Feeding behavior responses of the small copepod, *Paracalanus Parvus*, to toxic algae at different concentrations

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CONTENTS

01.

Research background

Ambitious projects to investigate how life in the sea helps the ocean store carbon

Posted: 19 October 2023

- The Natural Environment Research Council (NERC) have announced funding for three ambitious new projects to generate new data on how ocean biology impacts the storage of carbon.

The projects being funded by the Bio-Carbon programme include the PARTITRICS project, led by NOC's Professor Stephanie Henson. The £2.3 million PARTITRICS project will use shipboard observations and autonomous underwater vehicles (AUVs) to answer how organic matter is transformed through interactions between particles and organisms. It will also look at how this changes depending on depth, location, and season.

The next project, Coccolithophore controls on ocean alkalinity (CHALKY) will quantify how diversity and ecology influence the oceans' ability to absorb carbon dioxide. Part of the CHALKY project will examine the influence of marine viruses and grazing by zooplankton, microscopic animals such as copepods, foraminifera and sea snails that form a vital part of the ocean's food chain.

The Integ
(IDAPro)
ship-base
improve t
phytoplan
the basis of all life in the ocean and
ultimately responsible for an enormo
ocean carbon storage.

The three projects will also collabora
simultaneous mission funded by the
Research Infrastructure (FMRI) prog
seeks to enhance ocean exploration

nature > nature communications > review articles > article

Review Article | Open access | Published: 02 February 2023

Monitoring and modelling marine zooplankton in a changing climate

Lavenia Ratnarajah, Rana Abu-Alhaija, Angus Atkinson, Sonia Batten, Nicholas J. Bax, Kim S. Bernard, Gabrielle Canonico, Astrid Cornils, Jason D. Everett, Maria Grigoratou, Nurul Huda Ahmad Ishak, David Johns, Fabien Lombard, Erik Muxagata, Clare Ostle, Sophie Pitois, Anthony J. Richardson, Katrin Schmidt, Lars Stemmann, Kerrie M. Swadling, Guang Yang & Lidia Yebra

Nature Communications 14, Article number: 564 (2023) | Cite this article

Abstract

Zooplankton are major consumers of phytoplankton primary production in marine ecosystems. As such, they represent a critical link for energy and matter transfer between

1、The importance of zooplankton

2、The UK Biocarbon Initiative has launched three ambitious new projects

How do marine organisms affect carbon storage ?

Zooplankton——Copepods

- The class of copepods is one of the most abundant groups of marine planktonic organisms, playing a role in connecting primary productivity and higher trophic levels in the marine food web.
- copepods are small but have **fast movement speed.**
- The prey of the copepods is microplanktonic organisms (even smaller), so their feeding behavior is invisible.

communications
earth & environment

ARTICLE

Check for updates

https://doi.org/10.1038/s43247-023-00871-w OPEN

Zooplankton grazing is the largest source of uncertainty for marine carbon cycling in CMIP6 models

Tyler Rohr[1,2], Anthony J. Richardson[3,4], Andrew Lenton[5], Matthew A. Chamberlain[4] & Elizabeth H. Shadwick[1,5]

The current generation of Earth system models used by the United Nations to project future climate scenarios (CMIP6) relies heavily on marine biogeochemical models to track the fate of carbon absorbed into the oceans. Here we compare 11 CMIP6 marine biogeochemical models and find the largest source of inter-model uncertainty in their representation of the marine carbon cycle is phytoplankton-specific loss rates to zooplankton grazing. This uncertainty is over three times larger than that of net primary production and driven by large differences in prescribed zooplankton grazing dynamics. We run a controlled sensitivity experiment in a global marine biogeochemical model and find that small changes in prescribed grazing dynamics (roughly 5% of what is used across CMIP6 models) can increase secondary and export production by 5 and 2 PgC yr^{-1}, respectively, even when tuned to identical net primary production, likely biasing predictions of future climate states and food security.

Copepods feeding reasearch methods

Classical methods on copepods feeding

"black box" experiment , isotopic tracer technique, gut pigment analysis etc.

