May 8, 2026
2026 SPF Symposium

Dynamics of growth–feeding linkage in Japanese anchovy larvae:

Insights from field studies and laboratory feeding experiments

Shota Tanaka

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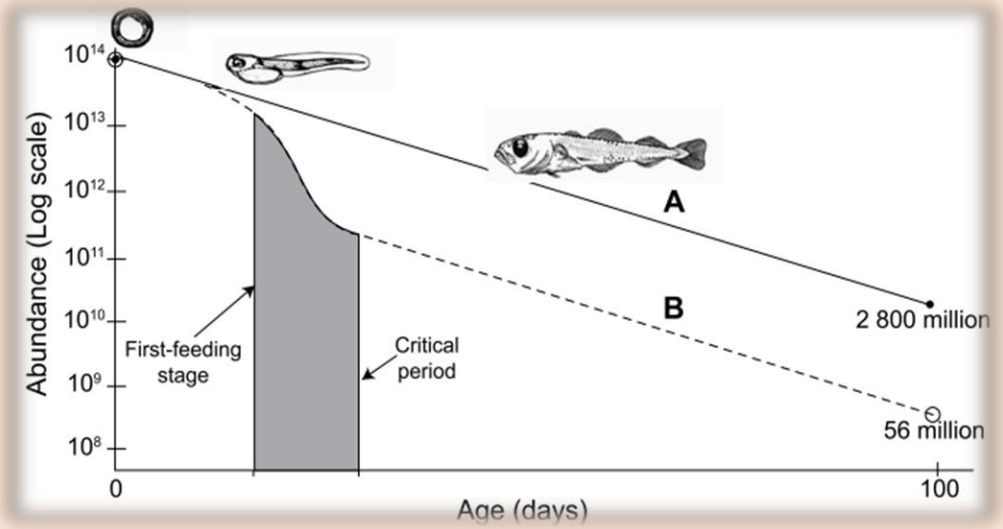
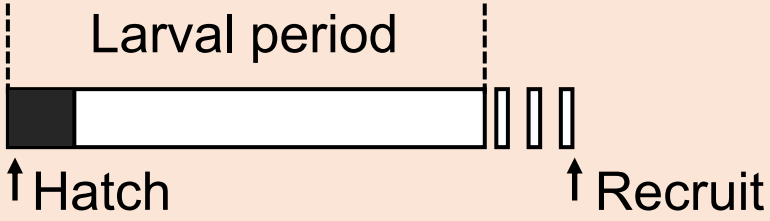
At what life stage is recruitment determined ?

"Critical period" hypothesis

(Hjort, 1914, 1926)



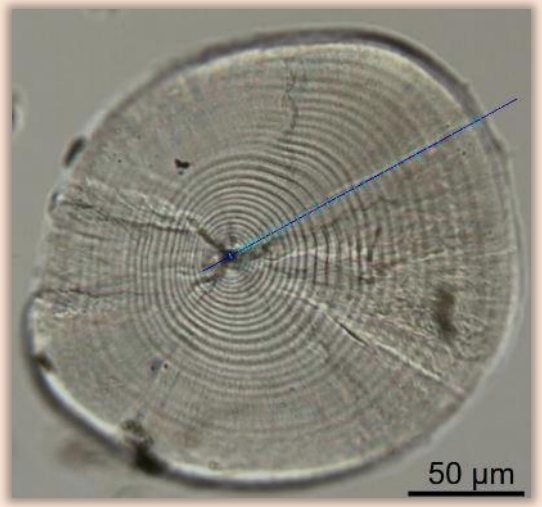
Year-class strength is determined in the short period after first feeding.

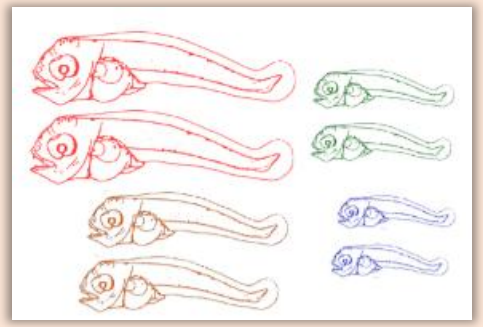


VS

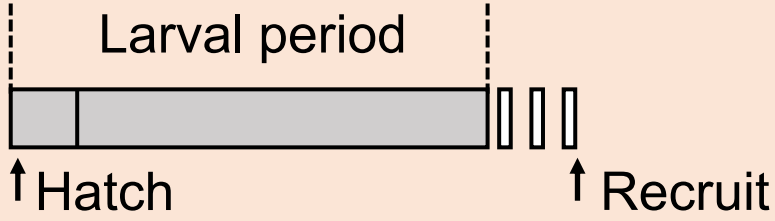
"Growth–survival" paradigm

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





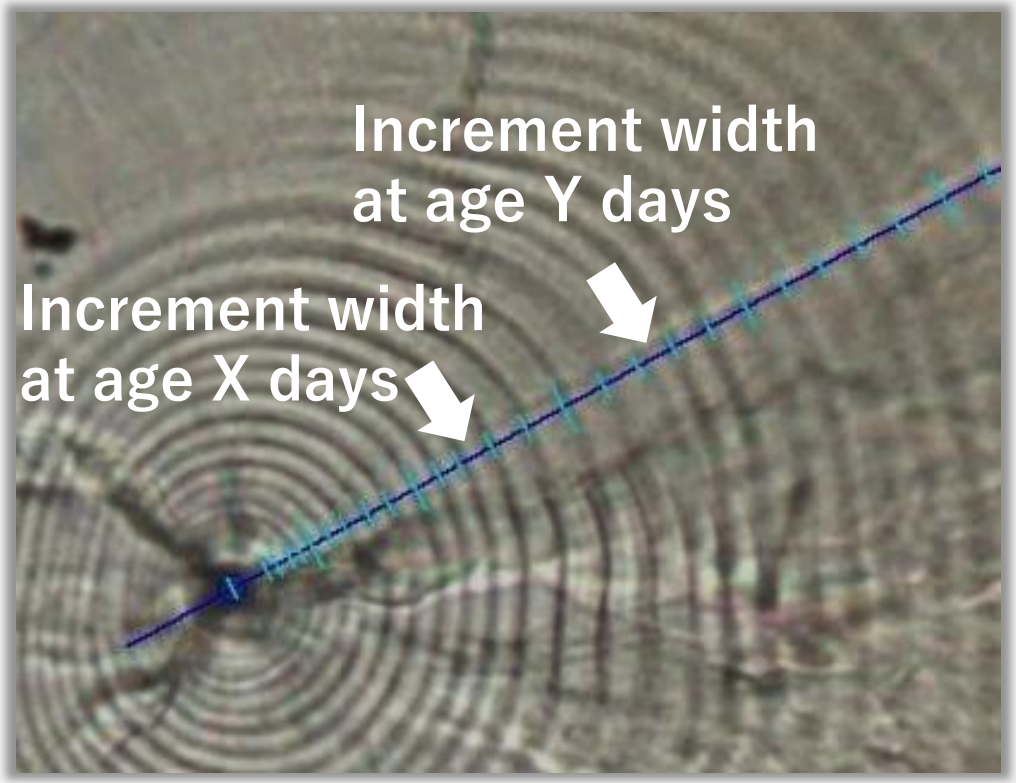
Fast growth throughout the early life influence recruitment.



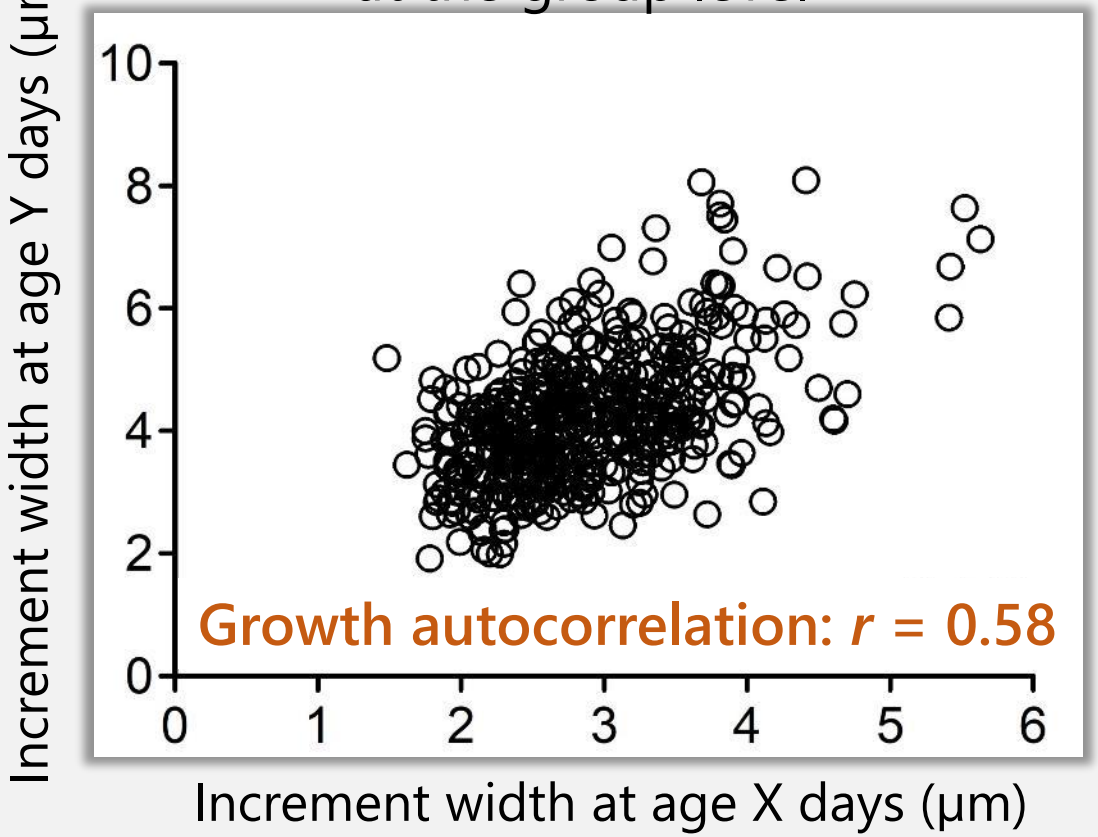
Growth autocorrelation
(Robert et al., 2014; Pepin et al., 2015)

Growth rate generally presents a pattern of autocorrelation.

