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# Growth–development patterns shape individual variation in feeding success in anchovy larvae:

## Laboratory-based hypothesis and field tests





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1: Graduate School of Agricultural and Life Sciences,  The University of Tokyo, Tokyo, Japan

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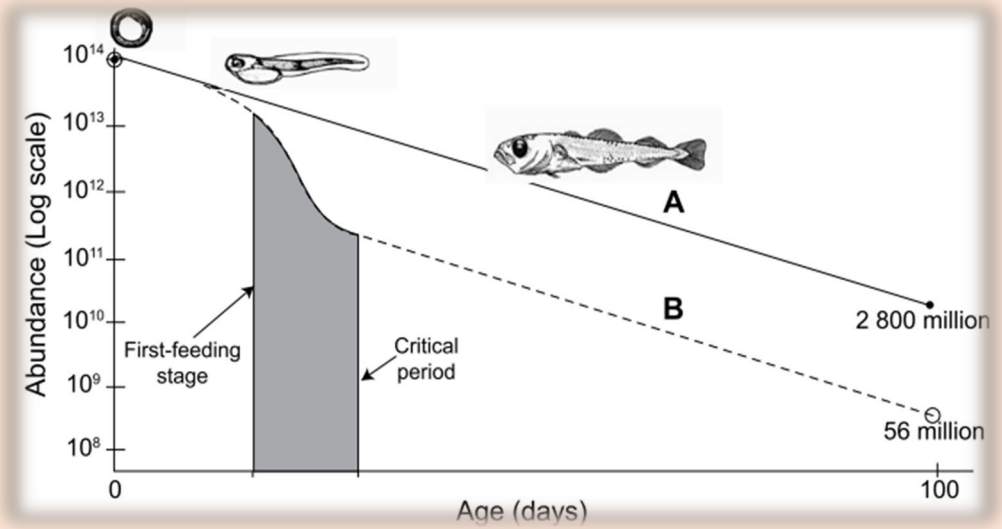
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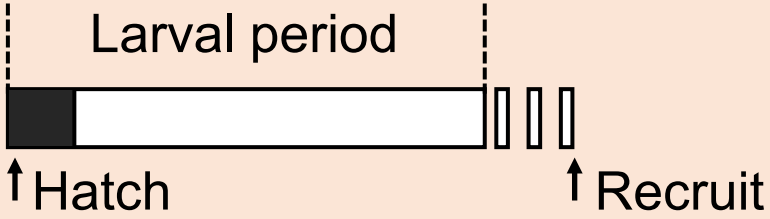
# At what life stage is recruitment determined ?

## "Critical period" hypothesis

(Hjort, 1914, 1926)



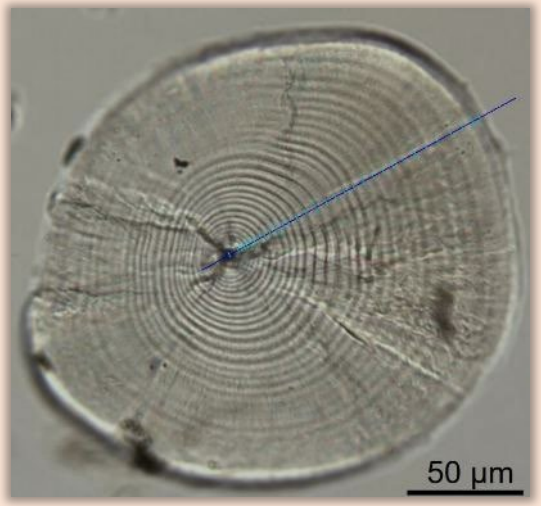

**Year-class strength is determined in the short period after first feeding.**

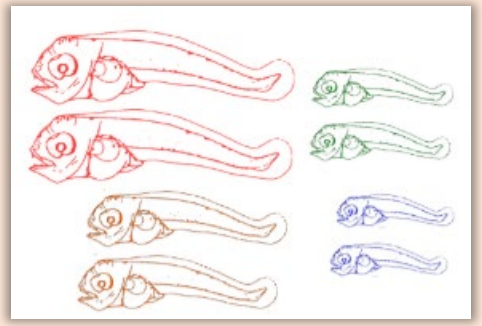



VS

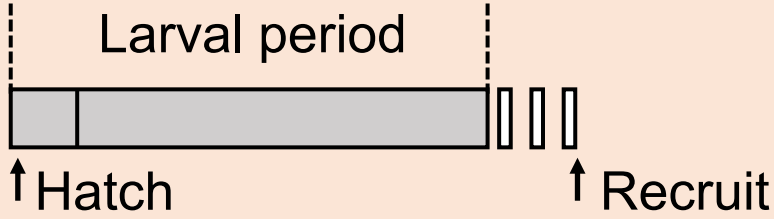
## "Growth–survival" paradigm

(Anderson, 1988; Robert et al., 2023)