Indirect, Invisible

- unable to visually analyze its feeding behavior (algae toxicity research)

1.1 Research background and significance

direct method---microscopic high speed viedo

— In 1995, Thomas Kiorboe used a high-speed micro-camera for the first time to observe the behavioral patterns of copepods intuitively.

- Ambush feeding
- Feeding current
- Cruising

Feeding current

Feeding behavior: By beating the appendages to bring the bait into the mouth for filter feeding, and by rejecting, regurgitating, and other behaviors to select the bait.

Main parameters of feeding behavior: beating frequency (BF), beating time (BT), and rejection behavior

1.1 Research background and significance

02.

Research objective and methods

2.1 Research objective

1、Whether copepod's feeding can be affected by **toxic algae ?**

2、Whether the **concentration of toxic algae** could have some effects on copepod's feeding?

--whether these effects can be proved by feeding behaviors?

2.2 Research methods

Experimental Organisms

Paracalanus parvus

- worldwide species
- important small copepod
- key species in northern China from spring to Autumn

Selection of algae

Types of Algae

- *Prorocentrum minimum**
- *Alexandrium minutum**
- *Thalassiosira weissflogii*

Concentration setting:

50 ~ 1000 cells/ml

Behavioral Observations

Recording method

- High-speed video capture feeding behaviors of individual organisms.
- Select starve-domesticated *P. parvus*
- shooting time never exceeding 10 minutes.

Statistical Analyses

Video analysis - - obtaining feeding behavior parameters.

- Beating frequency (BF),
- Beating time (BT),
- Rejection behavior

03.

Research result

3.1 Feeding Behavior of *P. parvus* on Different Concentrations of *P. minimum*

Beating frequency (BF)

- the BF **decreased significantly** when the concentration of *P. minimum* increased beyond 250 cells/mL.

Beating time (BT)

- **no significant differences** in the BT among each concentration of ($p > 0.05$, respectively).

- **BF of *P. parvus* was affected when the concentration of *P. minimum* was higher than 250 cells/mL.**

