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NANAIMO · CANADA

Degradation of *Acartia omorii* faecal pellets based on microplastic sizes

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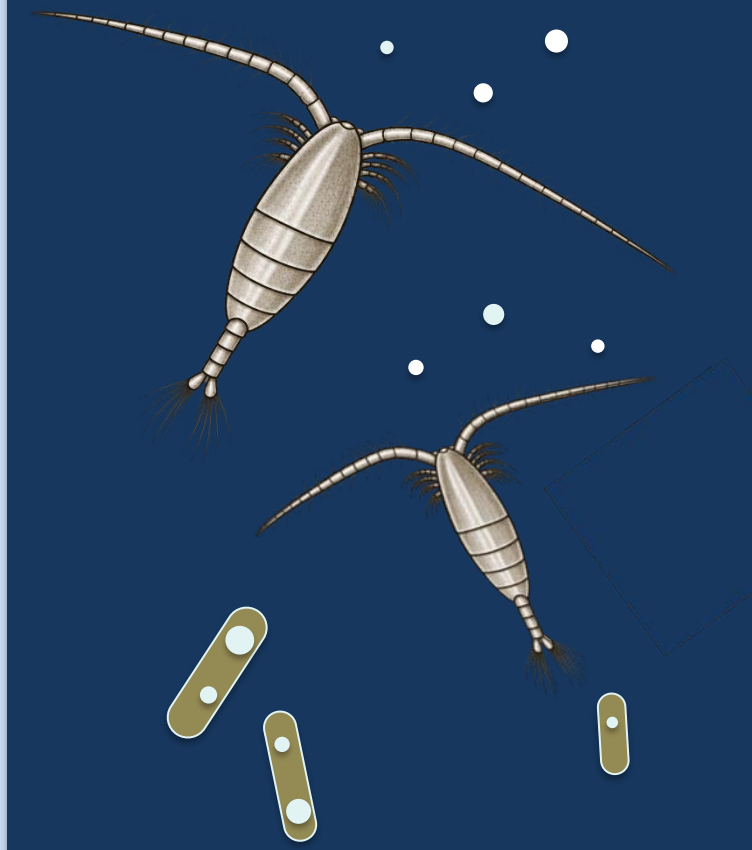
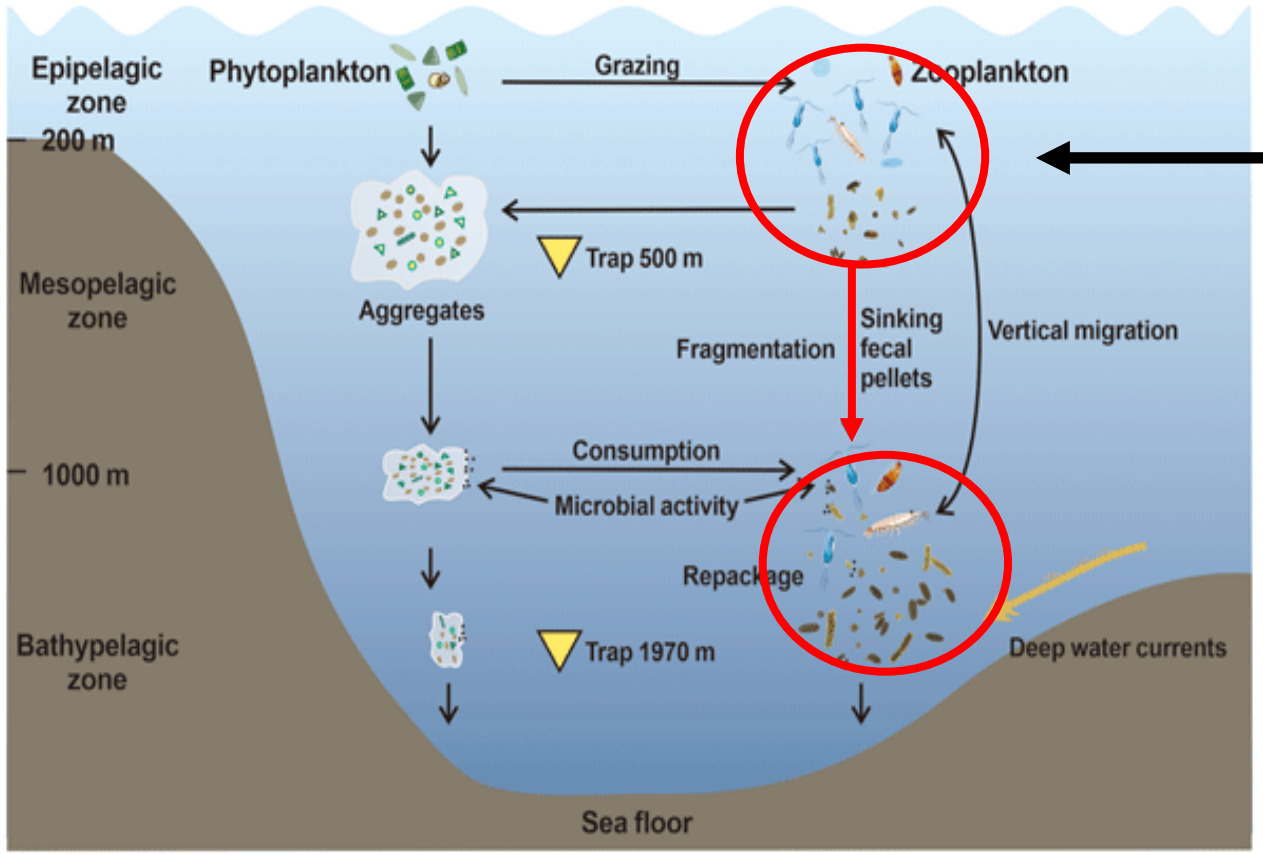
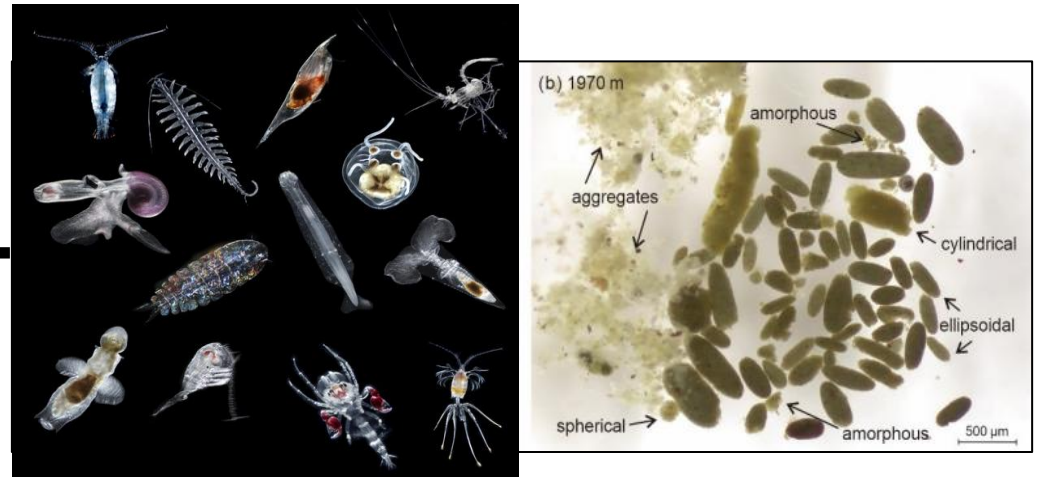