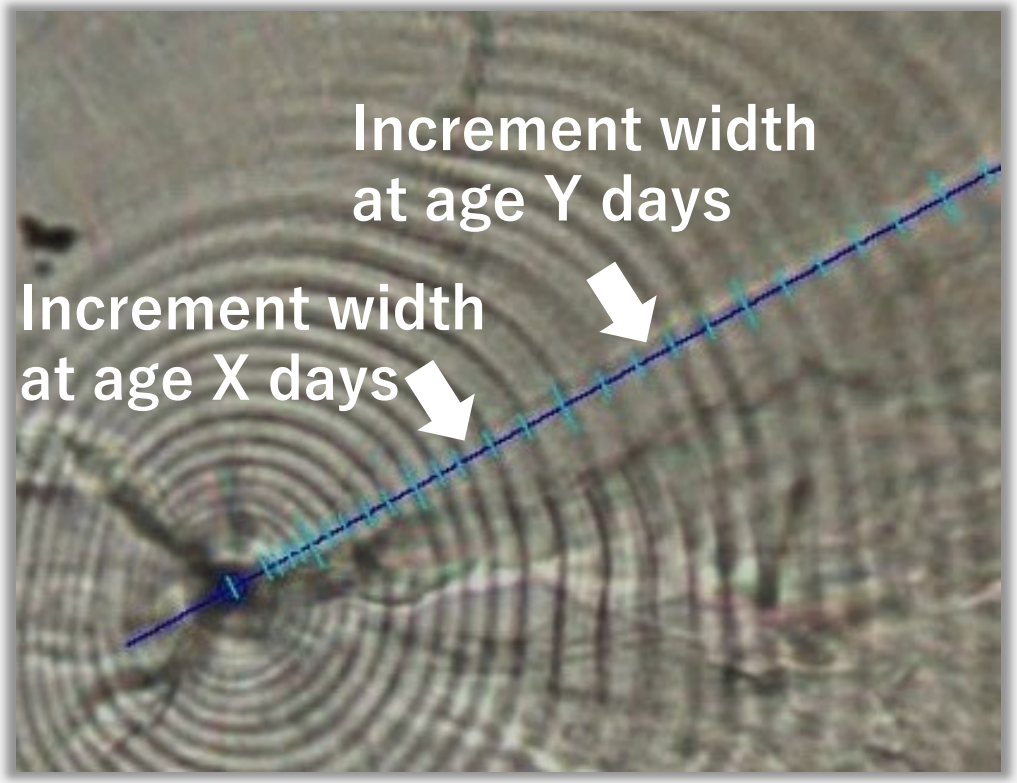



**Fast growth throughout the early life influences recruitment.**

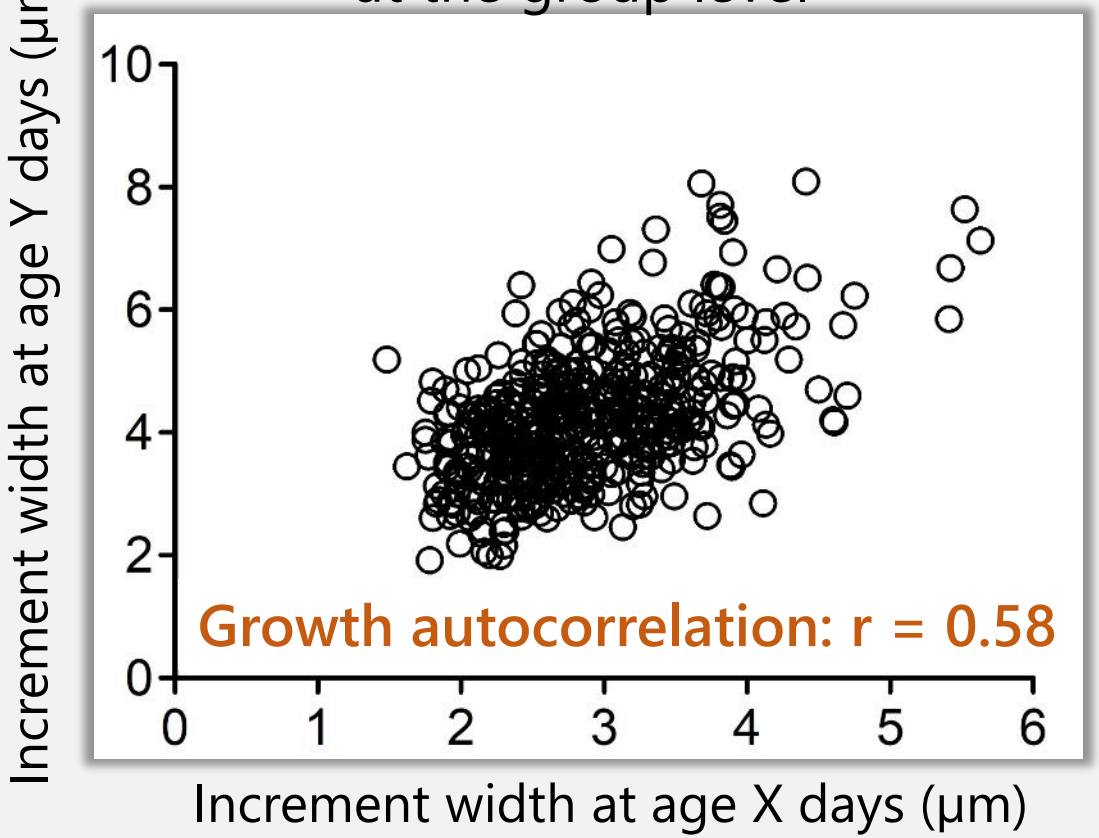


# Growth autocorrelation
## (Robert et al., 2014; Pepin et al., 2015)

Select daily otolith increment widths corresponding to two separate periods



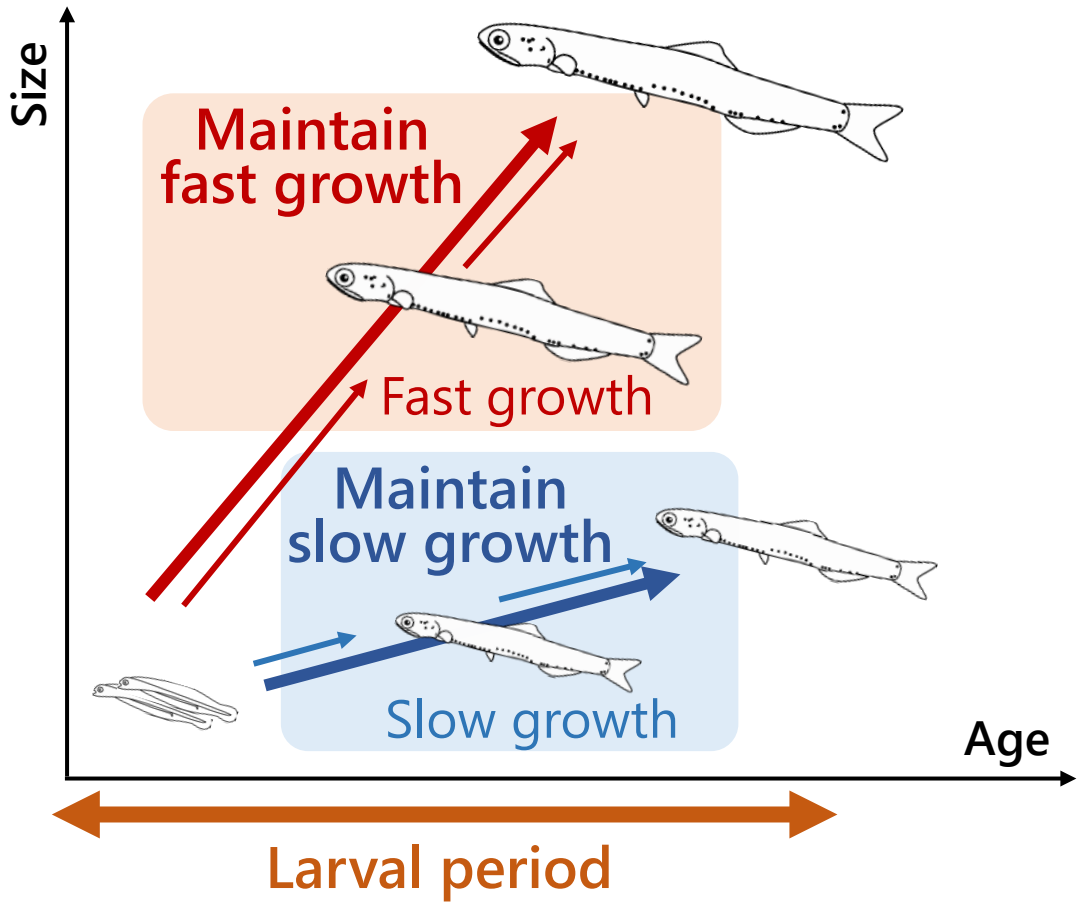

Calculate correlation coefficient at the group level



# Growth autocorrelation in clupeoid larvae

(Tanaka et al., 2023)

**Clupeoid species exhibited strong autocorrelation throughout the larval period.**




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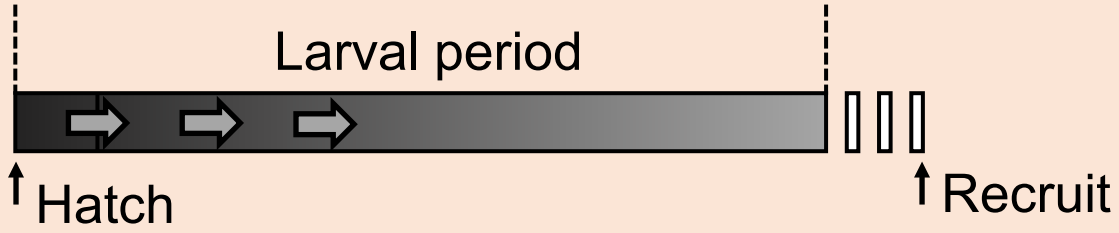
**Revisiting the role of early life growth for survival potential in three clupeoid species**

Shota Tanaka[1] | Shizuna Togoshi[1] | Naotaka Yasue[2] | Corinne M. Burns[3] | Dominique Robert[3] | Akinori Takasuka[1]

## Reconciled hypothesis

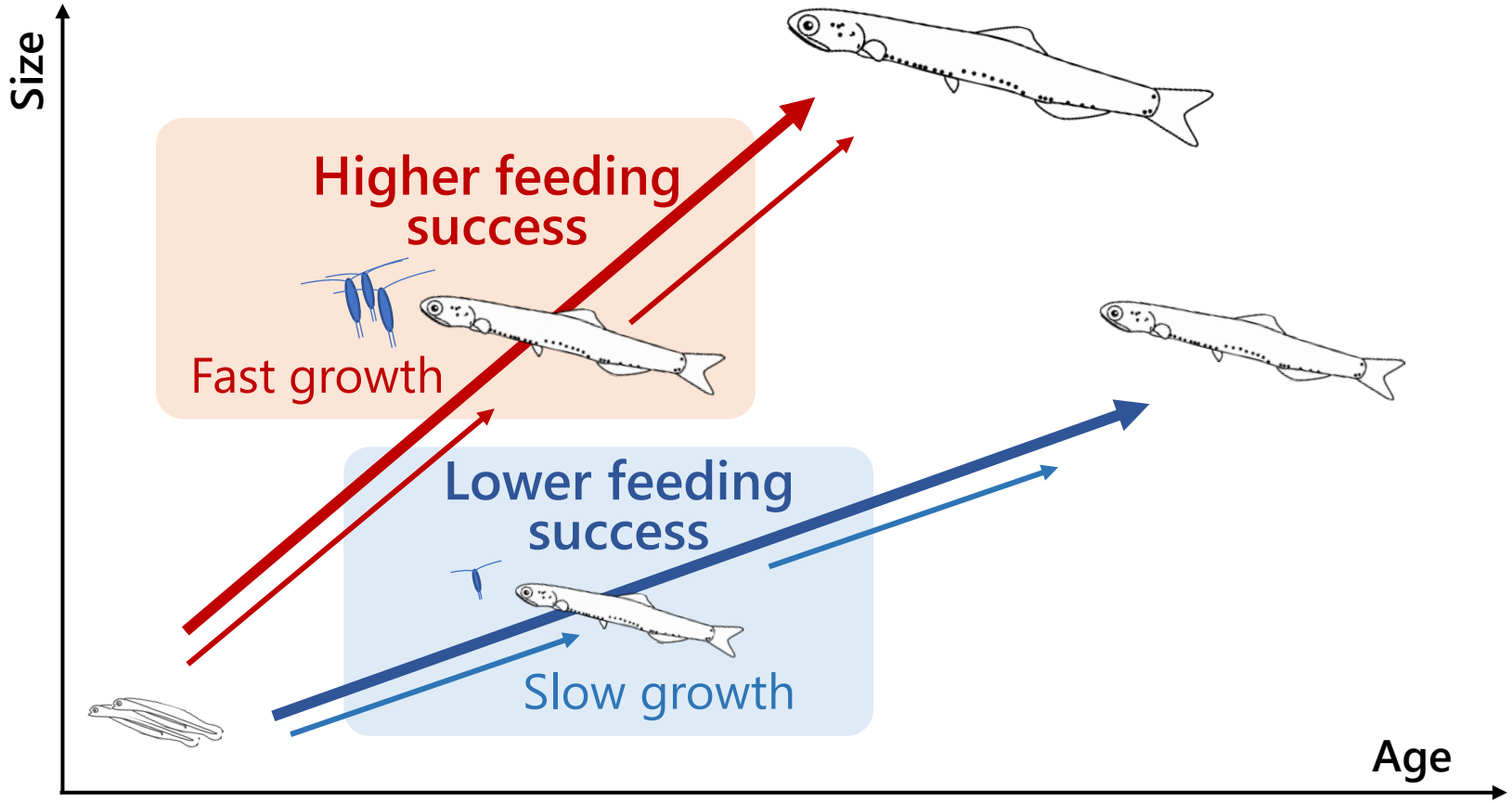
(Tanaka et al., 2023)

**Growth rate after first feeding influences growth rate throughout the early life.**



# Growth–feeding linkage

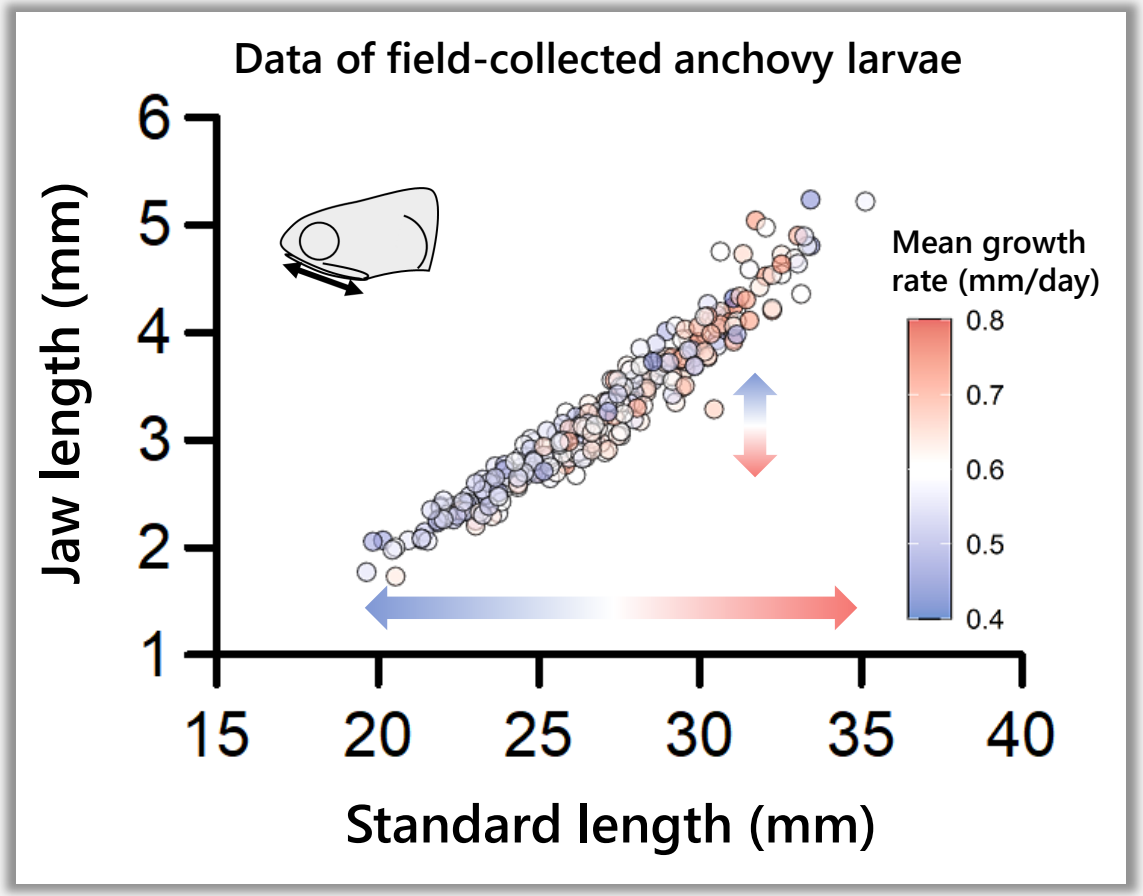
(Dower et al., 2009; Togoshi et al., 2024, Tanaka et al., 2026)




**The extent of the growth autocorrelation can be modulated by the growth–feeding linkage.**

# Growth–development patterns

**Morphological development** plays a key role in larval feeding performance.




ORIGINAL ARTICLE OPEN ACCESS

(Tanaka et al, 2026, *FOG*)

**Dynamics of Growth–Feeding Mechanisms in Japanese Anchovy Larvae Under Different Environmental Conditions**

Shota Tanaka[1] | Shizuna Togoshi[1] | Etienne Germain[2] | Naotaka Yasue[3] | Masahiro Nakamura[4] | Dominique Robert[2] | Akinori Takasuka[1]

Morphological development may be

- **positively associated with growth rate** through increases in somatic size.
- **negatively associated with growth rate, at a given somatic size.**