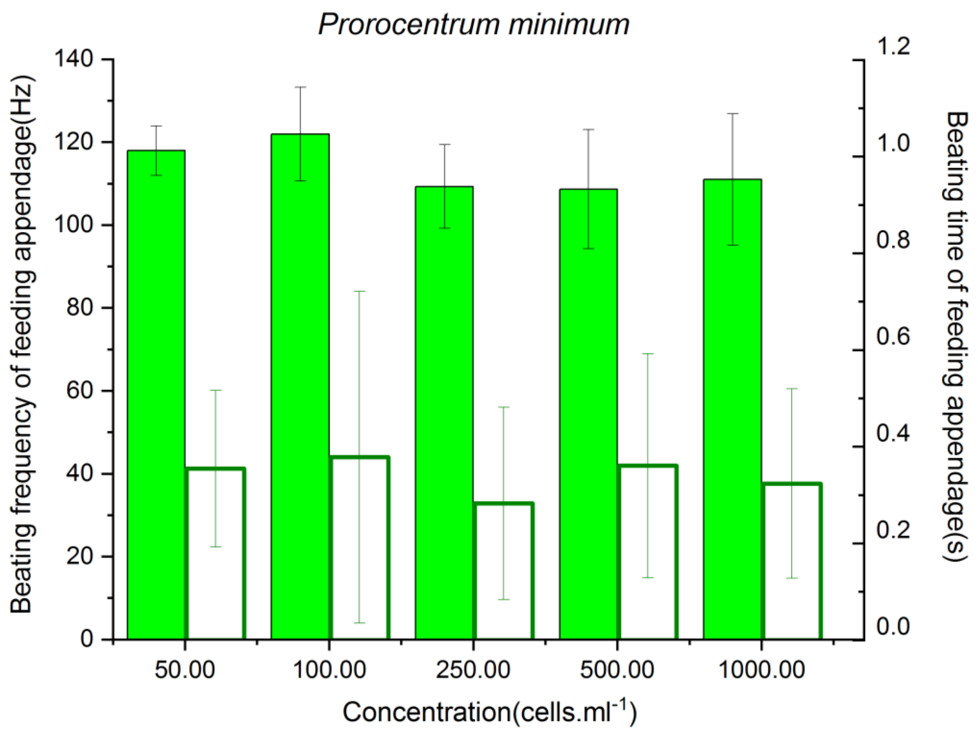

Figure 1. BF and BT of the feeding appendages of *P. parvus* fed on different concentrations of *A. minutum*. The BF is indicated by solid green bars (left y-axis; unit: Hertz), and the BT is depicted by white bars (right y-axis; unit: second).

3.2 Feeding Behavior of *P. parvus* on Different Concentrations of *A. minutum*

Beating frequency (BF)

- The lowest BF of 106.96 ± 2.39 Hz was observed **at 1000 cells/mL,** and differed significantly from those at concentrations of **100–500 cells/mL (p < 0.01).**

Beating time (BT)

significant decreased at concentration of **250 cells/mL, similar to 50 cells/mL**

✓ **BF** of *P. parvus* **was affected** when the **concentration** of A. *minutum* **reached to 1000 cells/mL** (red tide blooms).

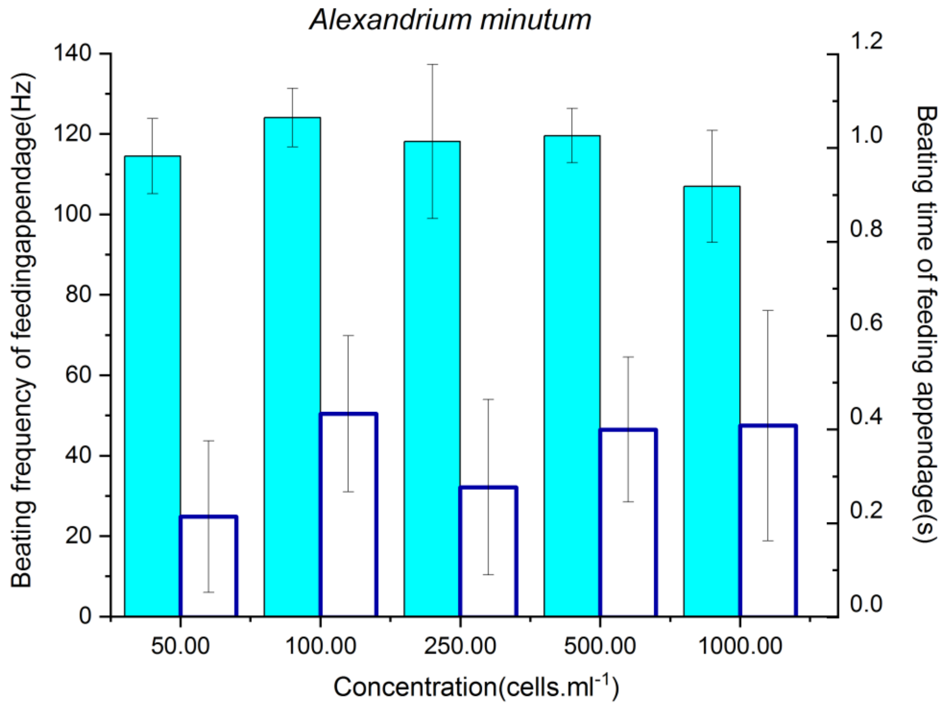

Figure 2. BF and BT of the feeding appendages of *P. parvus* fed on different concentrations of *A. minutum*. The BF of the feeding appendages are depicted by light blue bars (left y-axis; unit: Hertz), whereas the BT is depicted by white bars (right y-axis; unit: second).

3.3 Feeding Behavior of *P. parvus* on Different Concentrations of *T. weissflogii*

Beating frequency (BF)

- the **highest BF** of 124.93 ± 1.06 Hz was observed at concentration of **500 cells/mL**, which was similar with that at 1000 cells/mL ($p = 0.07$), and was higher than those at concentrations of 100 and 250 cells/mL ($p < 0.01$).