Select daily otolith increment widths corresponding to two separate daily ages



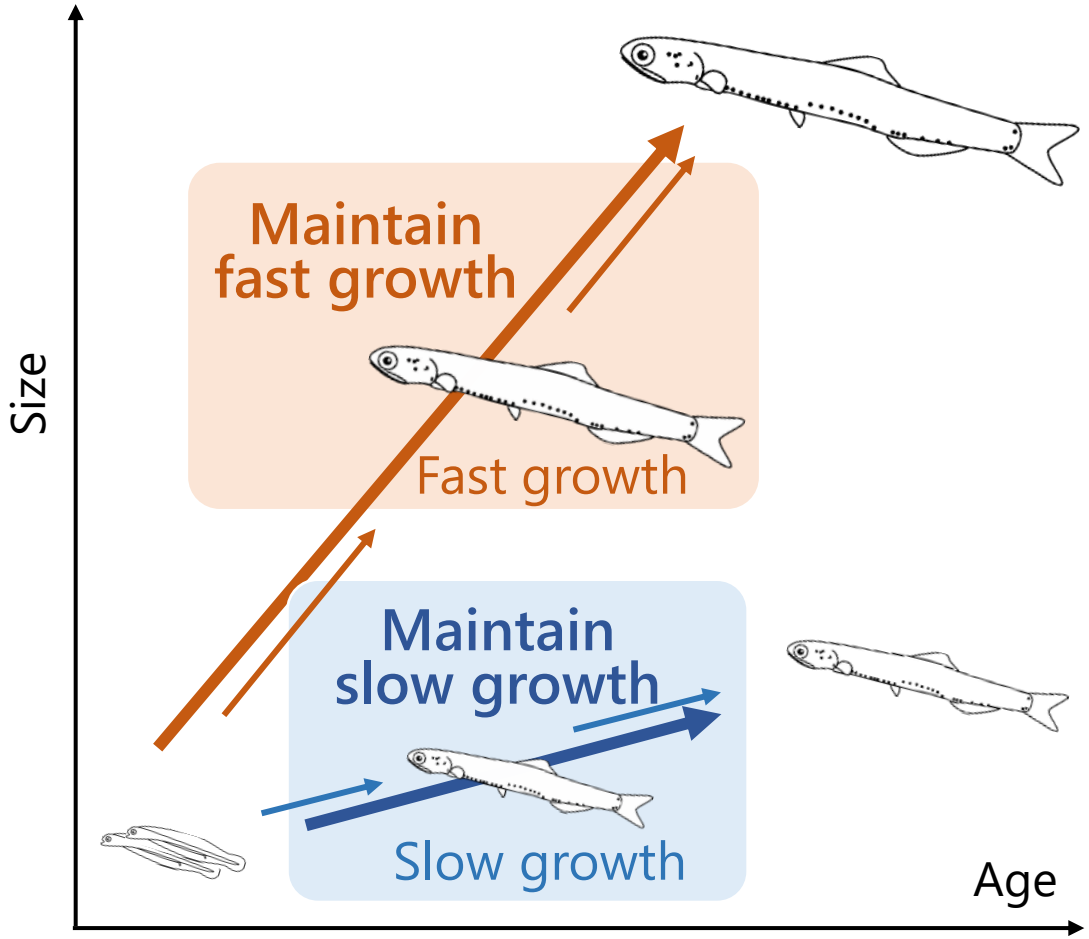
Calculate correlation coefficient at the group level



Growth autocorrelation in small pelagic fish (SPF) larvae

(Tanaka et al., 2023)

SPF showed strong growth autocorrelation throughout the larval stage.



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ORIGINAL ARTICLE

FISHERIES OCEANOGRAPHY WILEY

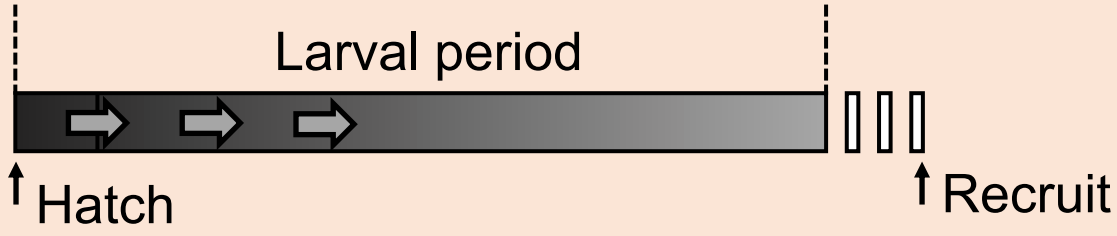
Revisiting the role of early life growth for survival potential in three clupeoid species

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

Reconciled hypothesis

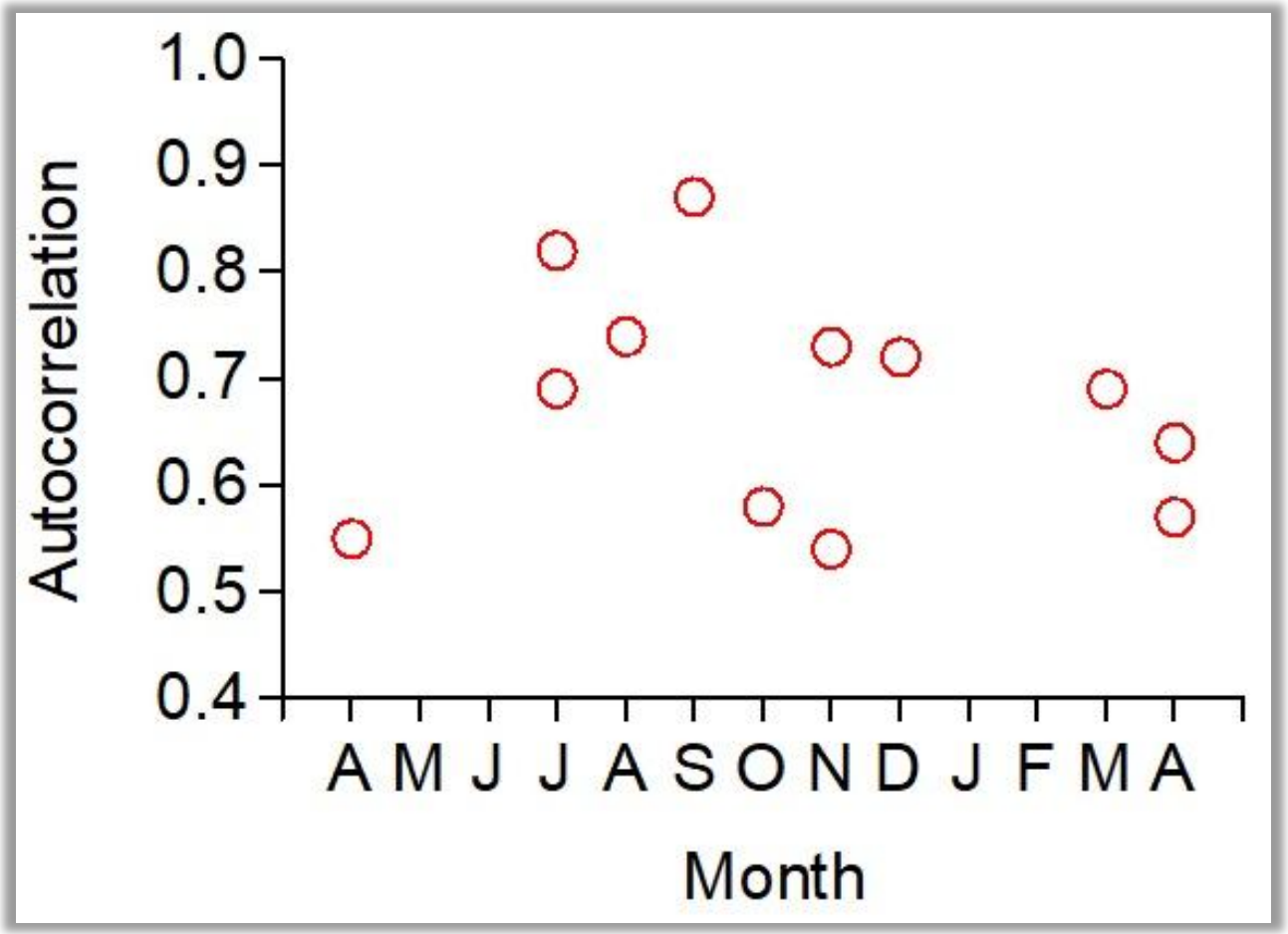
(Tanaka et al., 2023)

The growth rate after first feeding influence growth rate throughout the early life.



Dynamics of growth autocorrelation

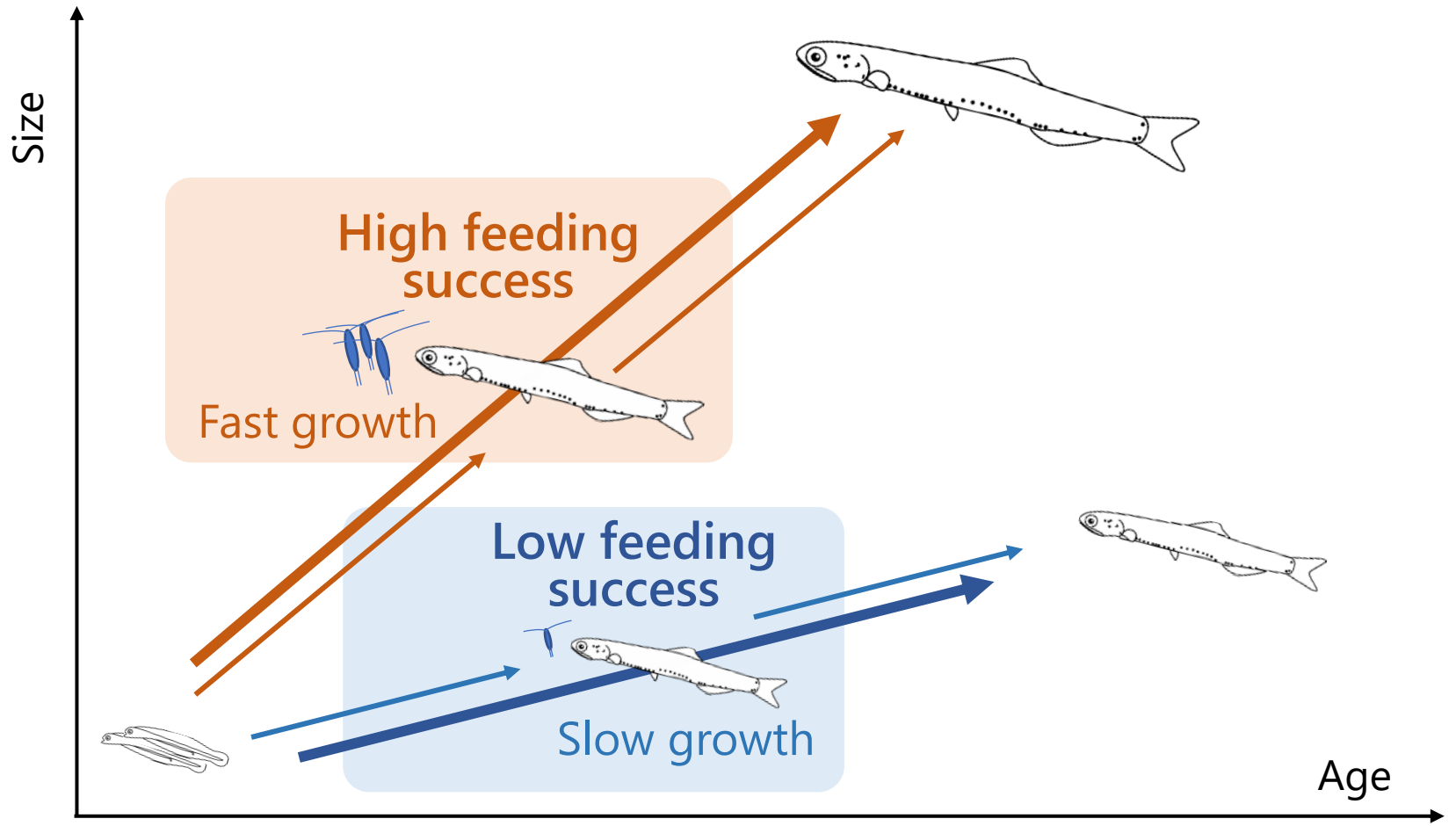
(Tanaka et al., in preparation)



