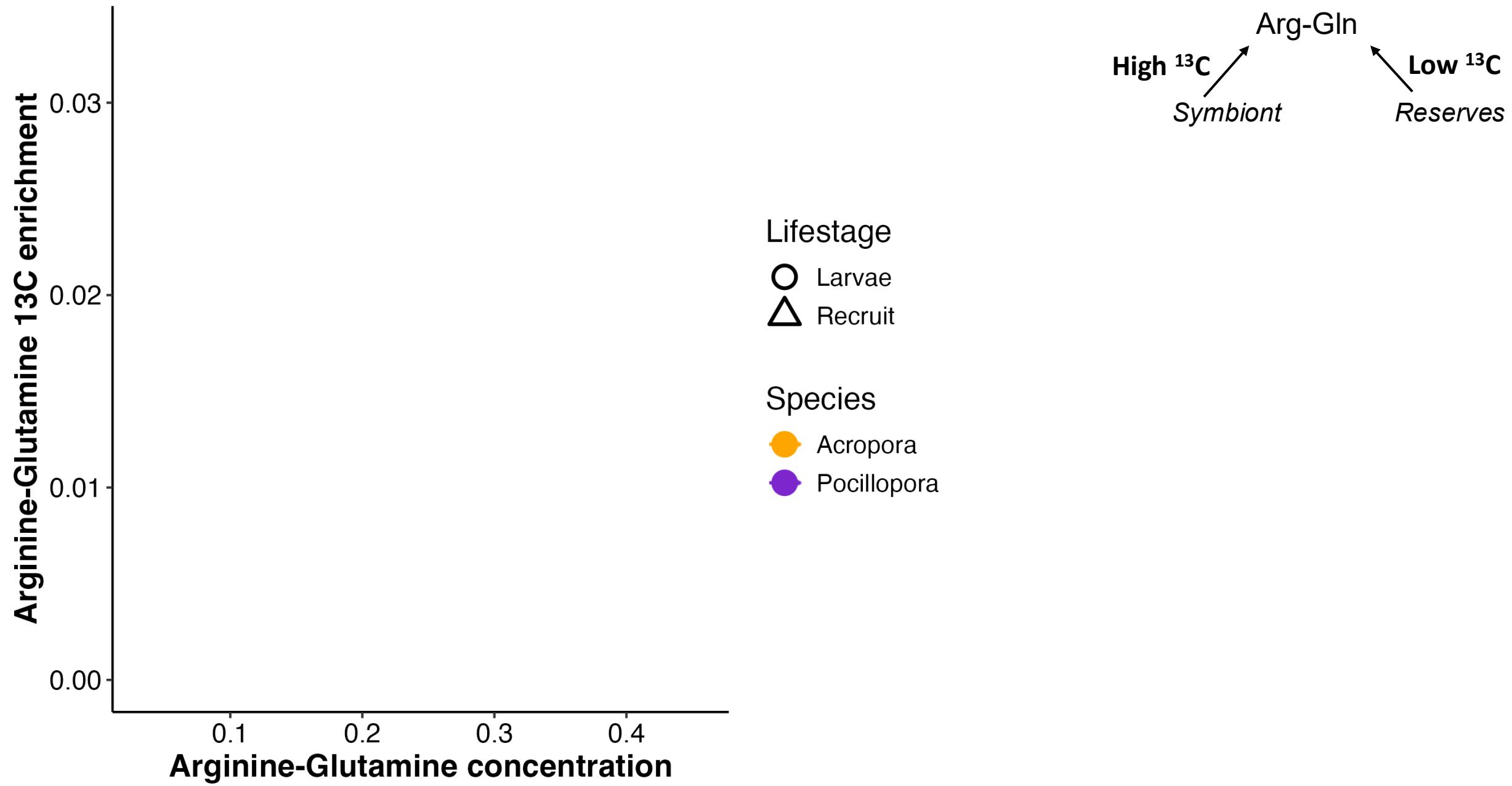


Lifestage
 ○ Larvae
 △ Recruit

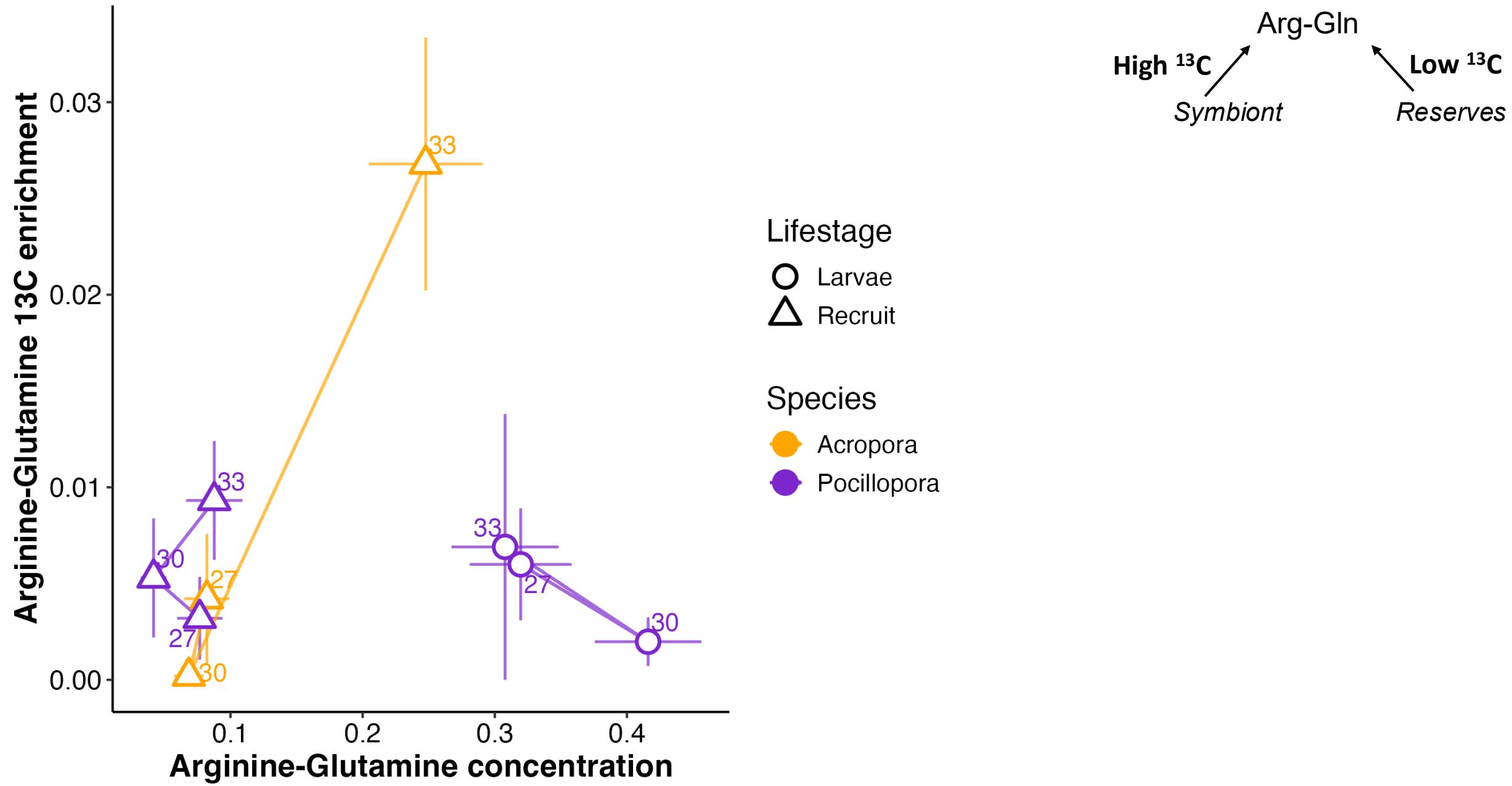