Beating time (BT)

- no significant differences in the BTs ($p > 0.05$ at all concentrations).

P. parvus exhibited **a more active feeding behavior when fed on** *T. weissflogii*, even its concentration reached 500–1000 cells/mL (red tides).

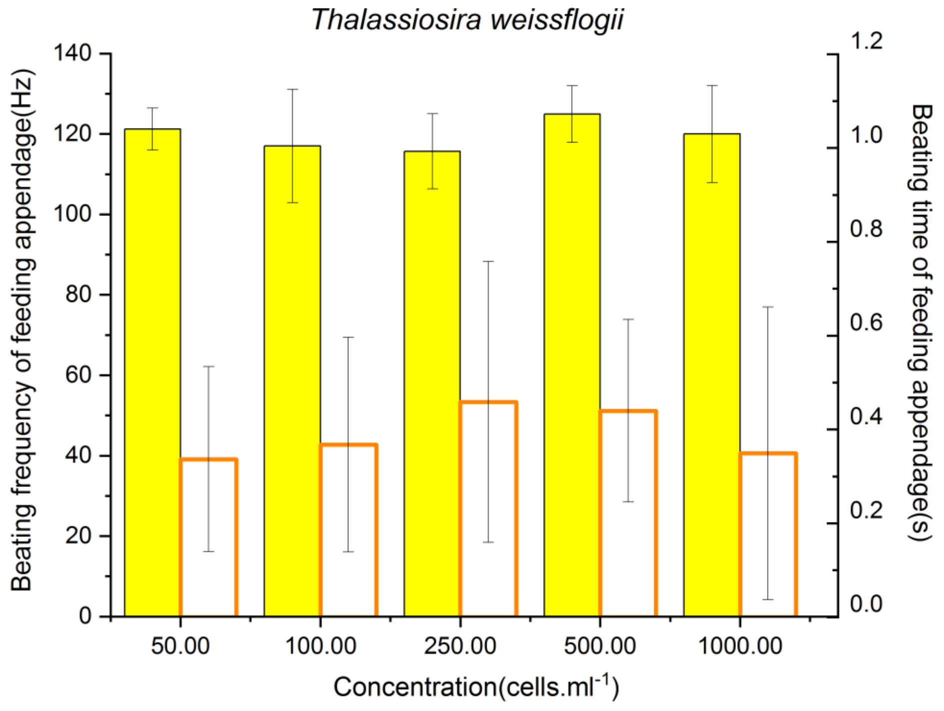

Figure 3. BF and BT of the feeding appendages of *P. parvus* fed on different concentrations of *T. weissflogii*. The BF is indicated by the yellow bars (left y-axis; unit: Hertz), and the BT is represented by the white bars (right y-axis; unit: second).