Seasonal samples of Japanese anchovy larvae.
(***Engraulis japonicus***)

Need to elucidate the underlying mechanisms

Growth–feeding linkage



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

Objectives

To examine the dynamics of growth–feeding linkage

Field studies

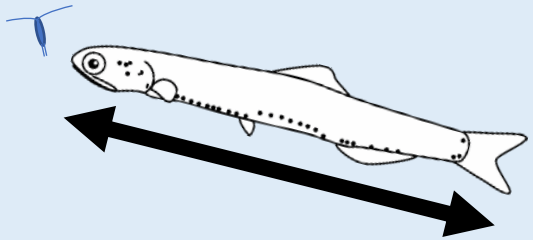
Test the dynamics of growth–feeding linkage

Laboratory feeding experiments

Test the mechanisms of growth–feeding linkage

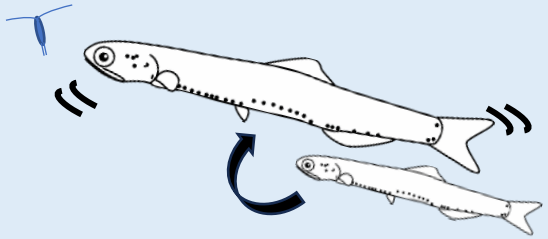
Growth–feeding mechanisms (Togoshi et al., 2024)

"Somatic size" mechanism



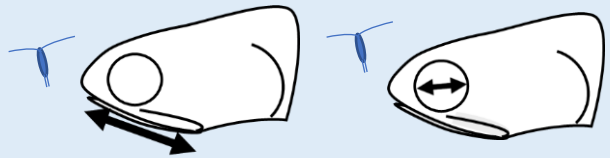
Higher swimming ability

"Growth rate" mechanism



Higher nutrient condition

"Morphological development" mechanism



Larger prey size
Higher visual acuity

Togoshi et al. (2024)

Test three mechanisms
in anchovy and round herring larvae
based on **prey presence/absence**

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ORIGINAL ARTICLE

FISHERIES OCEANOGRAPHY WILEY

Growth–feeding linkage in small pelagic fish larvae in the Kii Channel, Japan

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

Species	Sample ID	“Somatic size” mechanism	“Growth rate” mechanism	“Morphological development” mechanism	
				Jaw length	Eye diameter
Anchovy	A1	Effective	Contrary	–	–
	A2	Effective	NS	–	–
	A3	Effective	NS	Effective	Effective
	A4	Effective	Effective	Effective	Effective
	A5	Effective	NS	Effective	NS
	A6	Effective	Effective	NS	NS
Round herring	R1	Effective	Effective	–	–
	R2	Effective	Effective	Effective	Effective
	R3	Effective	Effective	Effective	Effective
	R4	Contrary	Contrary	Effective	Effective

Modified from Togoshi et al. (2024)

Dynamics of the growth–feeding linkage were suggested.

→Need to test quantitative feeding success

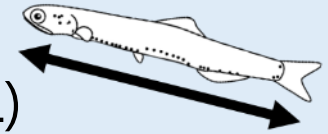
Materials & Methods

Japanese anchovy (*Engraulis japonicus*) larvae

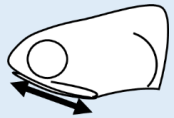
- Apr 2021–Apr. 2022
- 8 samples (A1–A8)
- *n* =2,347 individuals

Growth characteristics

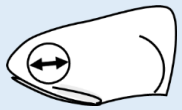
- Standard length (SL)



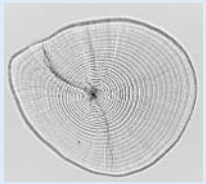
- Jaw length



- Eye diameter

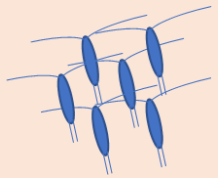


- Recent 3-day growth rate

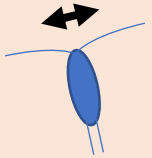


Feeding characteristics

- Prey 1/0



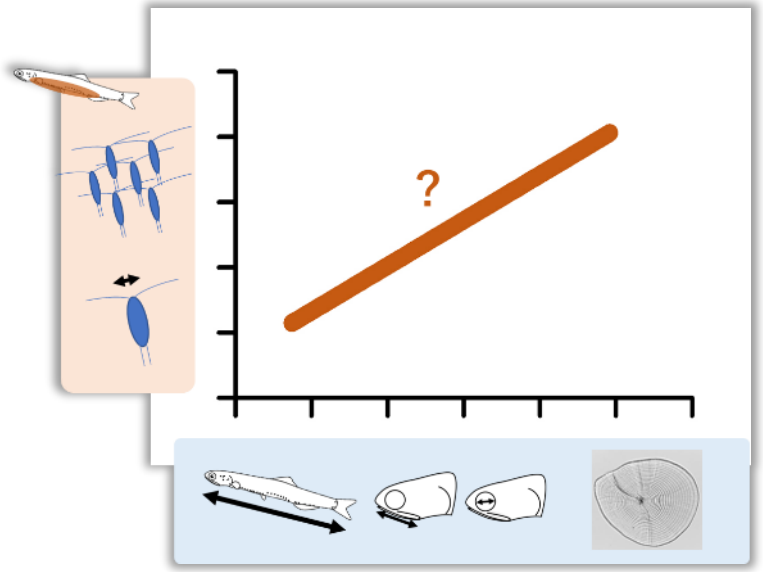
- Number
- Size



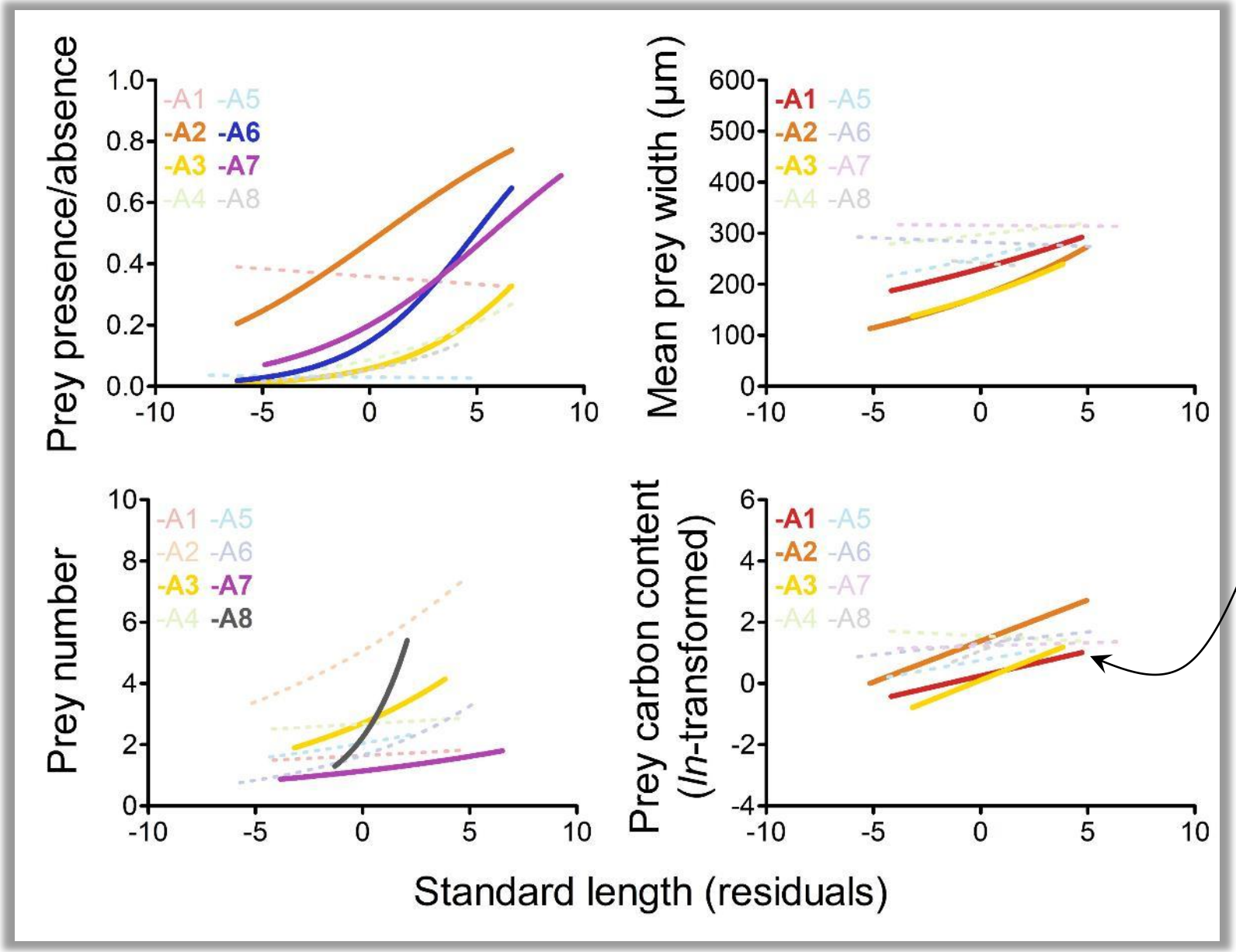
- Carbon content
  (using conversion formula)

Test relationships

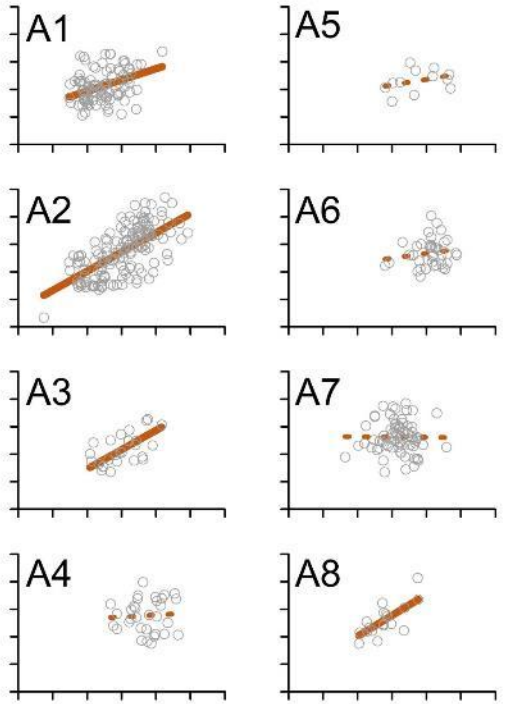
Generalized Linear Model (GLM)