Species
 ● Acropora
 ● Pocillopora



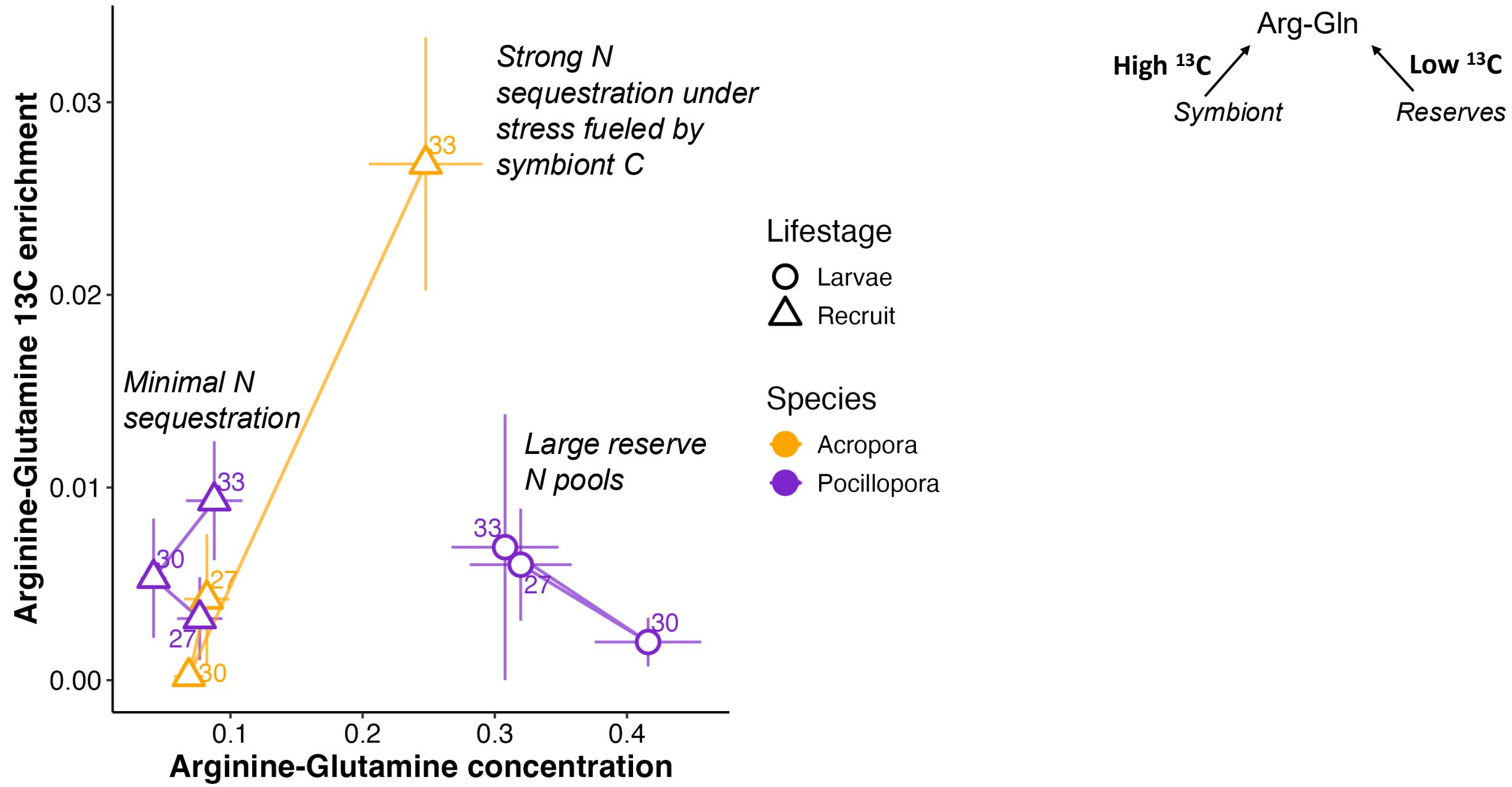
Nitrogen cycling is more active in recruits and is dependent on maternal reserves in larvae