3.4 Comparison of Feeding Behaviors on Different Concentrations of Three Algae

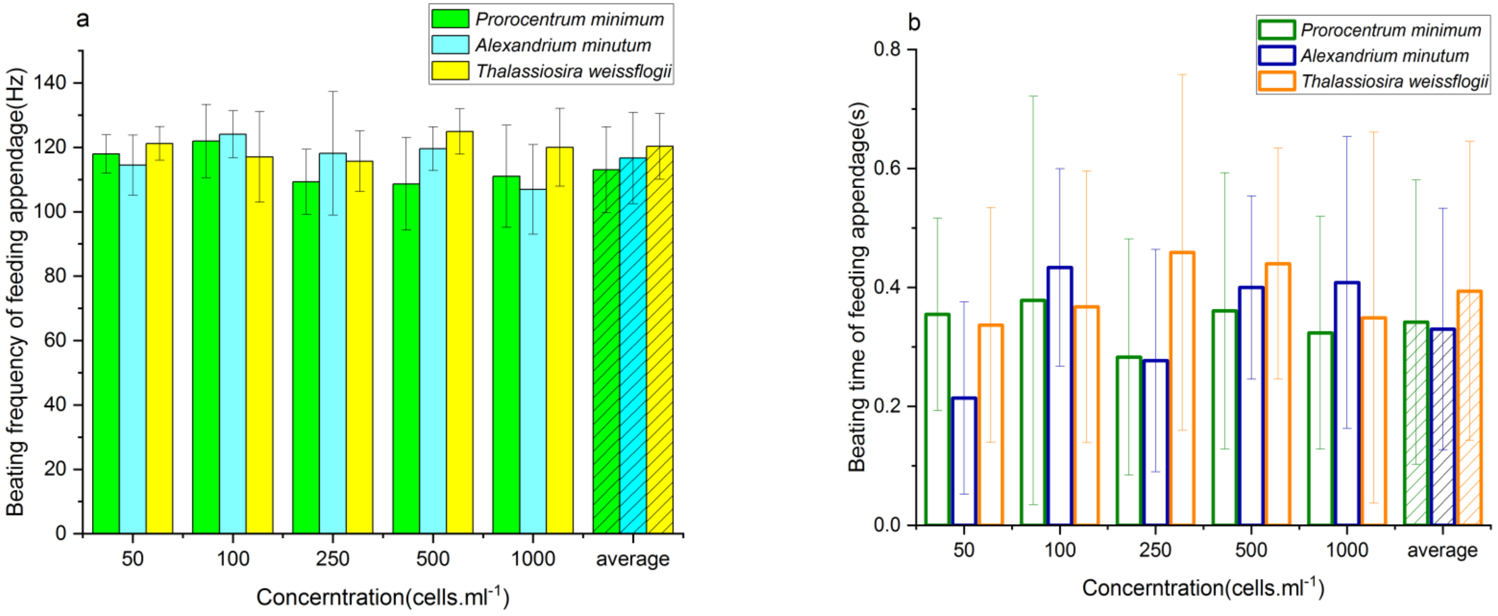

Figure 4. Feeding behavior of *P. parvus* fed on different concentrations of the three algal species. (a) BF and (b) BT of the feeding appendages.

On average:

- the BF and BT of *P. parvus* fed on T. Weissflogii (nontoxic diatom) were significantly higher than those of the other two algae (toxic dinoflagellates).
- Comparison in the two toxic dinoflagellates revealed that the BF in P. *minimum* was significantly lower than that in *A. minutum.*
- The feeding behavior of *P. parvus* was not negatively affected by the toxic dinoflagellates at low concentrations (≤100 cells/mL).

3.5. Comparison of Rejection Behavior of *P. parvus* Fed on Different Concentrations of the Three Algae

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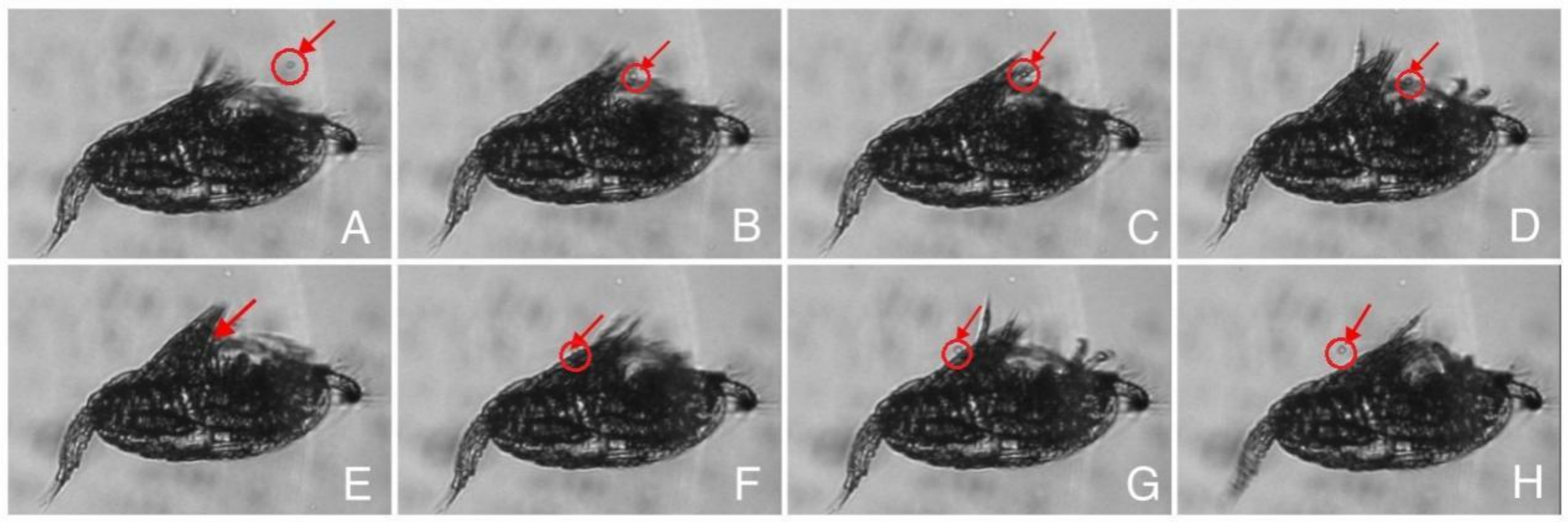
Process of prey rejection by *P. parvus*.