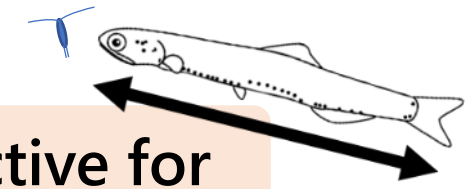


“Somatic size” mechanism



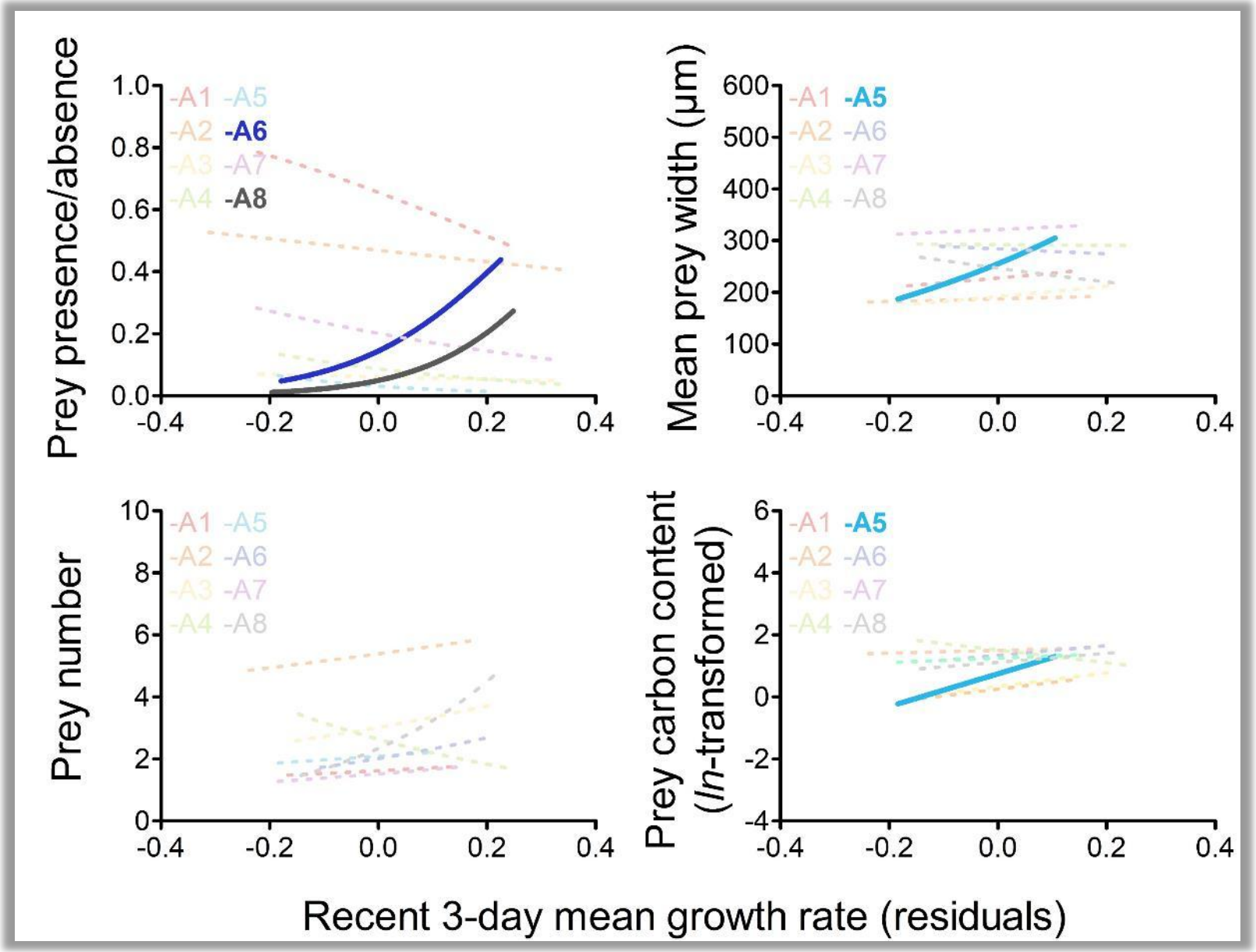
Solid lines indicate significant relationships.