**Contrasting patterns highlight the need to clarify growth–feeding linkage.**

# Objectives

**To investigate the growth–feeding linkage and its effects on growth autocorrelation**

## Laboratory experiments



To investigate growth–feeding linkage

## Field tests

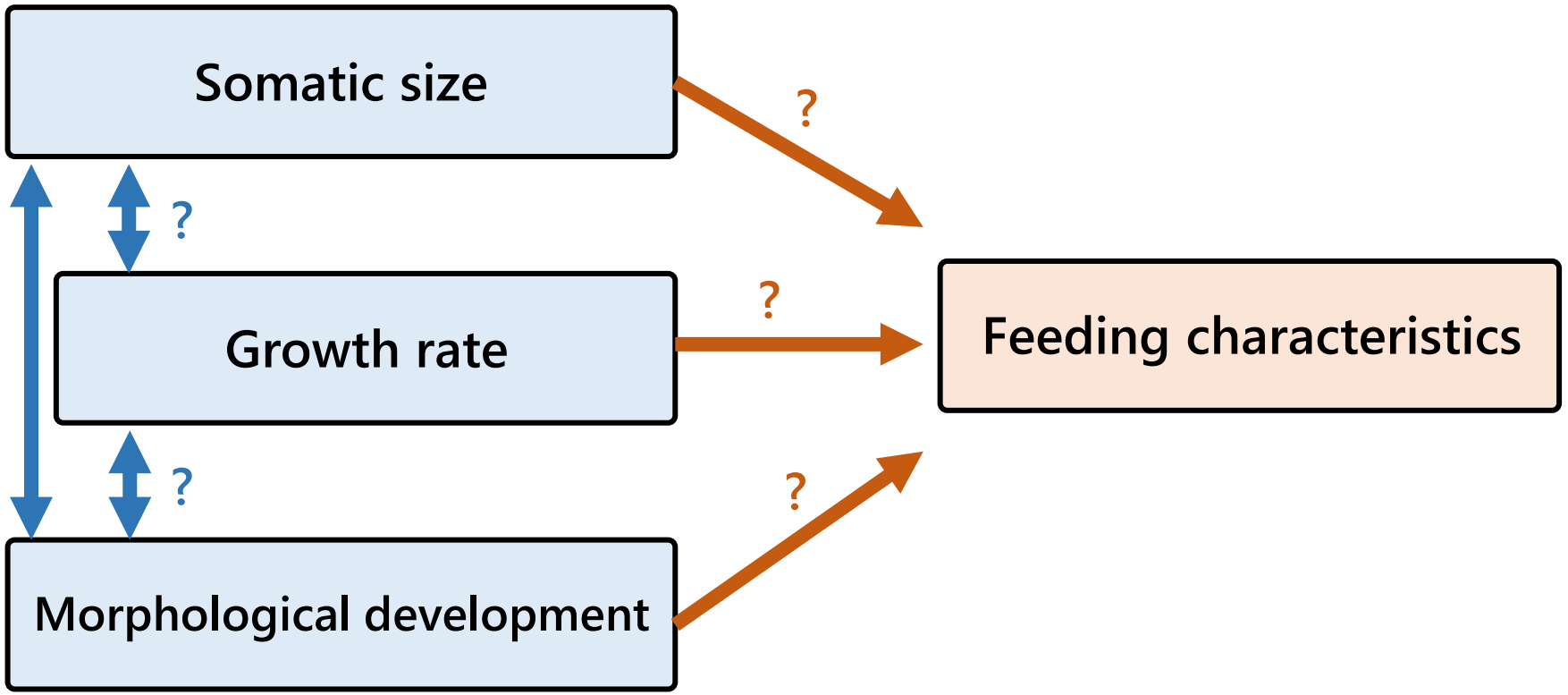


To test the effects on growth autocorrelation

# Objectives of laboratory experiments

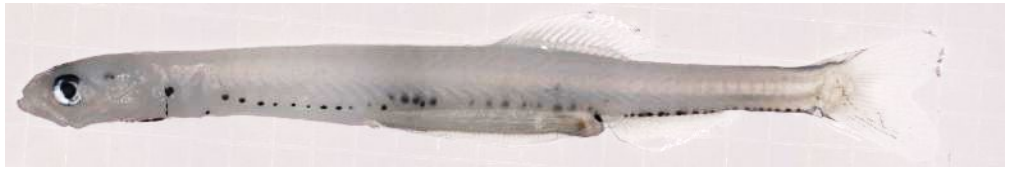
To investigate the growth–feeding linkage

1. To test the relationships among growth characteristics.
2. To test their effects on feeding characteristics.

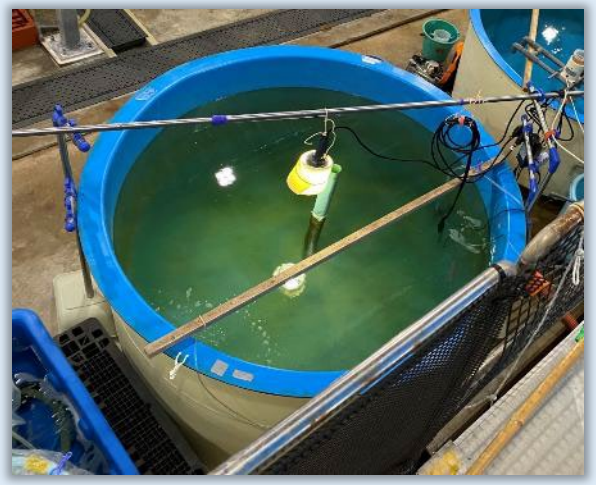


# Laboratory feeding experiments

We used Japanese anchovy *Engraulis japonicus* larvae for the experiments.

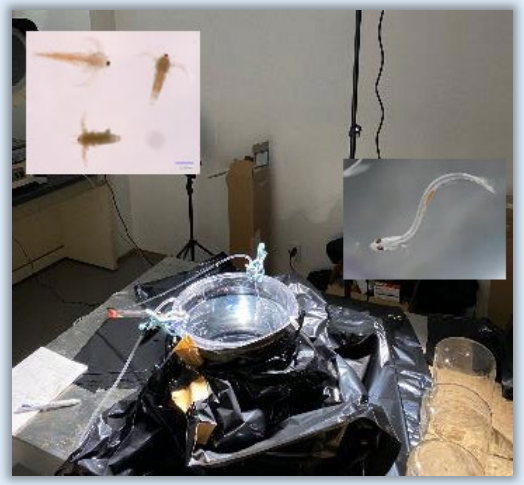


## Larval rearing



- Reared in the same tanks within each batch.
- Sampled at 24–40 dph.

## Feeding experiments



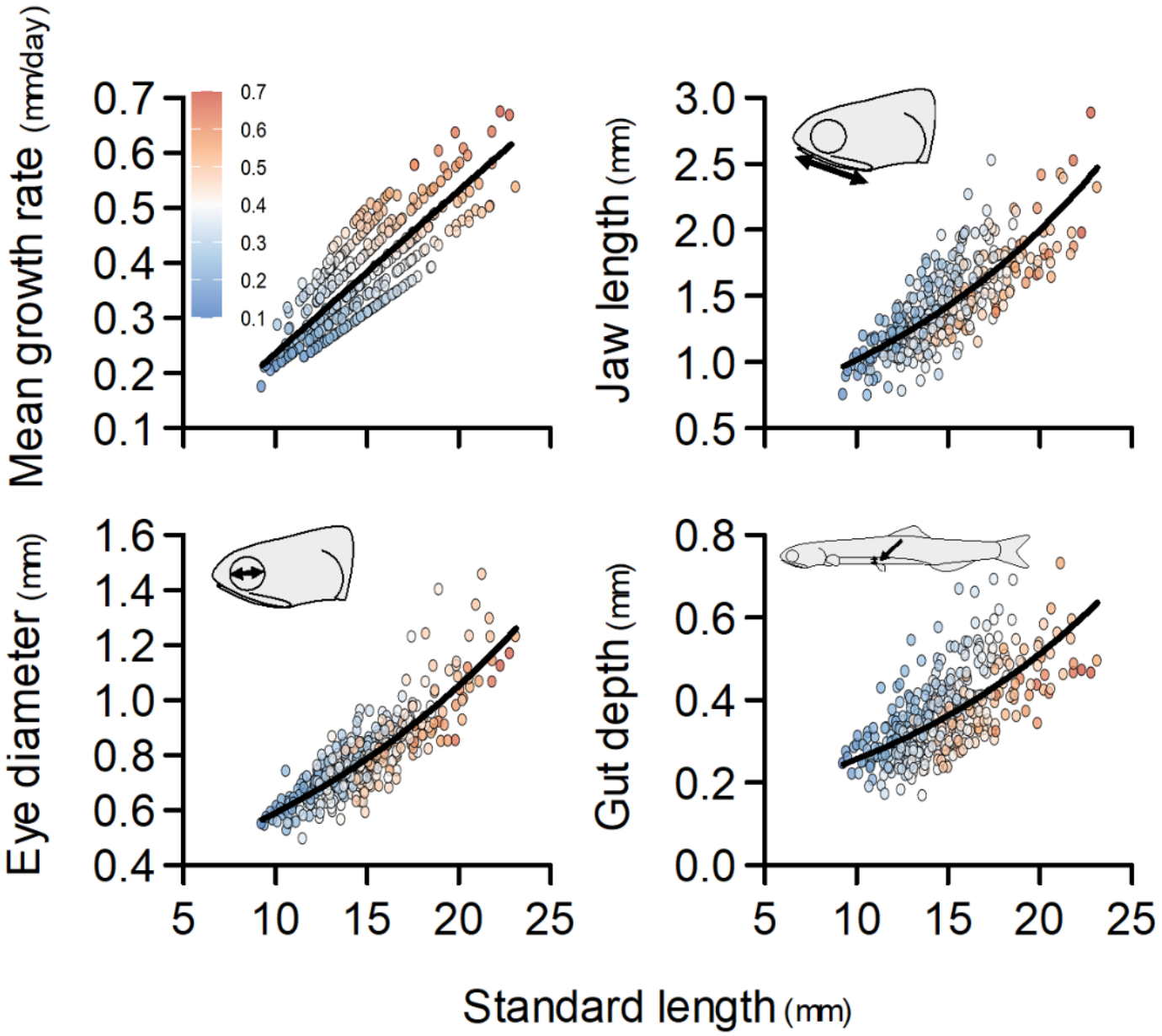
- Added three prey sizes.
- 5-min. feeding period