Introduction

- Zooplankton **faecal pellet (FP)** in marine ecosystem



(Wang, 2023)



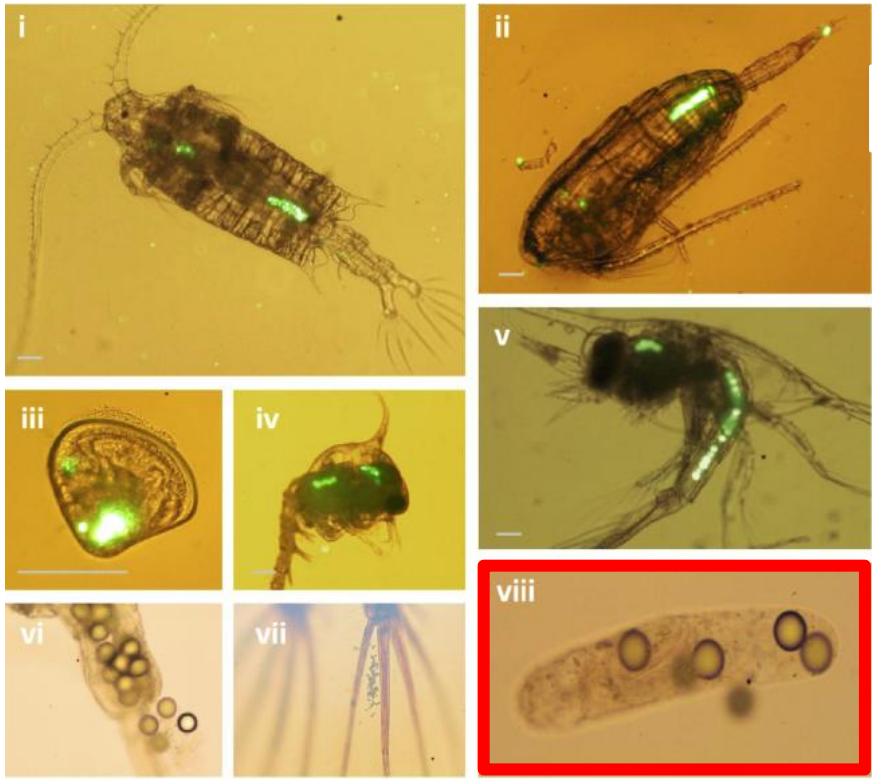
(Peijnenburg & Goetze, 2013)

- Zooplankton produce carbon-rich FPs that sink to deeper waters, contributing to the biological carbon pump (Turner, 2002).

- The contribution of FPs to carbon export depends on their sinking and degradation rates.

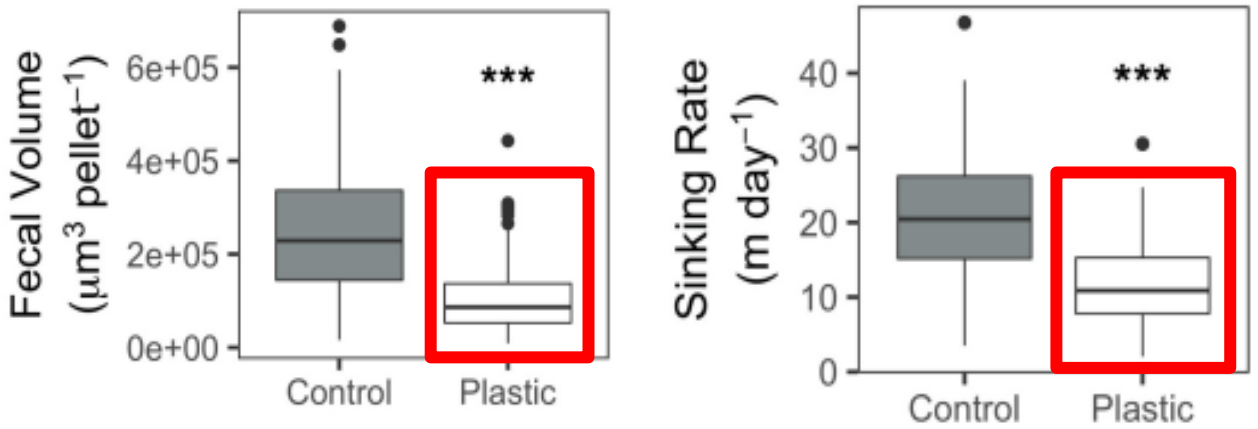
Introduction

- **Microplastic (MP)** in zooplankton **faecal pellet**



(Cole et al., 2013)

- MPs of various sizes can be ingested by zooplankton and incorporated into FPs.