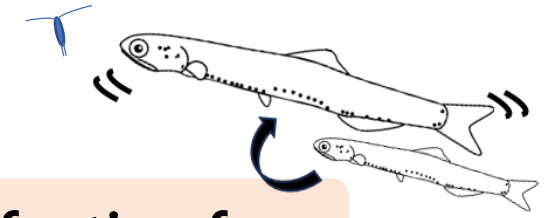




Effective for 3–4 samples

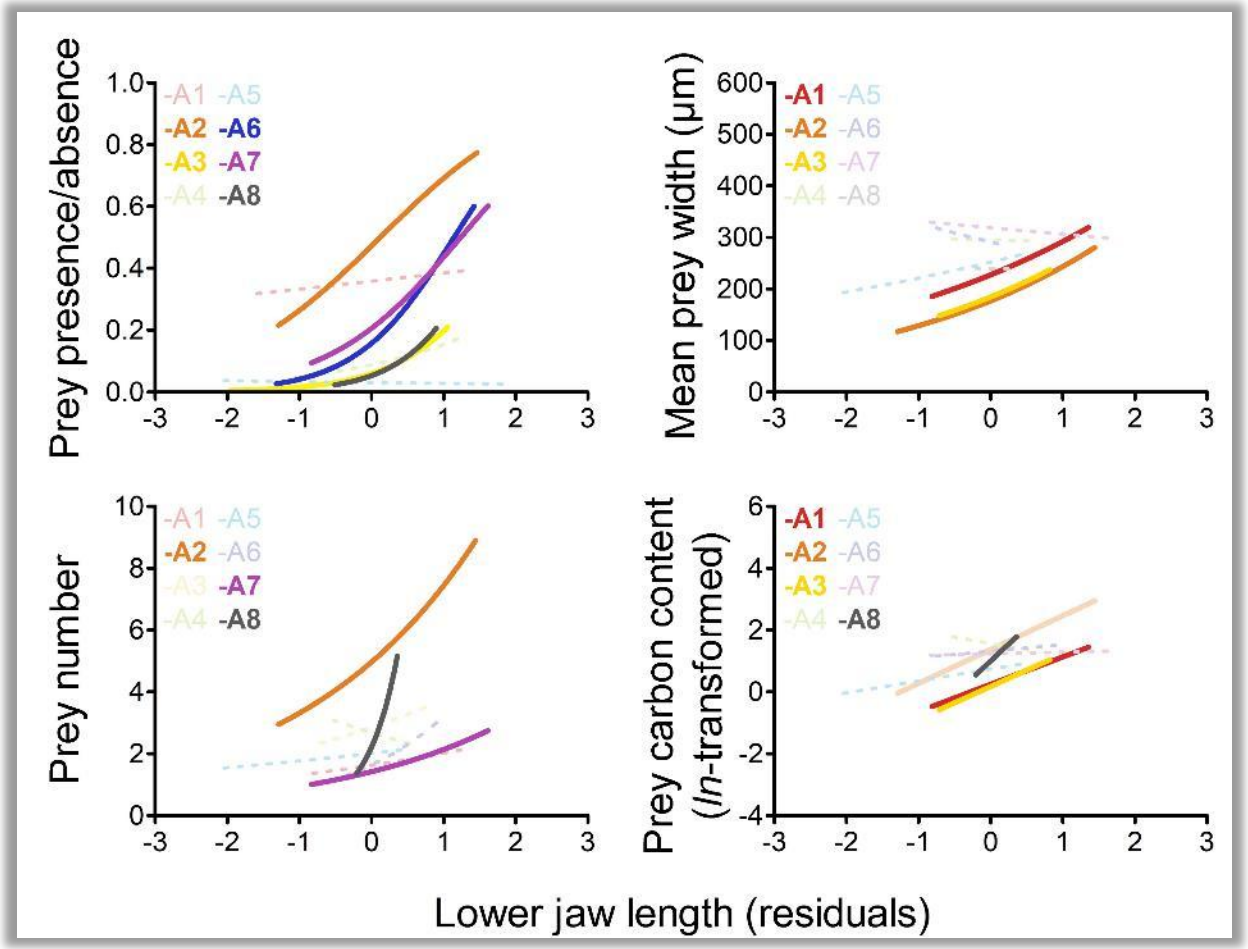
“Growth rate” mechanism

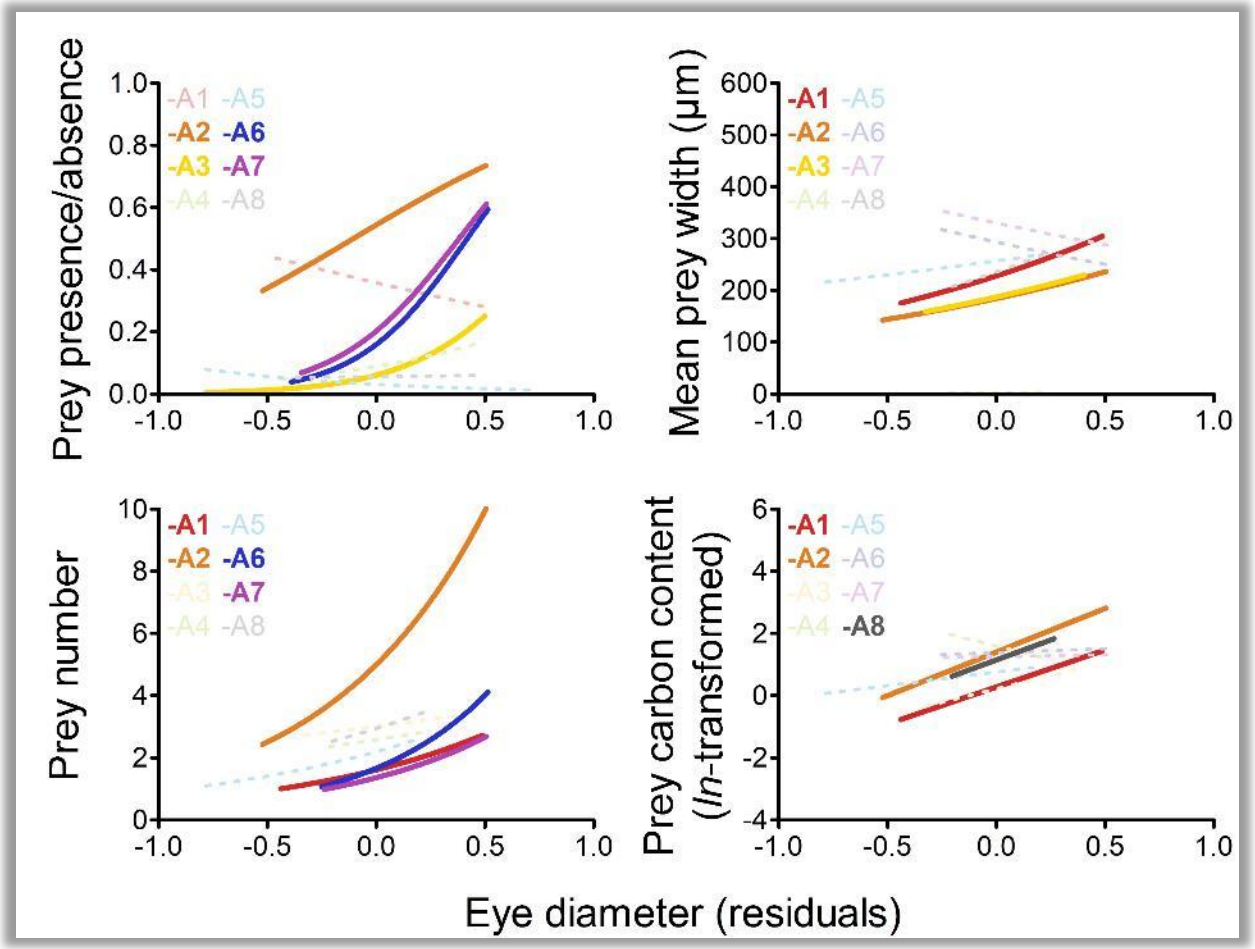




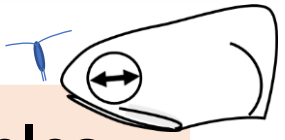
Effective for 0–2 samples

“Morphological development” mechanism





Effective for 3–5 samples



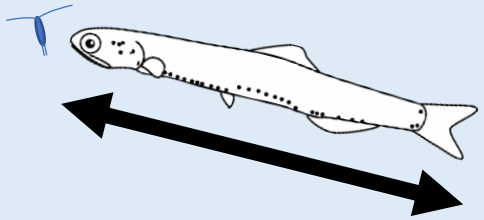
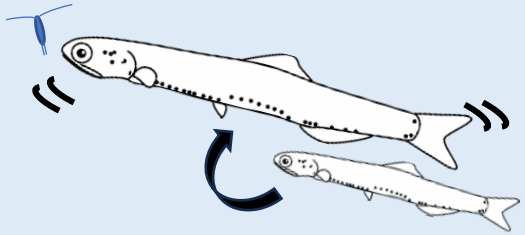
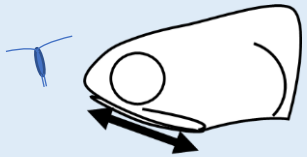
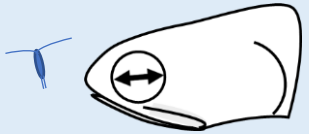
Effective for 3–4 samples

ID	“Somatic size” mechanism				“Growth rate” mechanism				“Morphological development” mechanism							
									Jaw length				Eye diameter			
	0 or 1	Number	Size	Carbon	0 or 1	Number	Size	Carbon	0 or 1	Number	Size	Carbon	0 or 1	Number	Size	Carbon
A1	NS	NS	Effective	Effective	NS	NS	NS	NS	NS	NS	Effective	Effective	NS	Effective	Effective	Effective
A2	Effective	NS	Effective	Effective	NS	NS	NS	NS	Effective	Effective	Effective	Effective	Effective	Effective	Effective	Effective
A3	Effective	Effective	Effective	Effective	NS	NS	NS	NS	Effective	NS	Effective	Effective	Effective	NS	Effective	NS
A4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A5	NS	NS	NS	NS	NS	NS	Effective	Effective	NS	NS	NS	NS	NS	NS	NS	NS
A6	Effective	NS	NS	NS	Effective	NS	NS	NS	Effective	NS	NS	NS	Effective	Effective	NS	NS
A7	Effective	Effective	NS	NS	NS	NS	NS	NS	Effective	Effective	NS	NS	Effective	Effective	NS	NS
A8	NS	Effective	NS	NS	Effective	NS	NS	NS	Effective	Effective	NS	Effective	NS	NS	NS	Effective

Dynamics of growth–feeding mechanisms across seasonal samples and feeding characteristics

Explanation for the dynamics

The dynamics in the growth–feeding mechanisms would be explained by different growth characteristics playing different roles in feeding success.

Larger somatic size	Higher growth rates	Larger jaw length	Larger eye diameter
			
Higher swimming ability	Higher nutrient condition	Larger prey size	Higher visual acuity

→ Need to examine relationships between growth and feeding characteristics

Objectives

To examine the dynamics of growth–feeding linkage

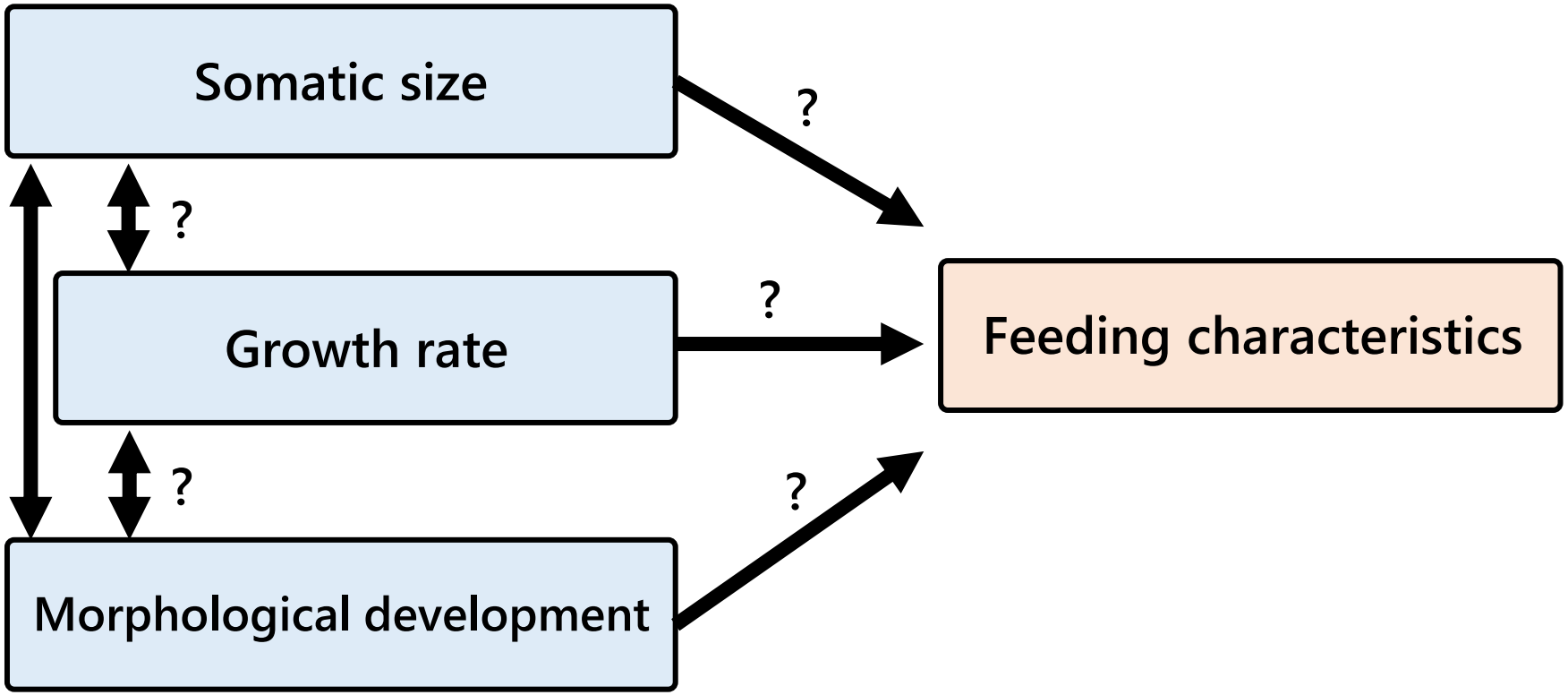
Field studies

Test the dynamics of growth–feeding linkage

Laboratory feeding experiments

Test the mechanisms of growth–feeding linkage

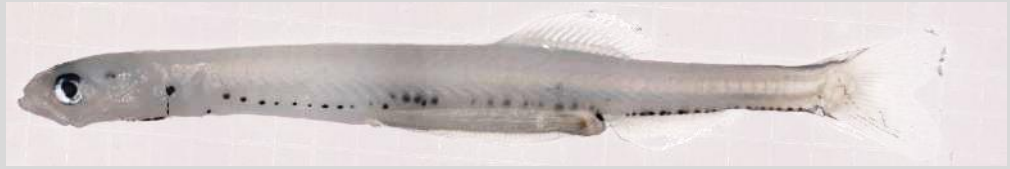
Mechanisms



Test the relationships between the growth and feeding characteristics.

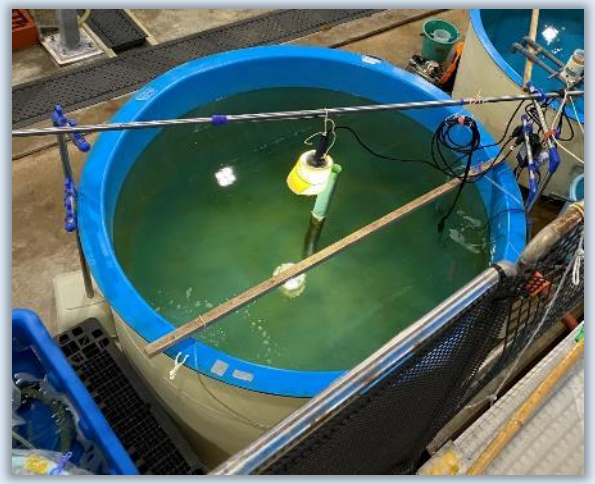
Laboratory feeding experiments

Japanese anchovy (*Engraulis japonicus*) larvae



- Oct.–Dec. 2023, Nov.–Dec. 2024
- *n* =402 individuals

Larval rearing

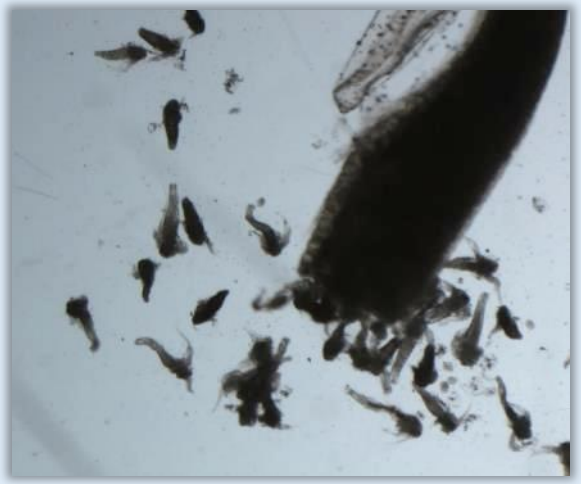


- Reared in the same tanks within each batch.
- Sampled at 24–40 dph.