## Measurements



- Morphological measurements
- Gut content analyses

# Growth characteristics




Somatic size

Positive

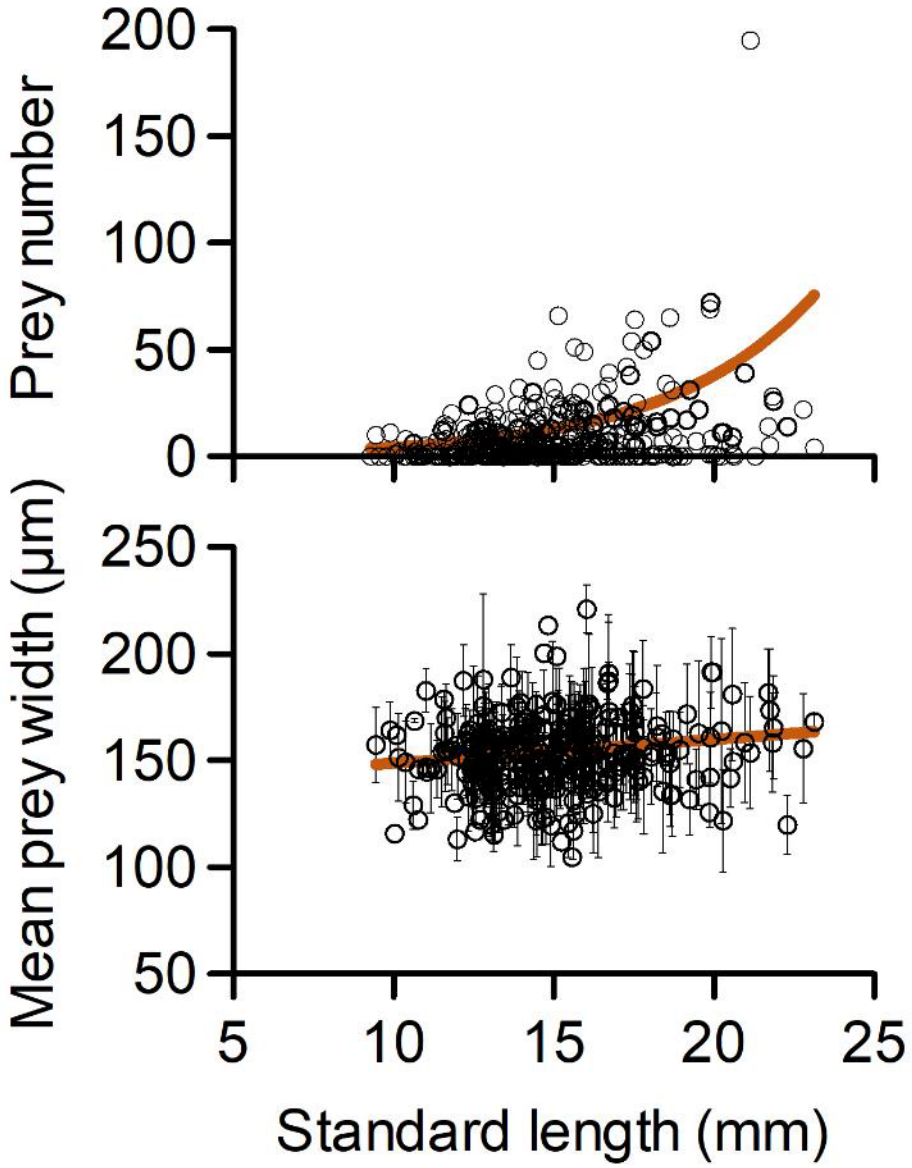
Growth rate

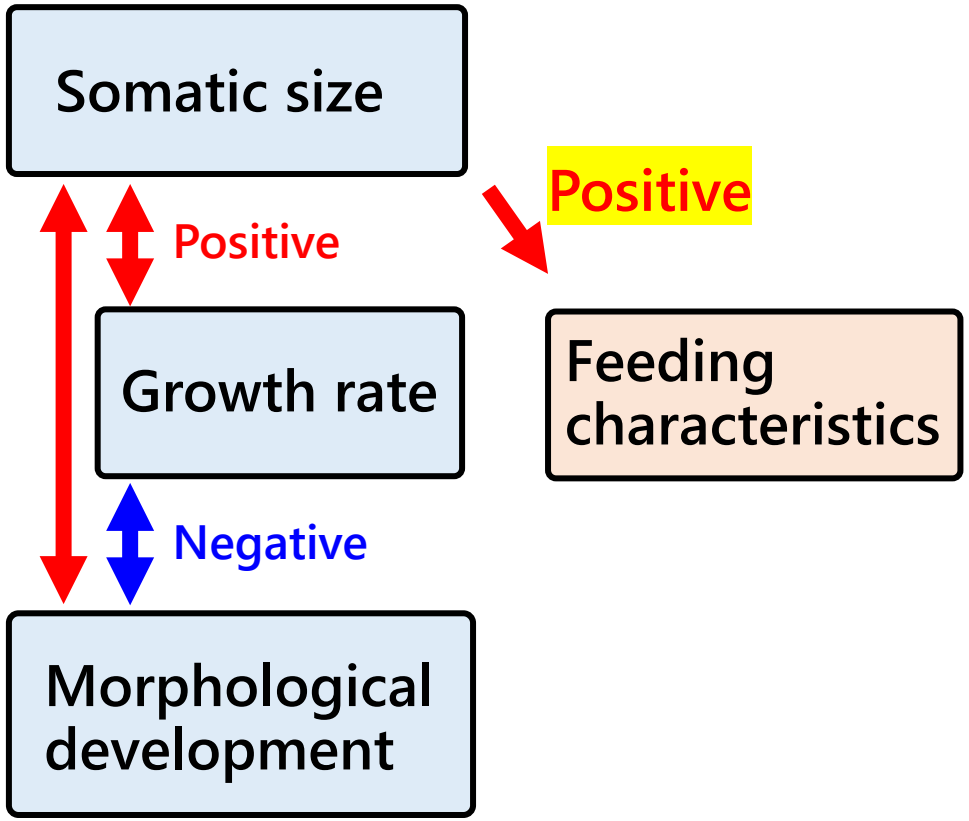
Negative

Morphological development

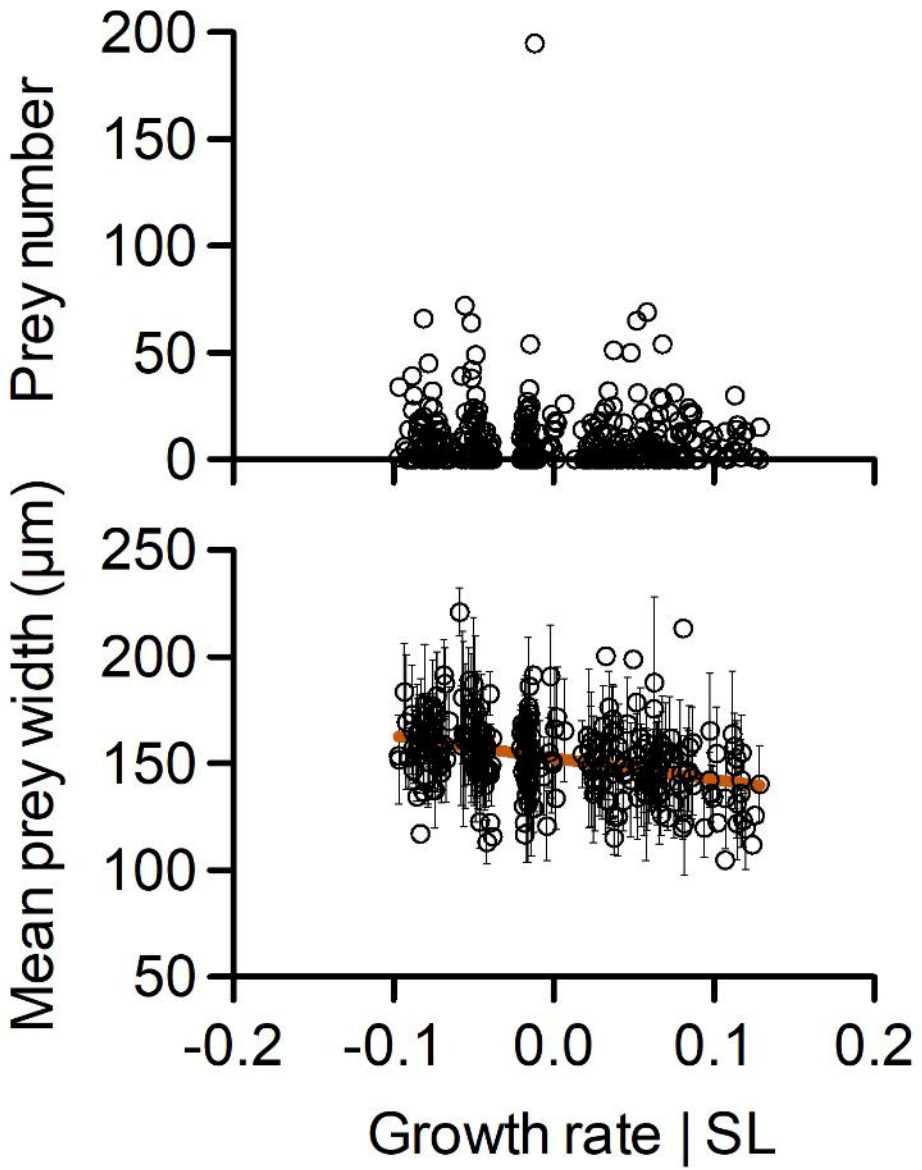
Feeding characteristics