Concentration	*P. minimum*	*A. minutum*	*T. weissflogii*	
			3.33%	n=30
			3.85%	n=26
			3.33%	n=20
			13.60%	n=44
			0.00%	n=35
			4.83%	
			5.14%	

... *P. parvus* fed on different concentrations of the three algae. (N represents the total number of videos analyzed for different concentrations of each algal species.)

4.1 Effects of Toxic Algae on the Feeding Behavior of Copepods

diatom

The BF and BT of *P. parvus* fed on the nontoxic *T. weissflogii* were significantly higher than those of *P. parvus* fed on the two toxic algae , indicating that **both the two toxic algae negatively affected the feeding behavior of *P. parvus.***

Dinoflagellate

The BF of *P. parvus* fed on *P. minimum* was significantly lower than that of the copepods fed on *A. minutum*, indicated that the **inhibitory effect of *P. minimum* was more pronounced than that of *A. minutum*.**

4.2. Effects of High Concentrations of Toxic Algae on the Feeding Behavior of Copepods

Concentration diatom

No negative impact on the feeding behaviors was found **with increasing concentration of *T. weissflogii***, and even a significant enhancement was observed, indicating a strong downward control ability of *P. parvus* on diatoms; however, significant negative impacts on the feeding behavious were found in the two toxic dinoflagellates.

Concentration dino-

The toxic dinoflagellates may be **negatively affect the feeding behaviors of *P. parvus* at concentrations higher than 250 cells/mL,** but not negatively affected at low concentrations (≤100 cells/mL).

Summary

1. The **two toxic algae negatively affected the feeding behavior** of *P. parvus*, and the inhibitory effect of *P. minimum* was more pronounced than that of *A. minutum*.
2. *P. parvus* has a strong downward control on diatoms but not on toxic dinoflagellate, as its feeding behavious were significantly impacted by the two toxic dinoflagellates.

3. The toxic dinoflagellates negatively affected the feeding behaviors of *P. parvus* at **concentrations higher than 250 cells/mL,**but had no negative effect at low concentrations (≤100 cells/mL).