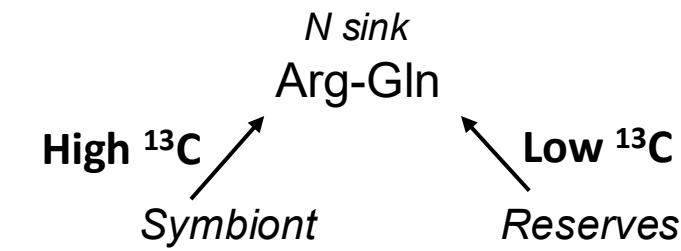
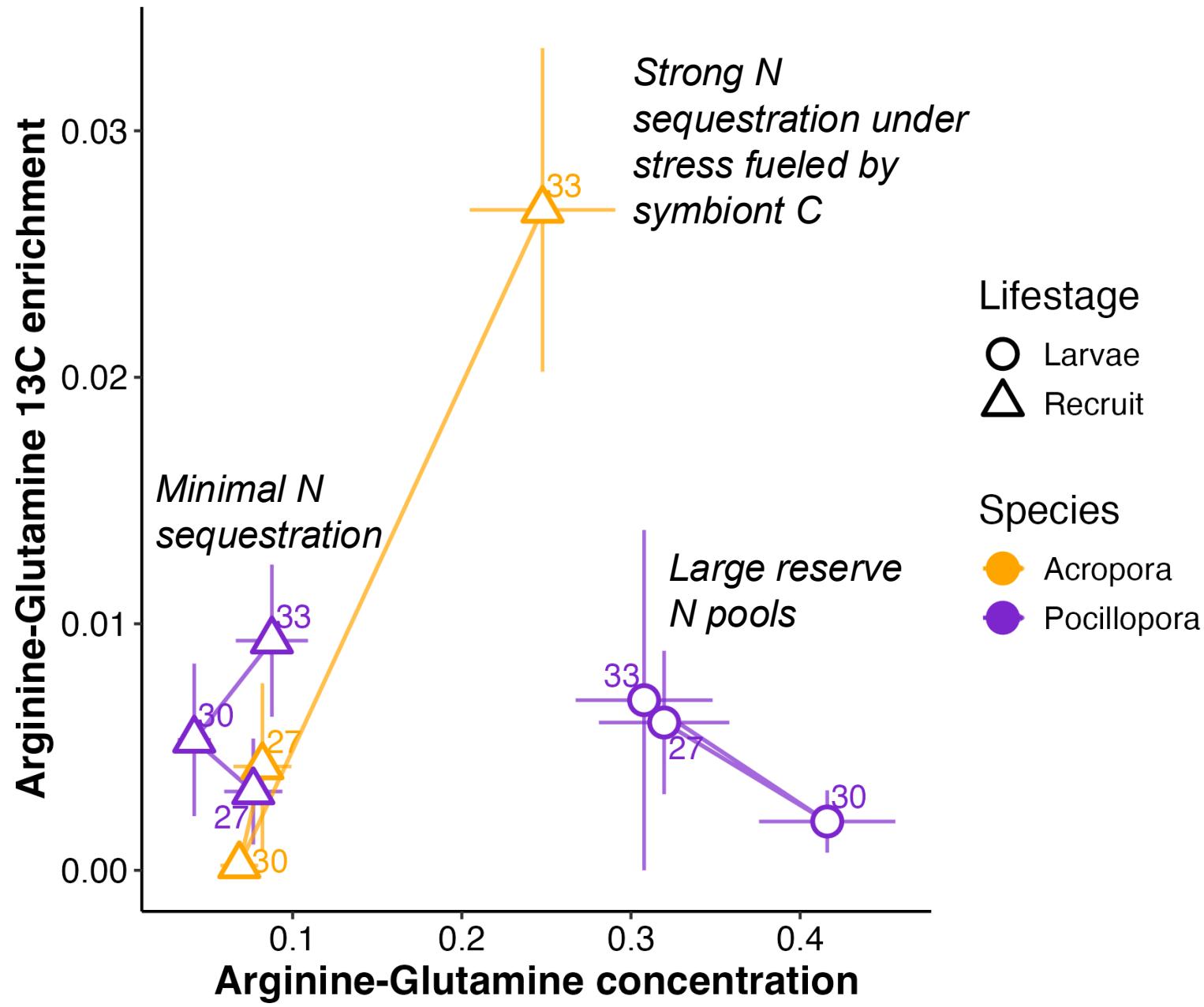
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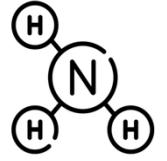
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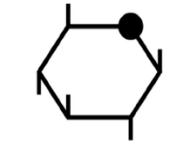