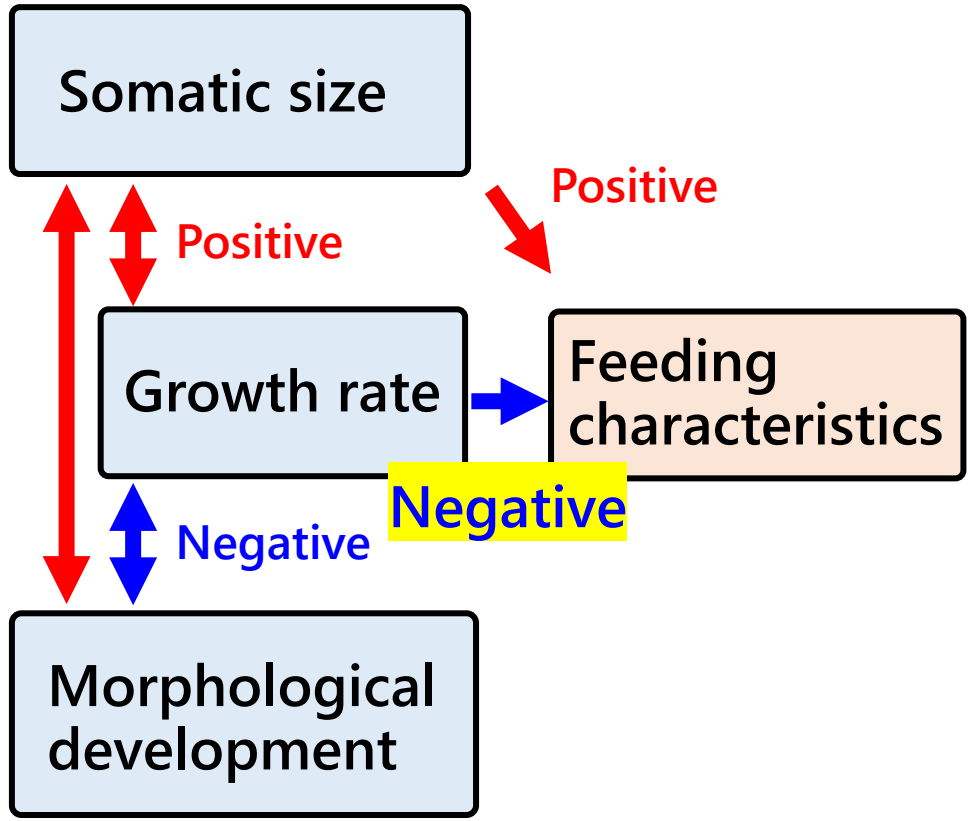
# SL–feeding characteristics



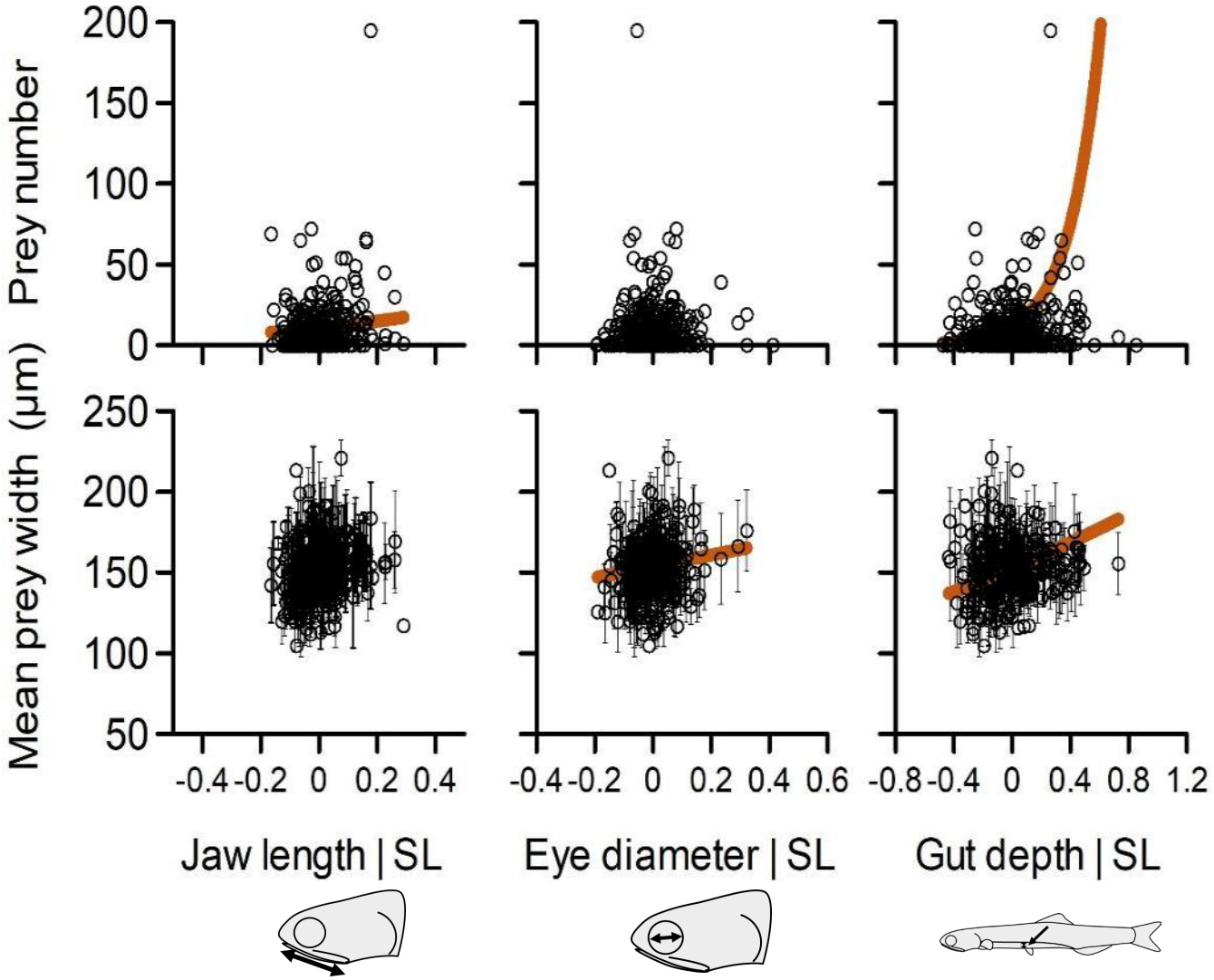



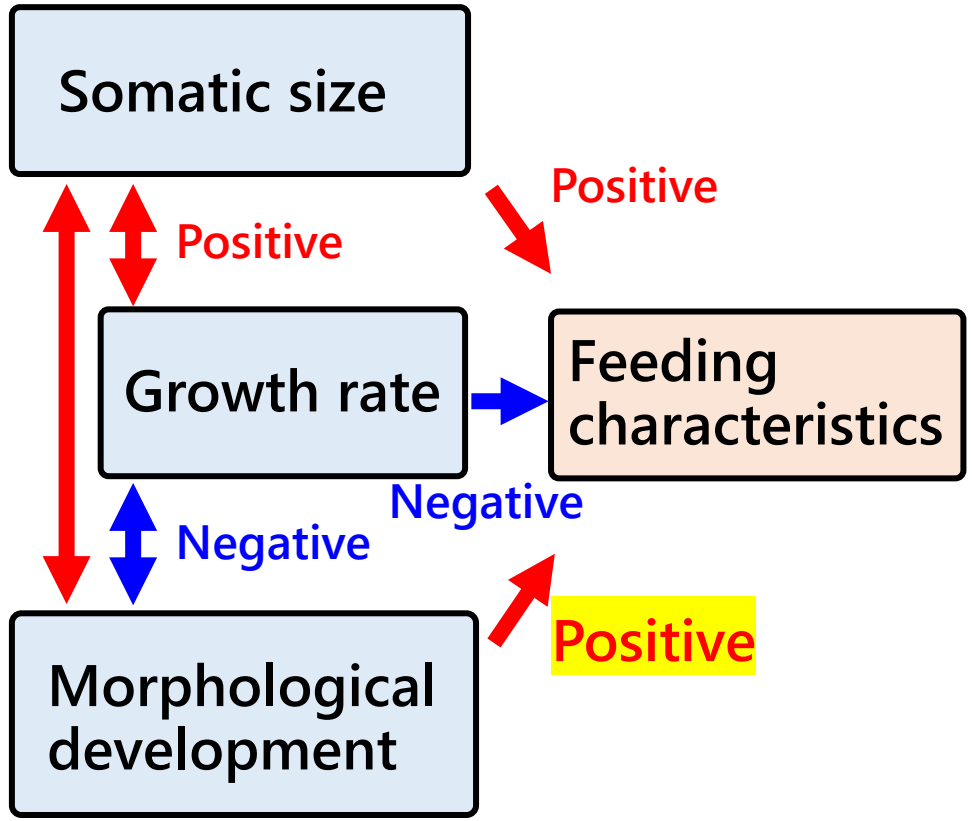
# Growth rate–feeding characteristics



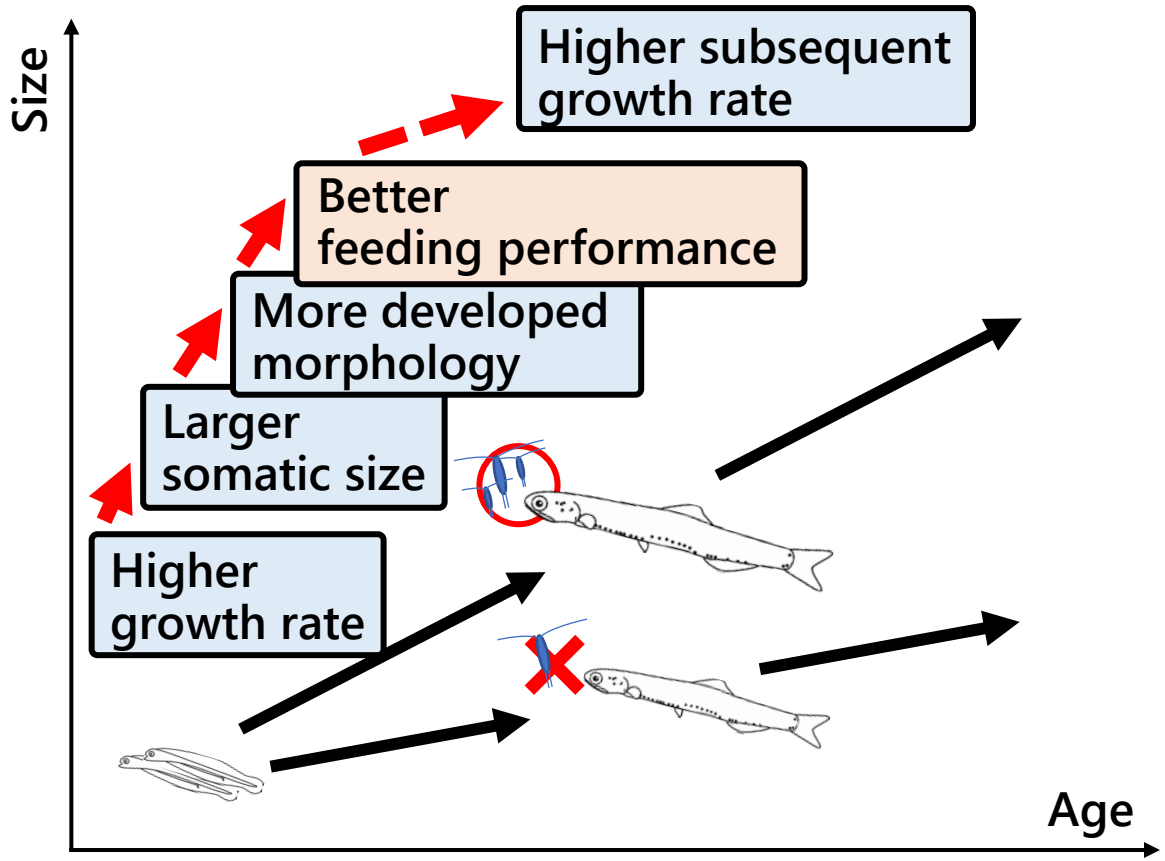



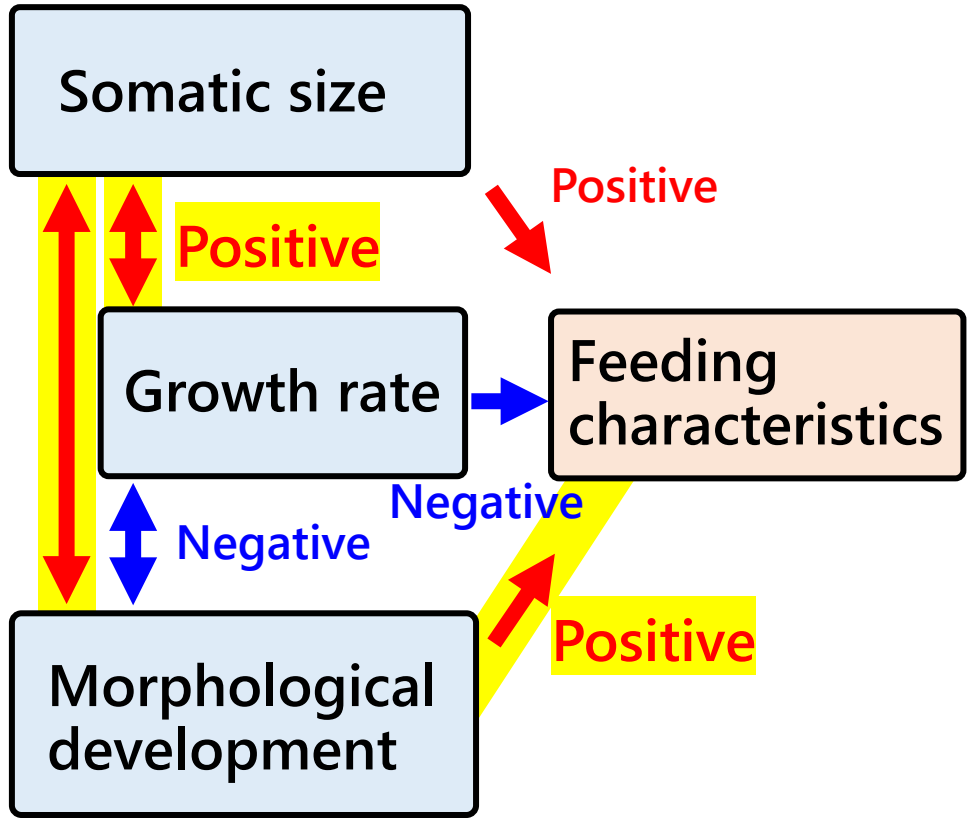
# Morphological development–feeding characteristics