Feeding experiments

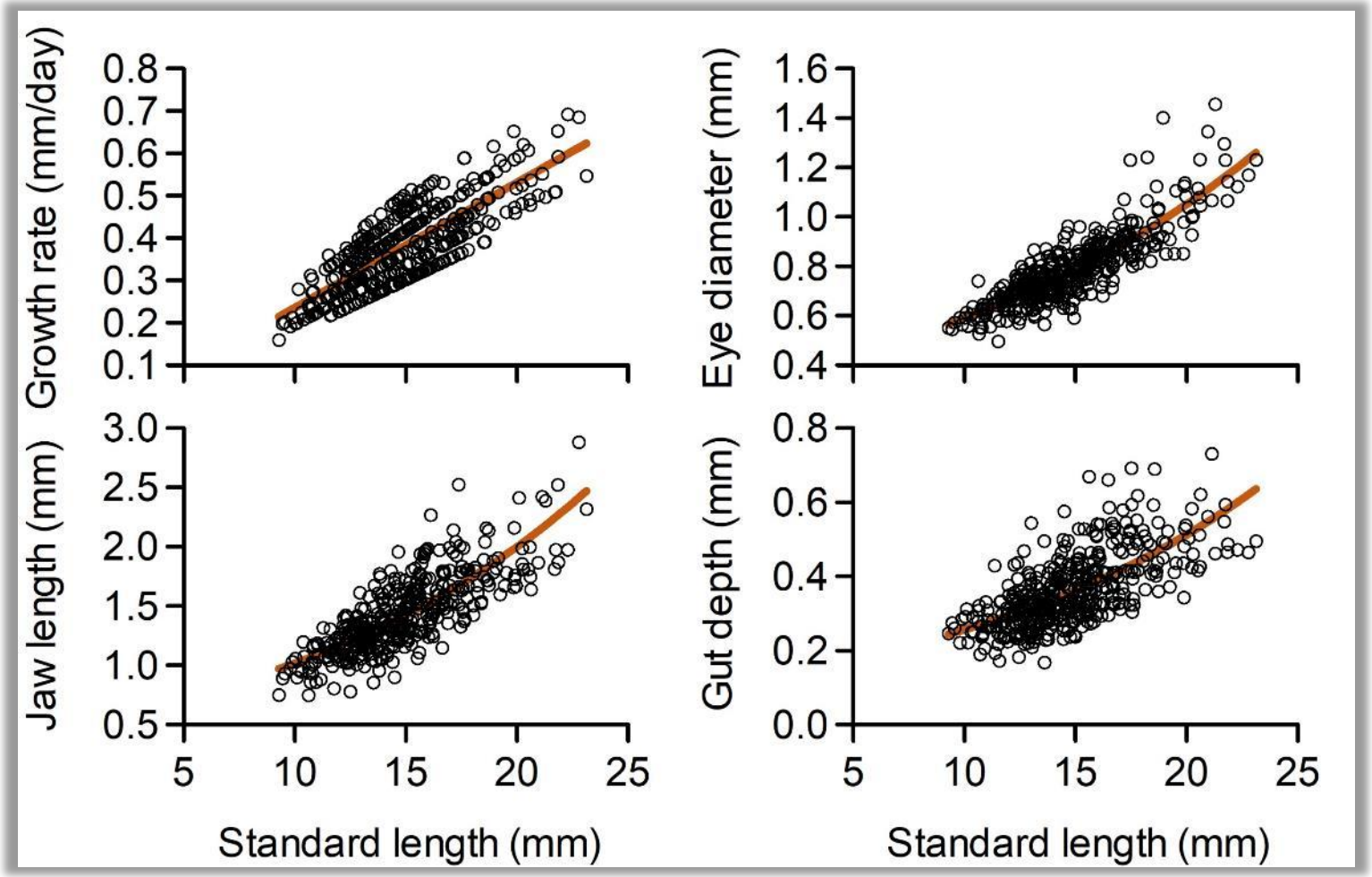
- Added three prey sizes.
- 5-min. feeding period

Measurements

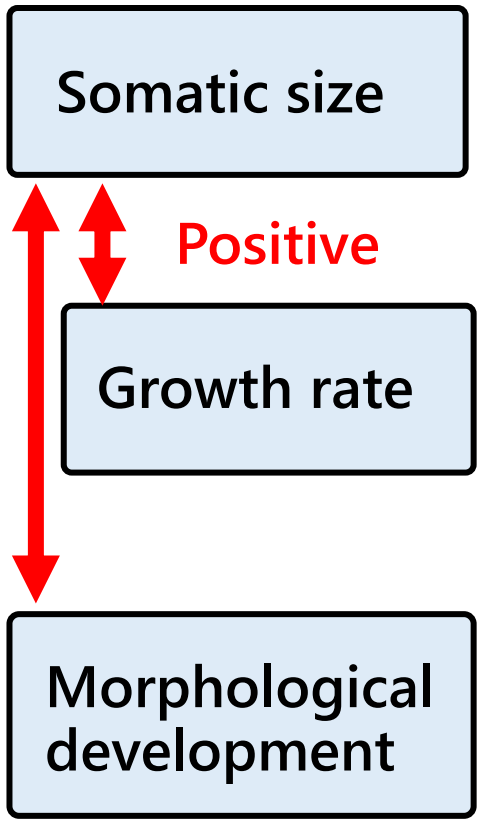


- Morphological measurements
- Gut content analyses

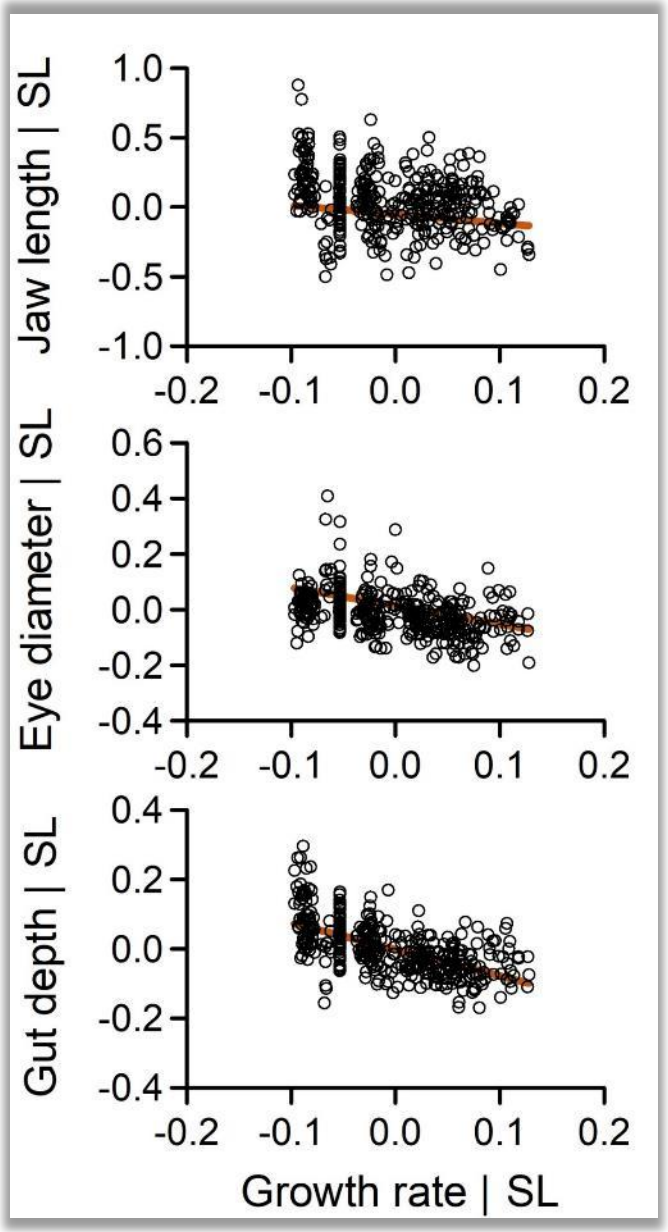
SL–growth rate, SL–morphological developments

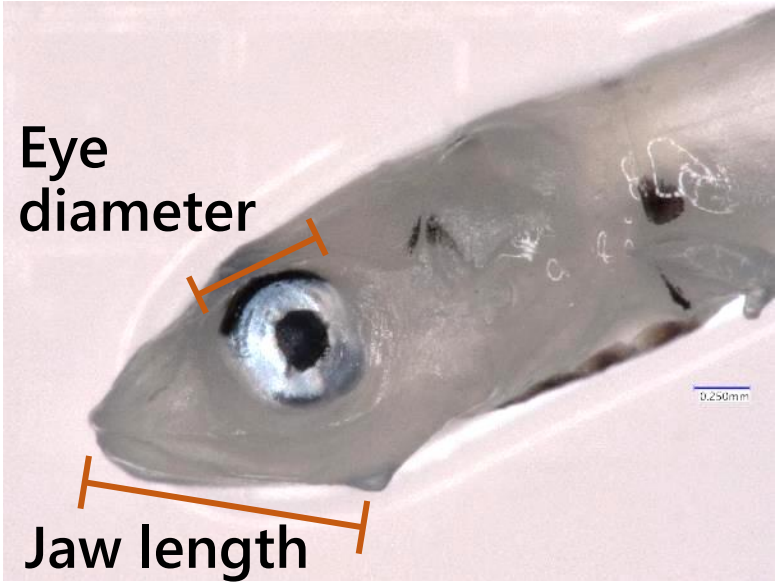


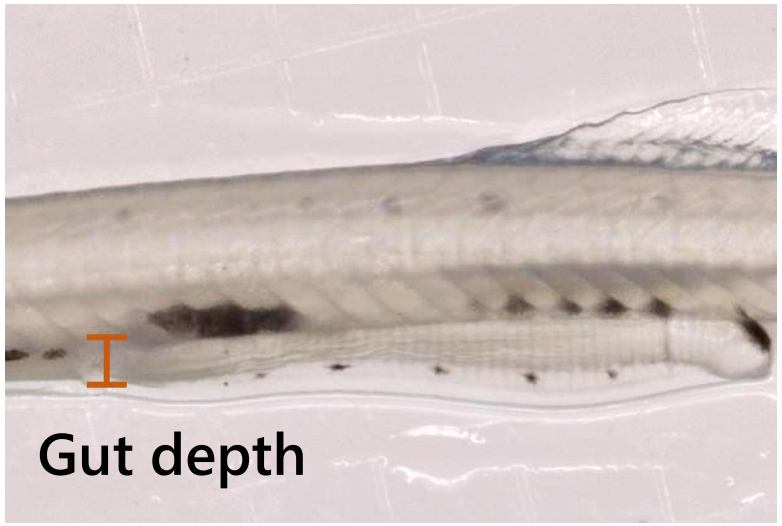
Larger larvae showed faster growth and more developed morphology.