Ding, ZX, Sun XH, et al., 2023

FEEDING BEHVIORS RESPONSES OF TWO COPEPODS-PARACALANUS PARVUS AND CALANUS SINICUS TO THREE TYPICAL RED TIDE ALGAE WITH DIFFERENT CONCENTRATIONS

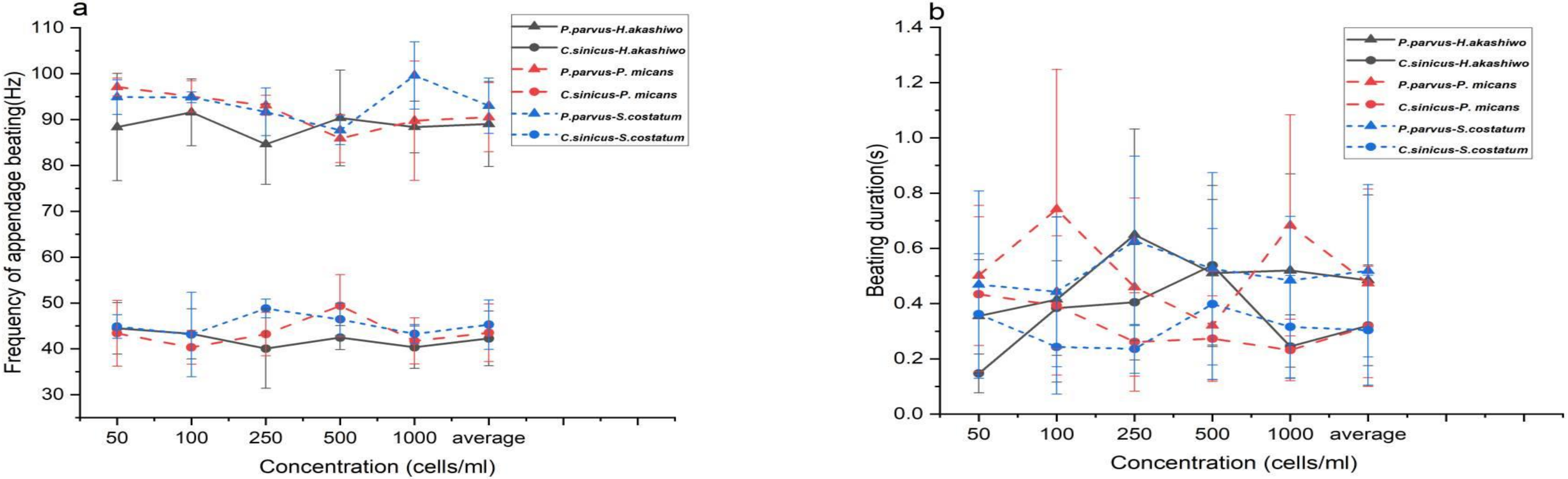


Figure 5. Feeding behavior of *P. parvus* and *C.sinicus* fed on three algae at different concentrations. (a) BF and (b) BT of the feeding appendages.

All the average BFs and BTs of *P. parvus* fed on three algae were significantly higher than those of *C. sinicus*, *indicating that*, comparing with *C. sinicus*, ***P. parvus* displays more active feeding behavior than *C. sinicus*.**

Ding, ZX, Sun XH, et al., in review

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FEEDING BEHVIORS RESPONSES OF TWO COPEPODS-PARACALANUS PARVUS AND CALANUS SINICUS TO THREE TYPICAL RED TIDE ALGAE WITH DIFFERENT CONCENTRATIONS