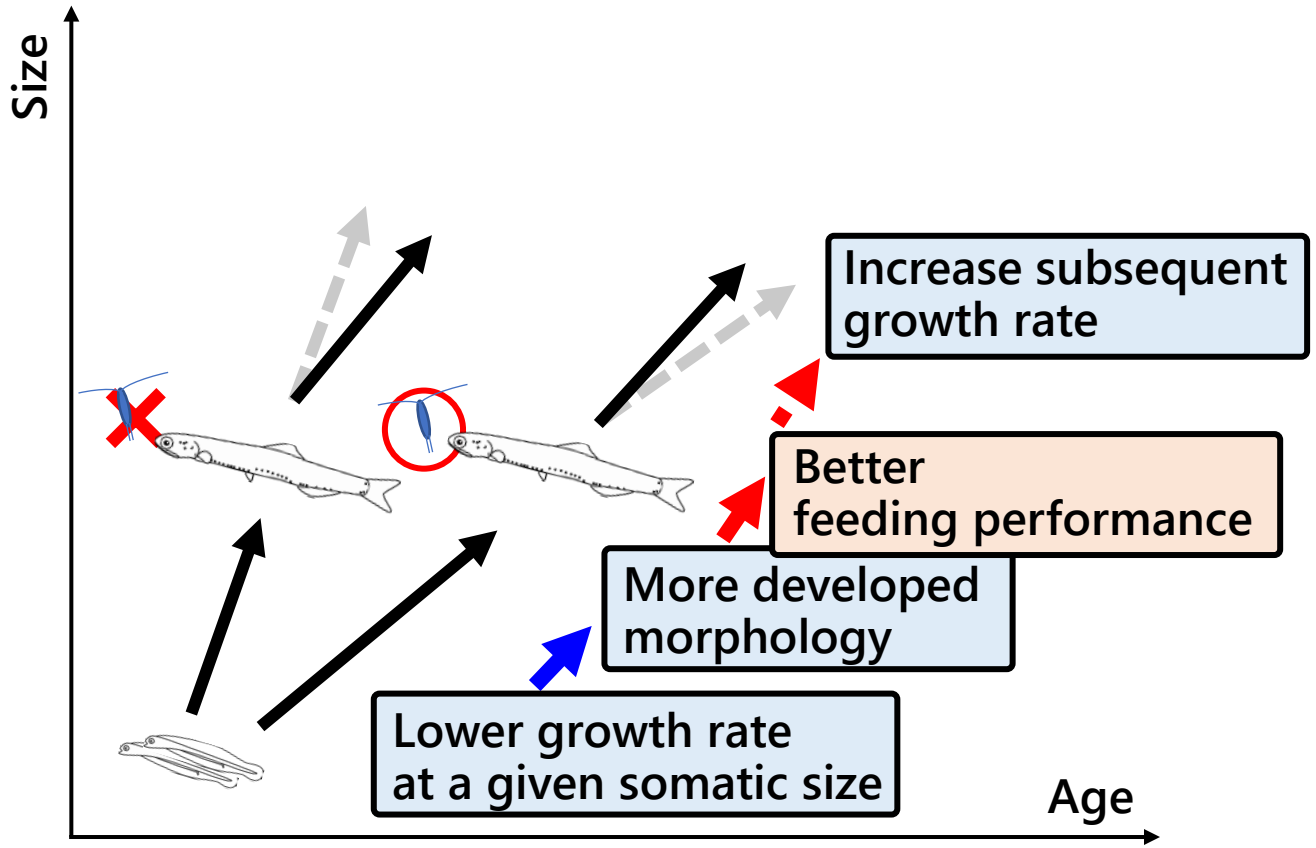
# Size-mediated developmental pathway

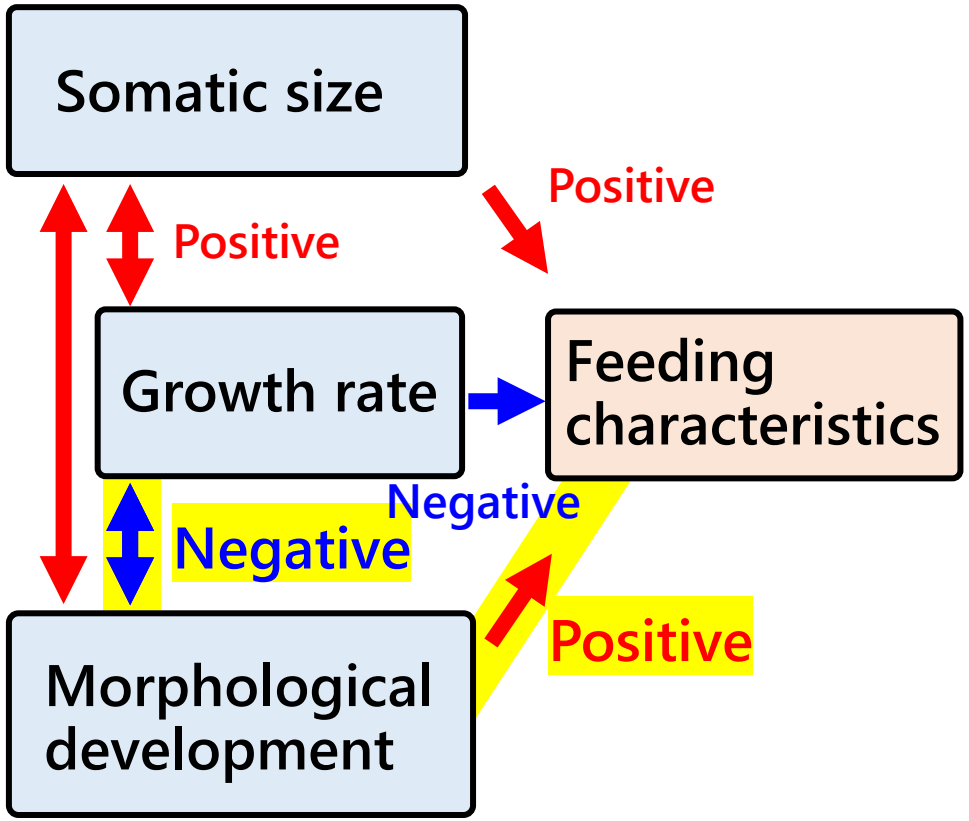



Promoting persistent growth differences (growth autocorrelation)

# Size-independent developmental pathway

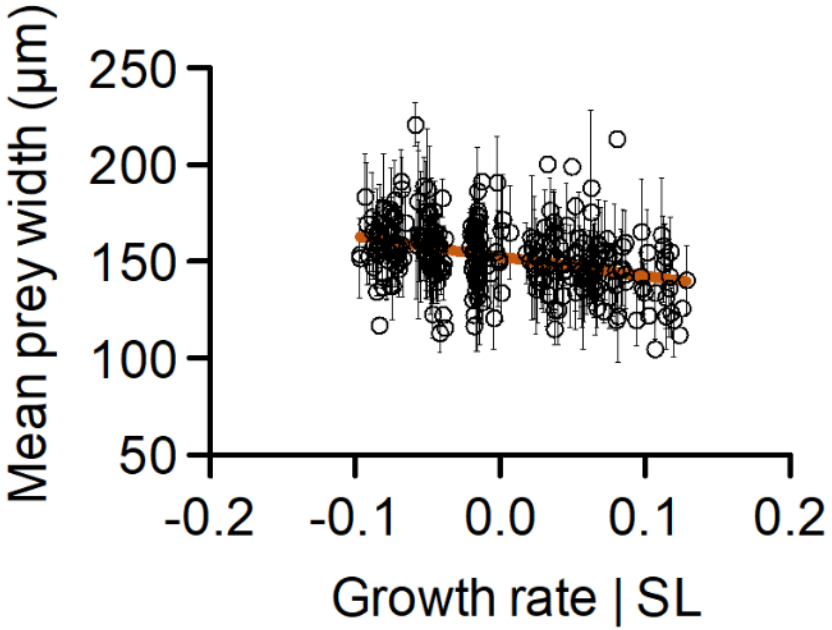


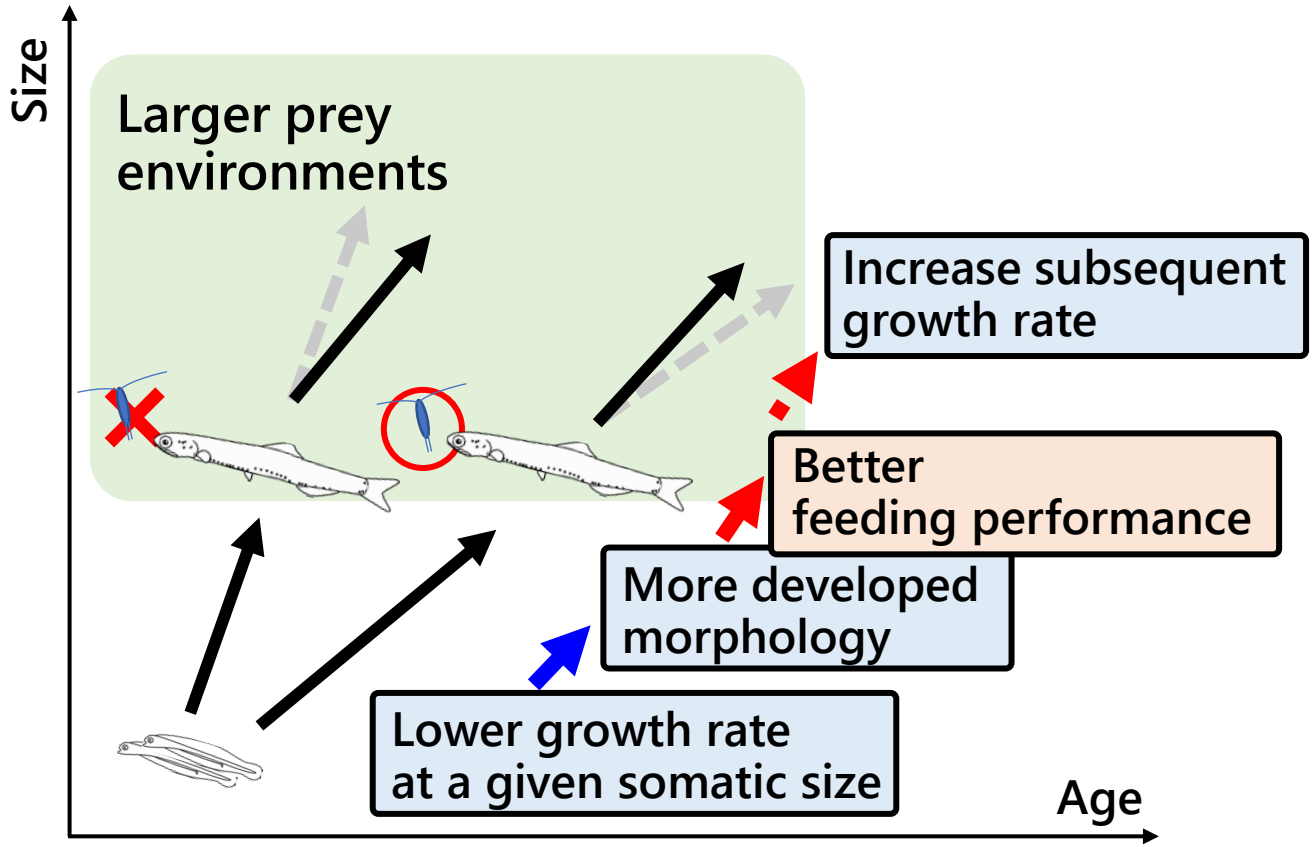

Compensatory process for persistent growth differences

# Hypotheses

Slower growing larvae consumed larger prey items.