Nitrogen sequestration is highly temperature sensitive in *Acropora* and is dependent on reserves in larvae



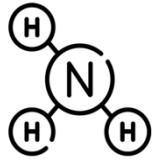
Metabolic
Strategy





Metabolic
Strategy

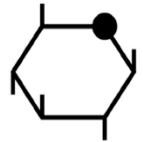
High, stable translocation



N cycling fueled by
translocated C

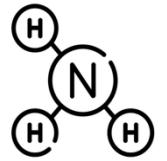
Symbiont-dependent C and N
metabolism with temperature
sensitive N metabolism



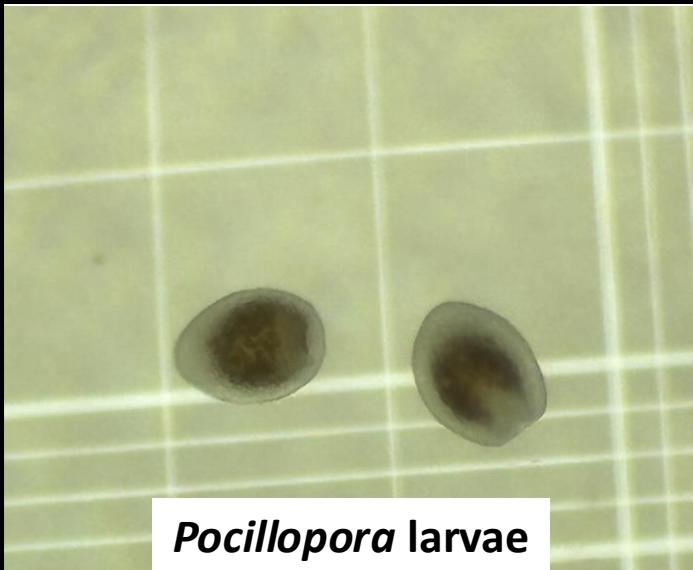


Metabolic Strategy

N cycling fueled by translocated C



Symbiont-dependent C and N metabolism with temperature sensitive N metabolism



High, stable translocation

Tight nutritional exchange

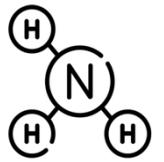
Steady N pools and metabolism

Steady and conservative C and N metabolism



Metabolic Strategy

High, stable translocation



N cycling fueled by translocated C

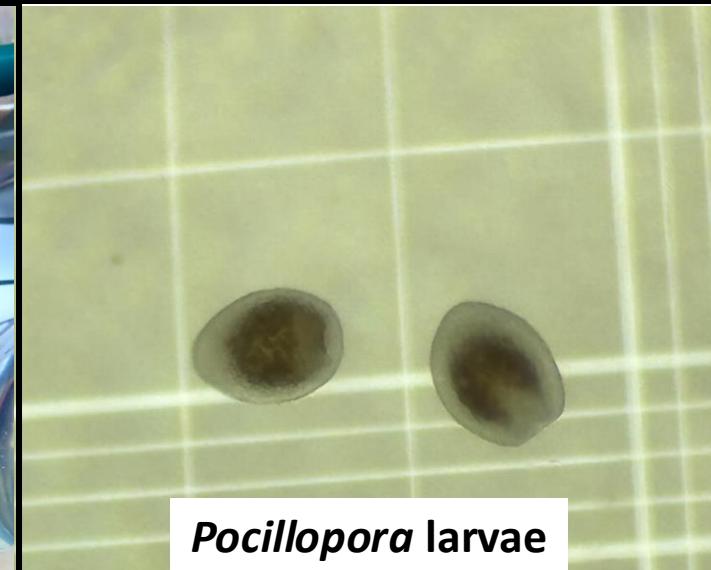
Symbiont-dependent C and N metabolism with temperature sensitive N metabolism



Acropora recruits



Pocillopora recruits



Pocillopora larvae

Early stages of active translocation

Large maternal N stores

Tight nutritional exchange

Steady N pools and metabolism

Steady and conservative C and N metabolism

Early symbiotic exchange and reliance on maternal reserves

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- NSF Rules of Life E5 Coral