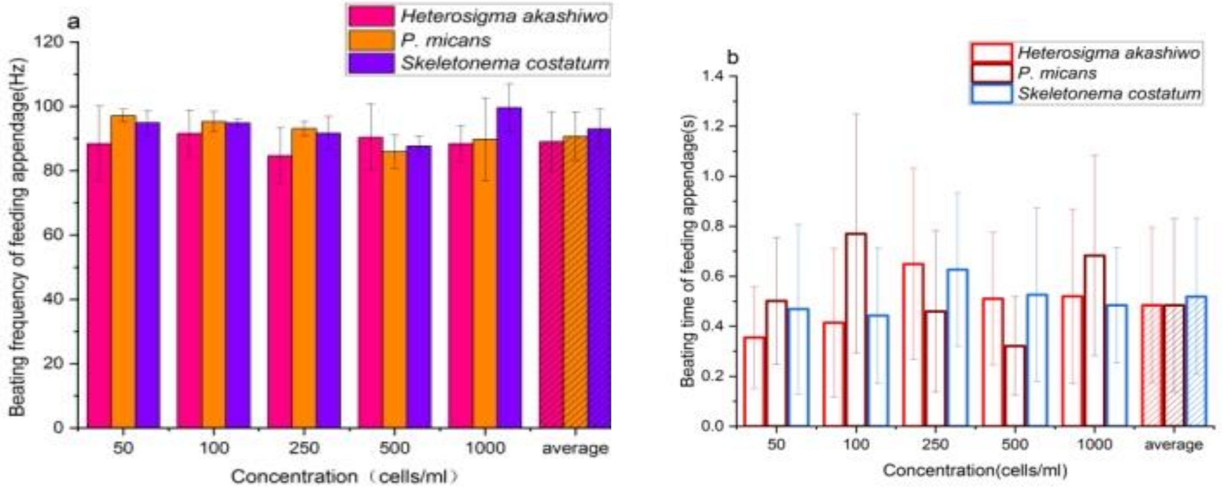

Figure 6. Feeding behavior of *P. parvus* fed on different concentrations of the three algal species. (a) BF and (b) BT of the feeding appendages.

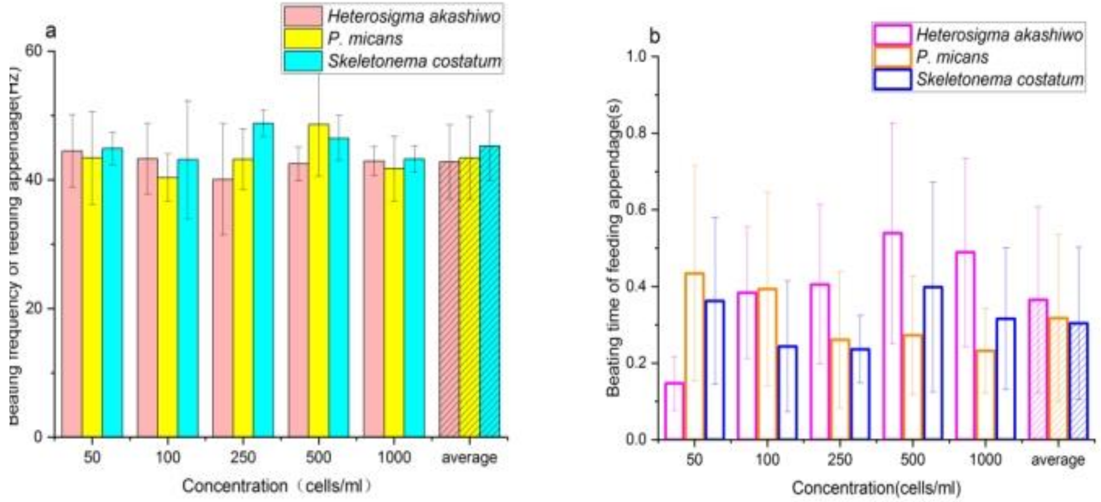

Figure 7. Feeding behavior of *C.sinicus* fed on different concentrations of the three algal species. (a) BF and (b) BT of the feeding appendages.

P. parvus **:**

- **The average BF** fed on ***S. costatum*** (diatom) was significantly **higher than** those of the other algae; **no significant differences** in the average **BTs** in these three algae.
- With alga concentration increasing, *a decreasing trend in P. micans, but not in the other two agale.*

***C.sinicus*:**

The average BF fed on ***S. costatum*** (diatom) was significantly **higher than** those of the other algae; **however,** the average **BTs** fed on ***S. costatum*** (diatom) **was significantly lower than** those of the other algae.

With alga concentration increasing, **a <u>decreasing trend</u> in BF** (R^2=0.573) when feeding on ***H.akashiwo*** *;*

With alga concentration increasing, a **<u>decreasing trend in BT</u>** (R^2=0.865) when it fed on ***P. micans***,

P. parvus could exhibit a stronger top-down control over *S. costatum* than the other two algae

C. sinicus could feed on *S. costatum and no negative response with increasing alga concentration*

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THANKS

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