**Under larger prey environments, growth autocorrelation could be weakened.**



# Objectives of field study

**To test the relationship between prey size and growth autocorrelation.**

# Datasets

**Field-collected Japanese anchovy larvae**

- Apr. 2021–Apr. 2022
- 12 samples (~300 individuals for each sample)
- Gut content data
- Otolith-based growth data



**Most data are from Tanaka et al. (2026, *FOG*)**


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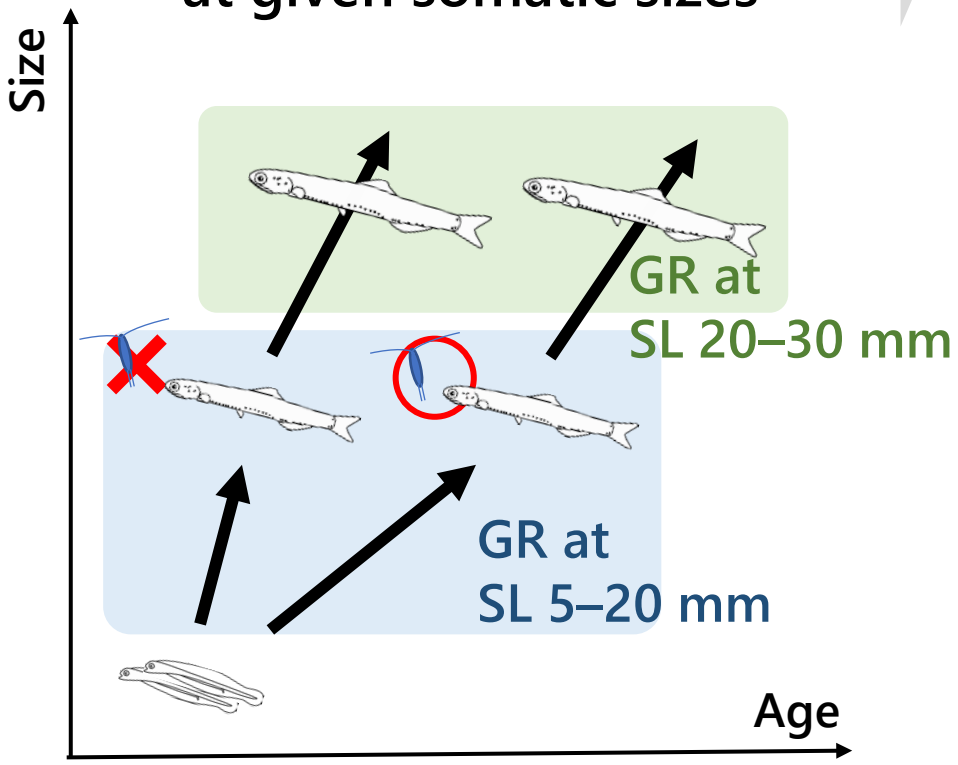
Dynamics of Growth–Feeding Mechanisms in Japanese Anchovy Larvae Under Different Environmental Conditions

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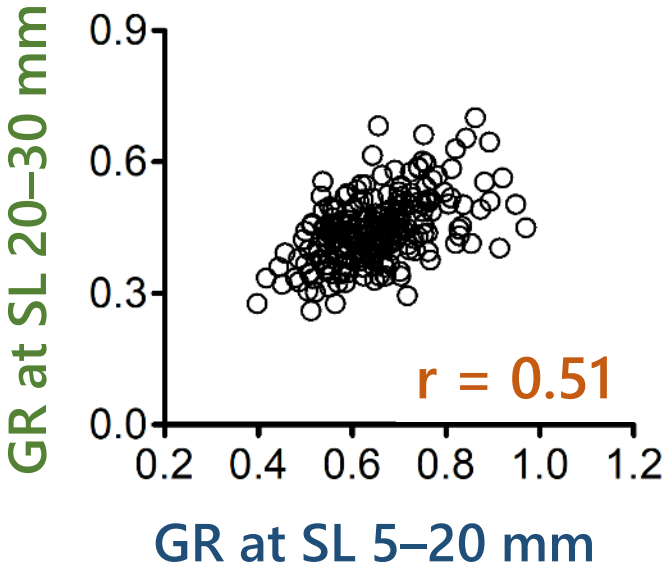
# Hypothesis

**Under larger prey environments, growth autocorrelation is weakened.**

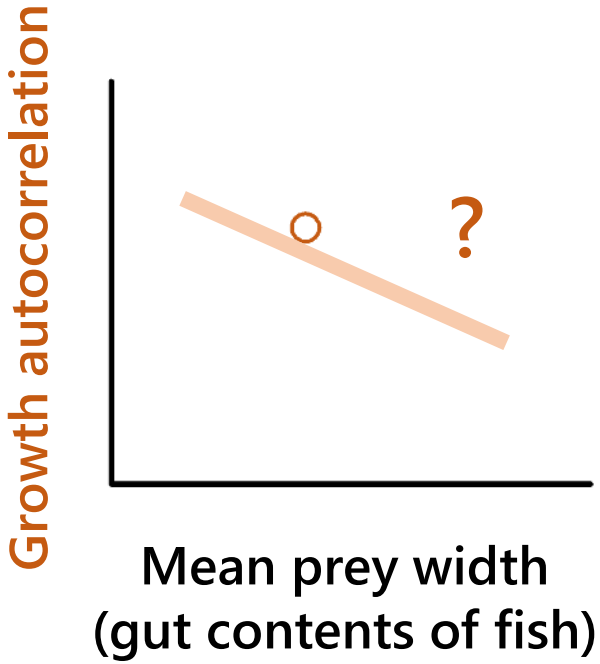
**Back-calculate growth rates at given somatic sizes**