Growth rate–morphological developments







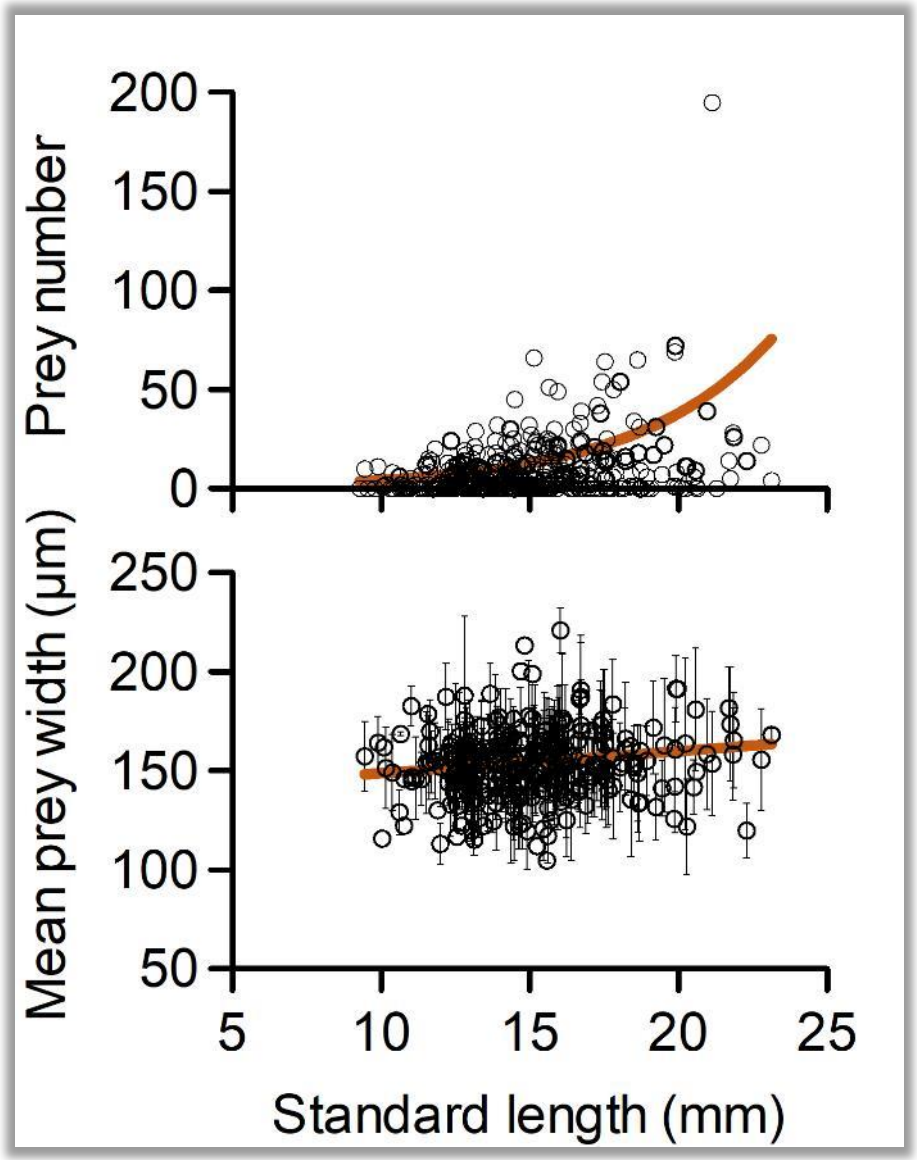
Faster-growing larvae had smaller morphology at a given size.

Growth rate

Negative

Morphological development

SL–feeding characteristics



Larger larvae consumed more and larger prey items.

Somatic size

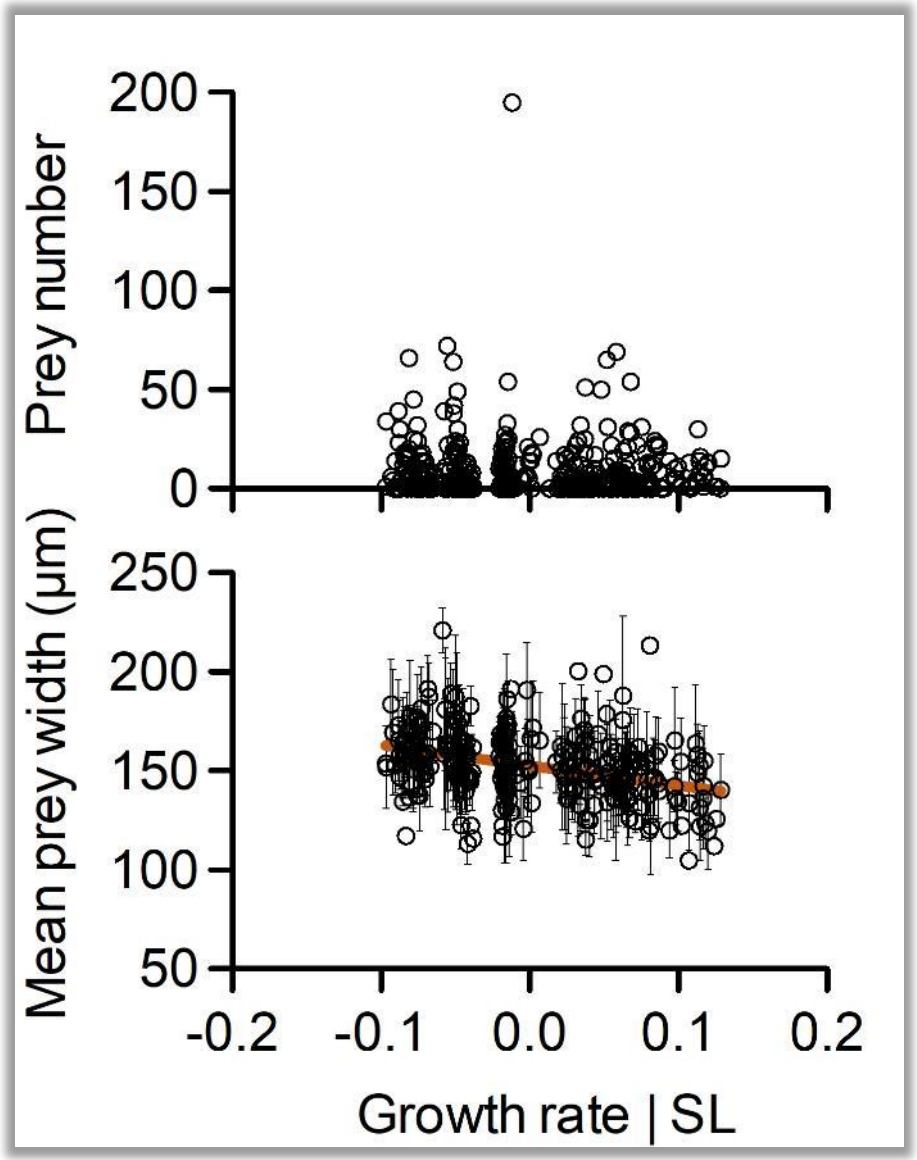
Positive

Growth rate

Feeding characteristics

Morphological development

Growth rate–feeding characteristics



Faster-growing larvae consumed smaller prey items at a given size.

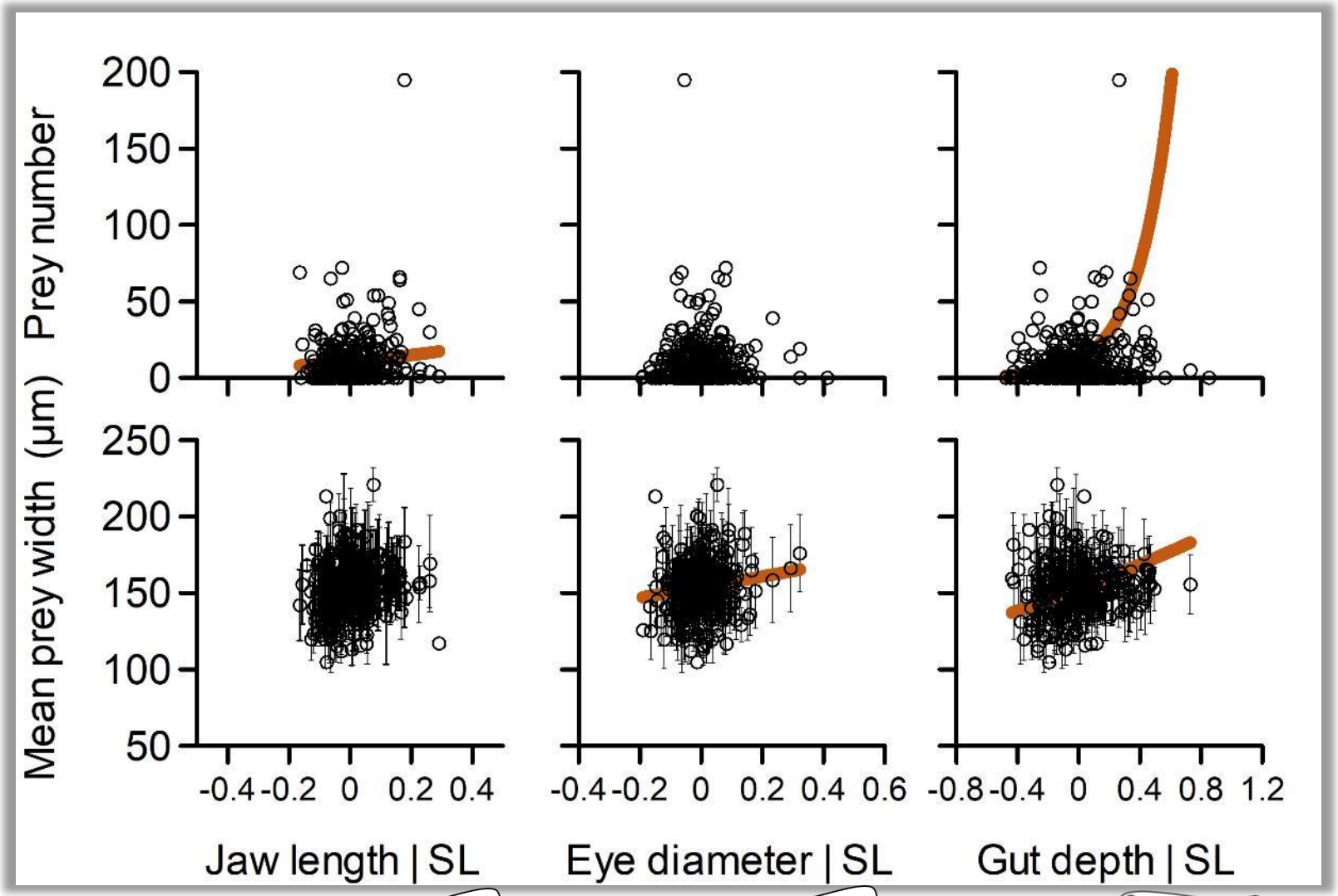
Somatic size

Growth rate → **Feeding characteristics**

Negative

Morphological development

Morphological developments–feeding characteristics



More-developed larvae consumed larger prey items at a given size.