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- Roberts Lab (UW), Putnam Lab (URI)
- UCB Gump Station boating, diving, staff, and facilities support

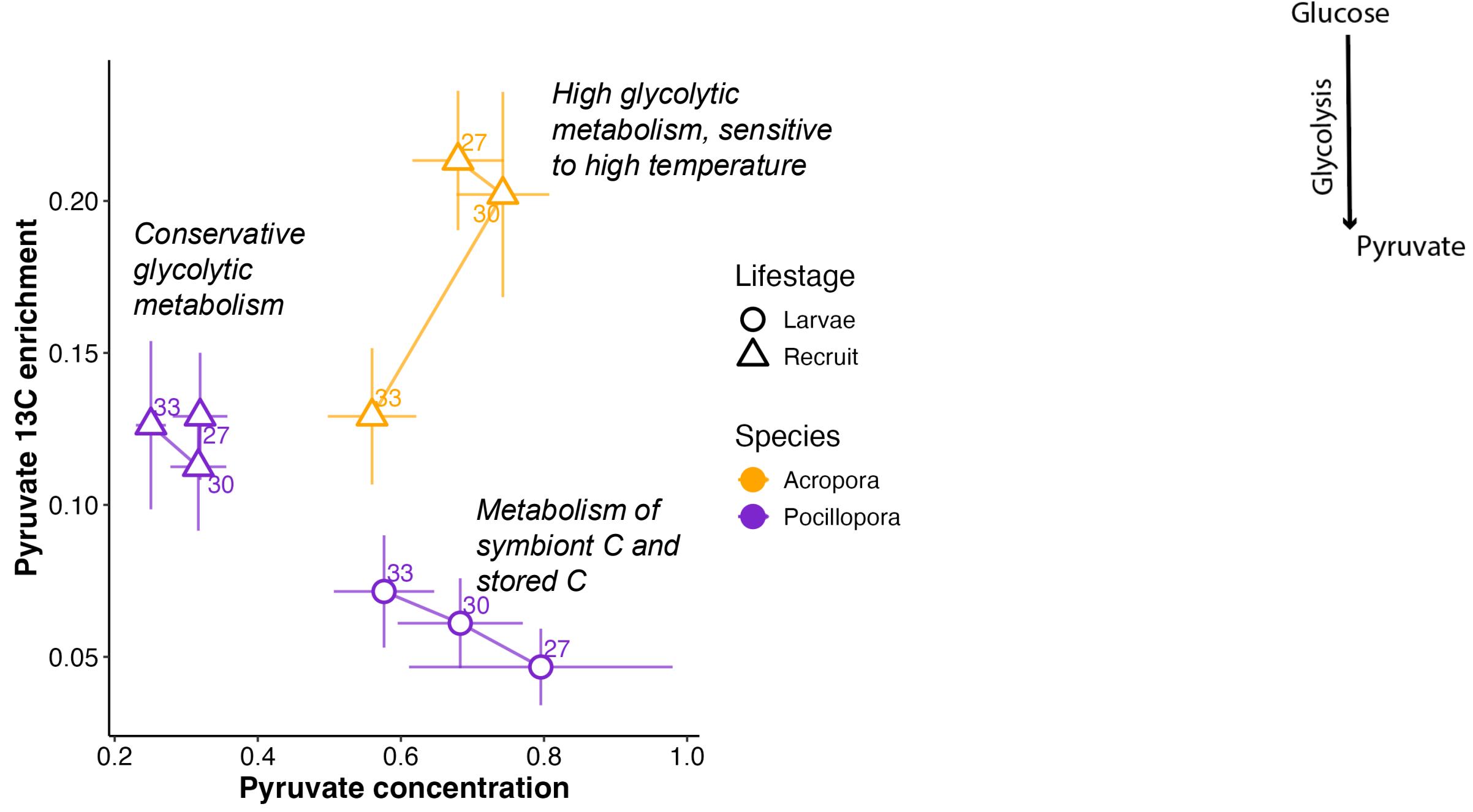


<https://linktr.ee/ashuffmyer>

ashuff@uw.edu

Open data, code, and notebooks here!





P[group:treatment]=0.001