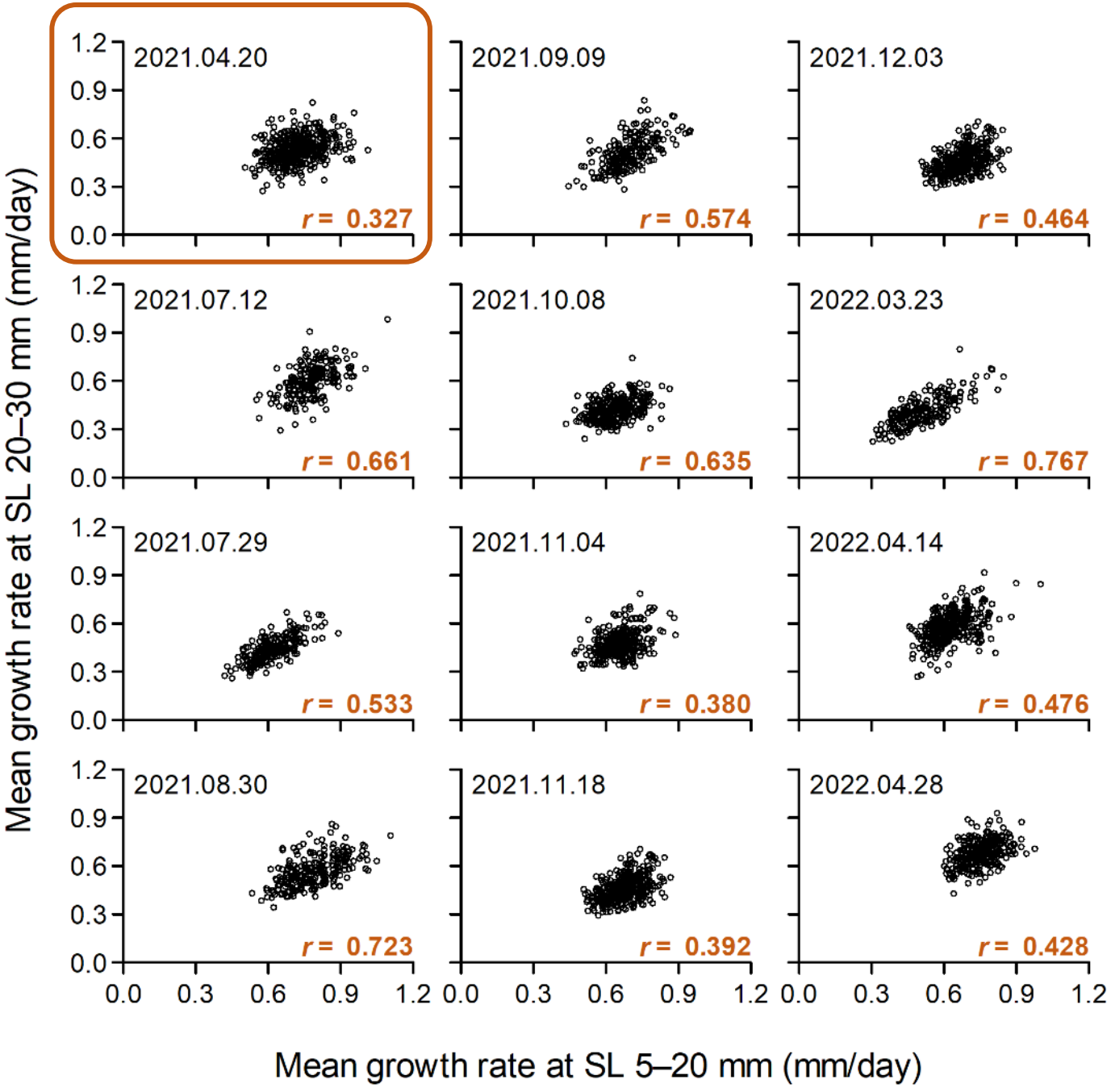



**Calculate correlation (growth autocorrelation)**



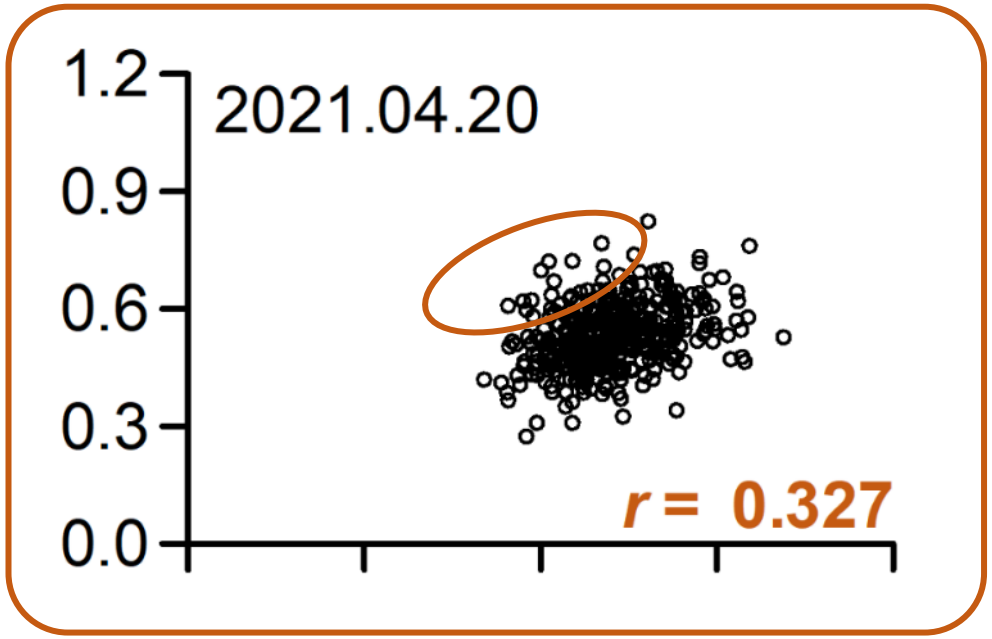

**Test relationship against prey size**



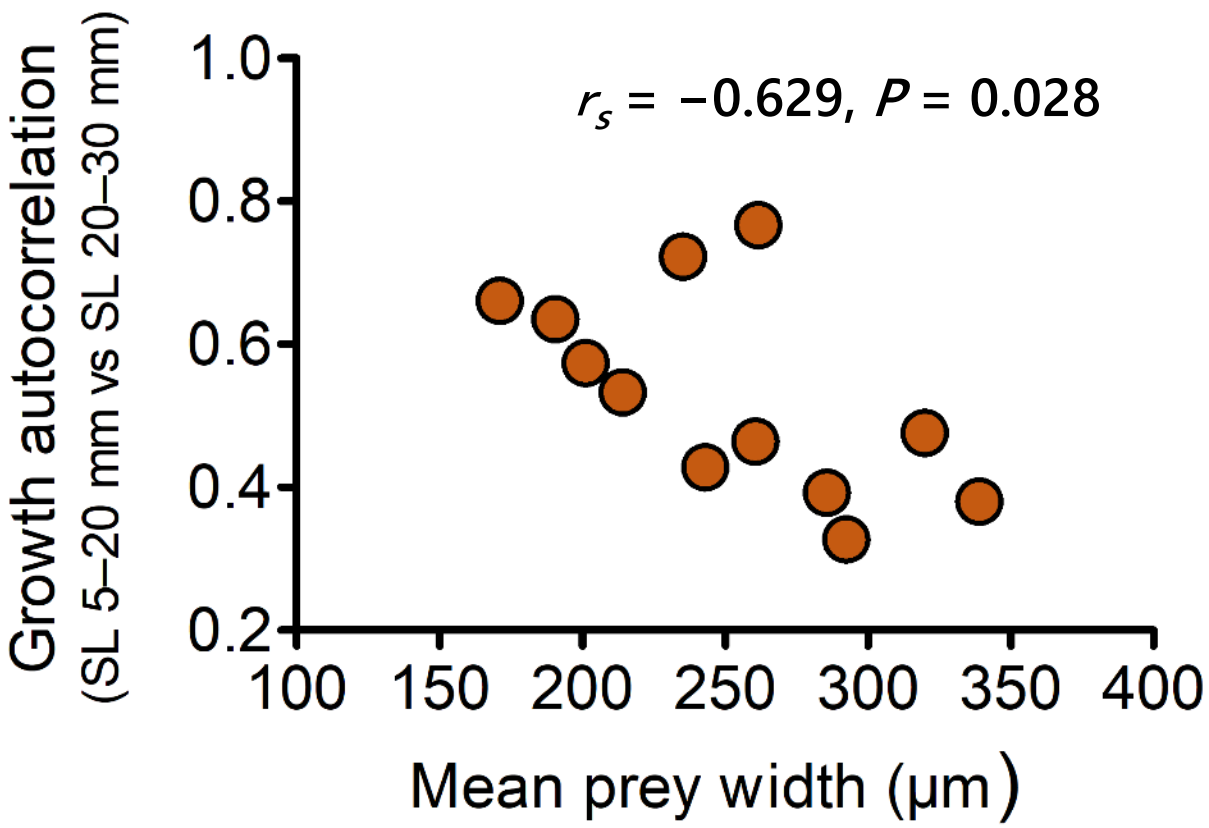



# Growth autocorrelation

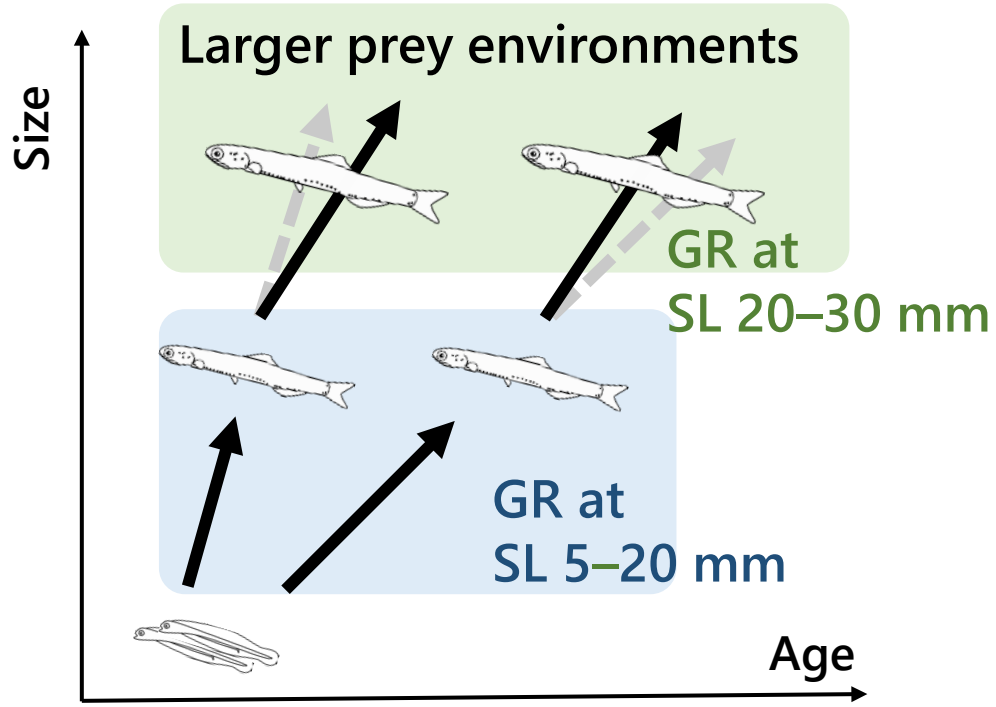
- Correlation values were positive across all samples.
- **In some samples, previously slower-growing larvae showed increased growth rate.**



# Growth autocorrelation under larger prey environments



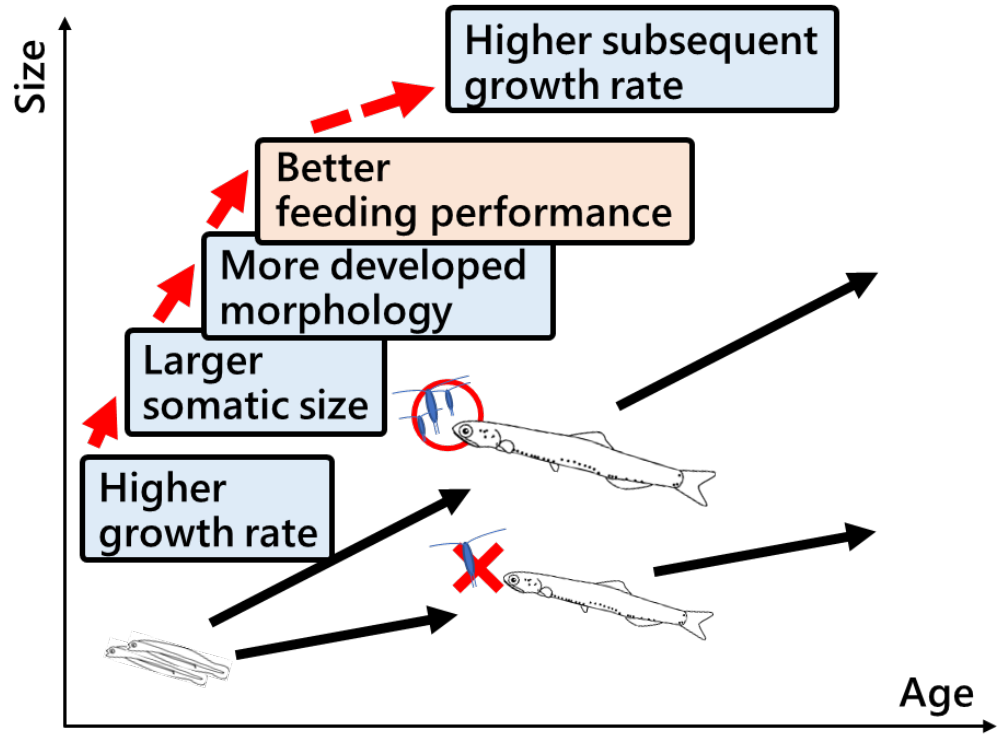

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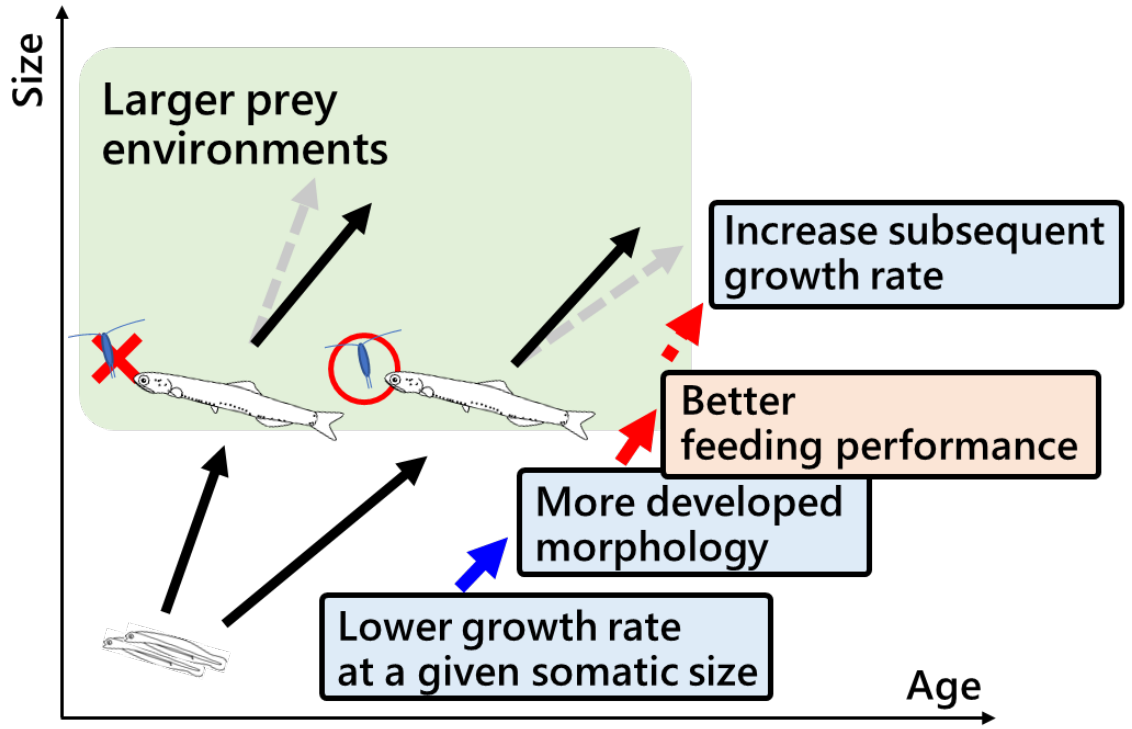

**Consistent with the proposed size-independent developmental pathway**

# Mechanisms underlying variability in growth autocorrelation

## Size-mediated developmental pathway




## Size-independent developmental pathway




**The extent of growth autocorrelation would reflect a balance between two contrasting growth–feeding pathways.**