Somatic size

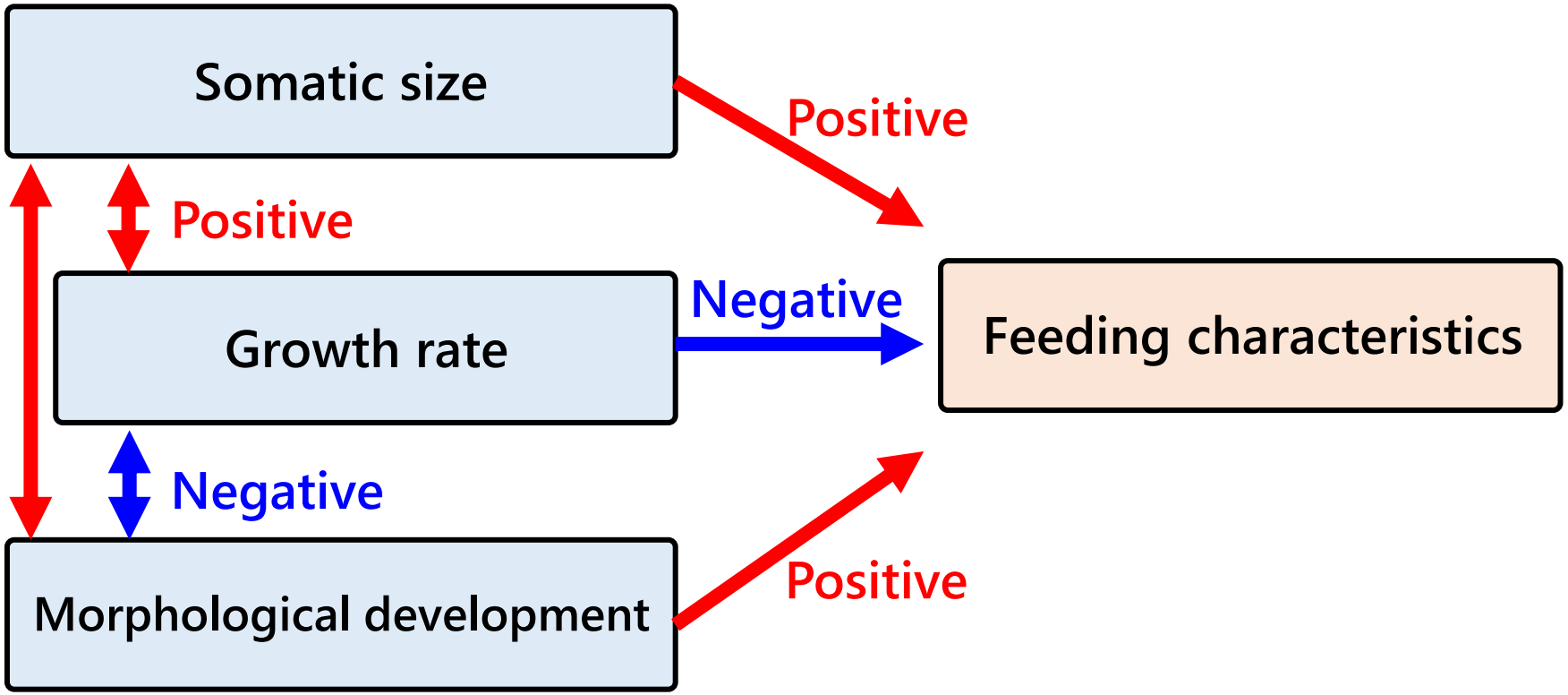
Growth rate

Feeding characteristics

Positive

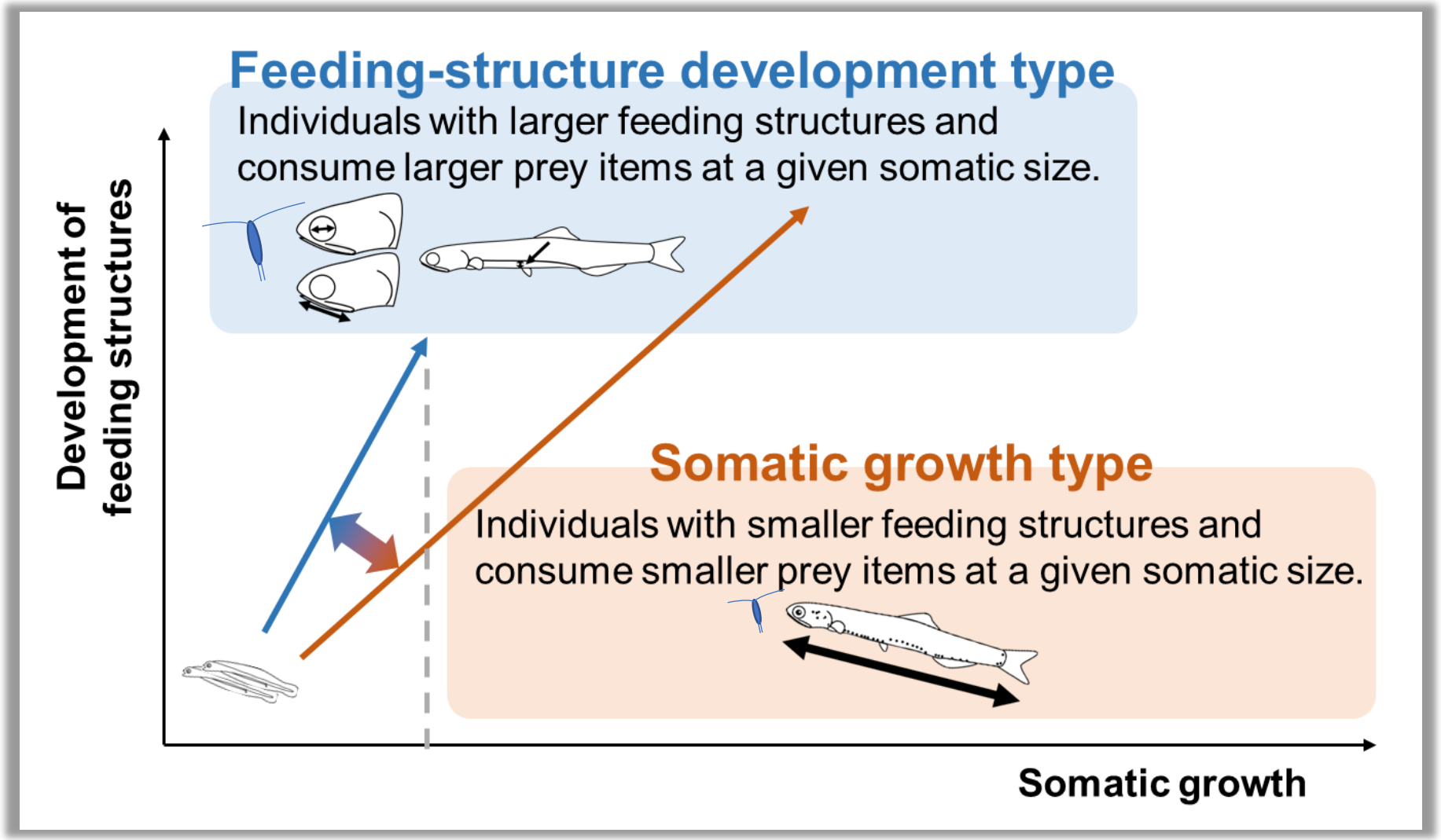
Morphological development

Summary



Negative relationship between growth rate and morphological development leads to negative effects of growth rate on feeding characteristics.

Individual variability

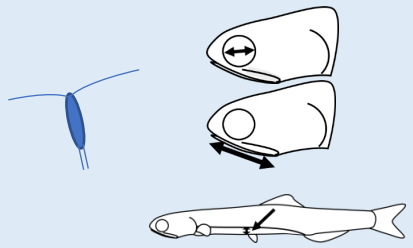


There can be great variability in growth–development pattern.

Mechanisms of the dynamics

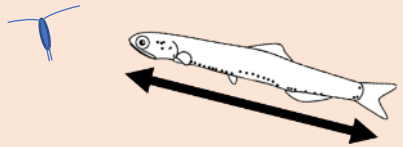
Individual variation in feeding characteristics

Development type



Consume larger prey at a given size

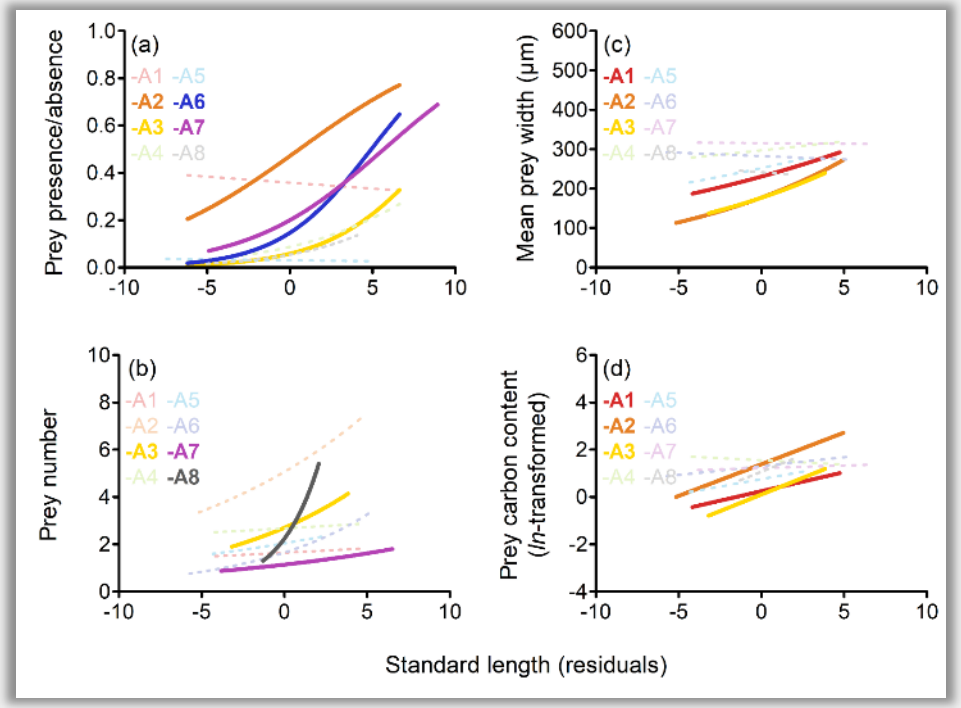
Growth type



Consume smaller prey at a given size

Prey field fluctuation

Dynamics of growth–feeding linkage



Considering individual variation and prey field may help explain the dynamics of growth–feeding linkage and growth–survival relationship.