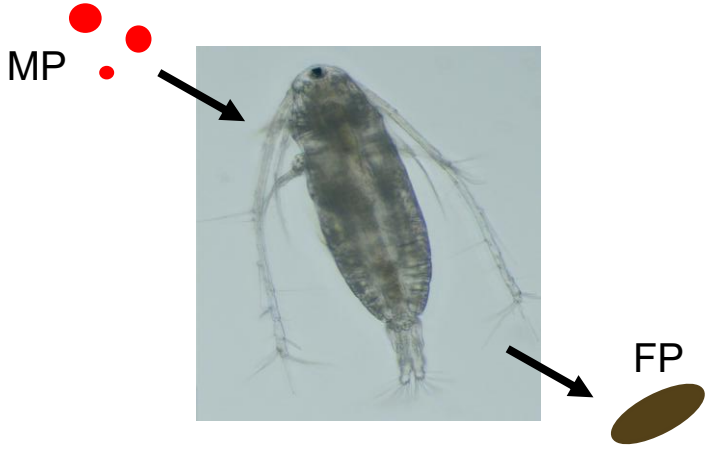


(Shore et al., 2021)

- MPs can alter the physical properties of FPs, potentially affecting their degradation.

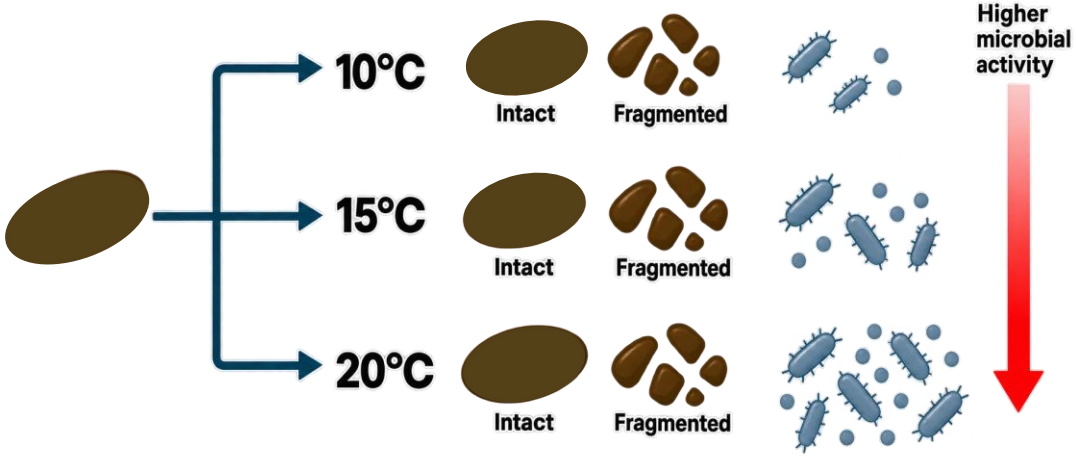
Introduction

- Study objective
  - To **quantify the effects of microplastic sizes on faecal pellet degradation**

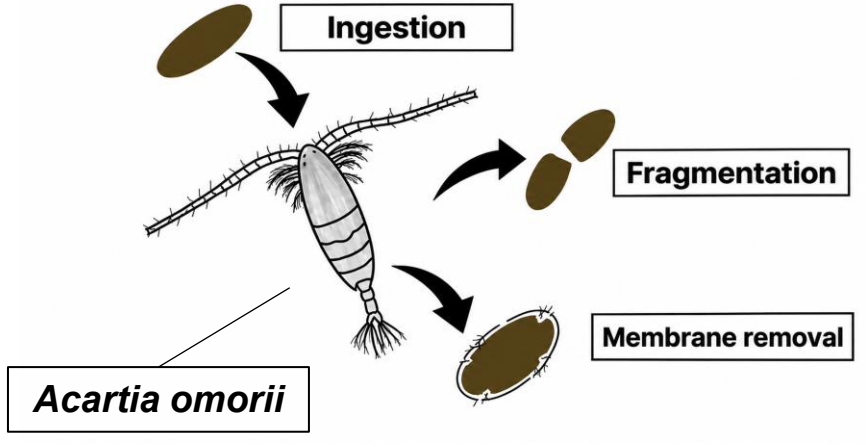


- ***Acartia omorii*** is a common and abundant coastal copepod in Korean coastal waters (Yoo et al., 1991; Kang, 2011).

(1) **Temperature-dependent** degradation



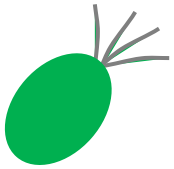
(2) **Copepod-mediated** degradation



Materials & Methods

- **Microplastic** exposure & **faecal pellet** analysis

Tetraselmis tetrathele



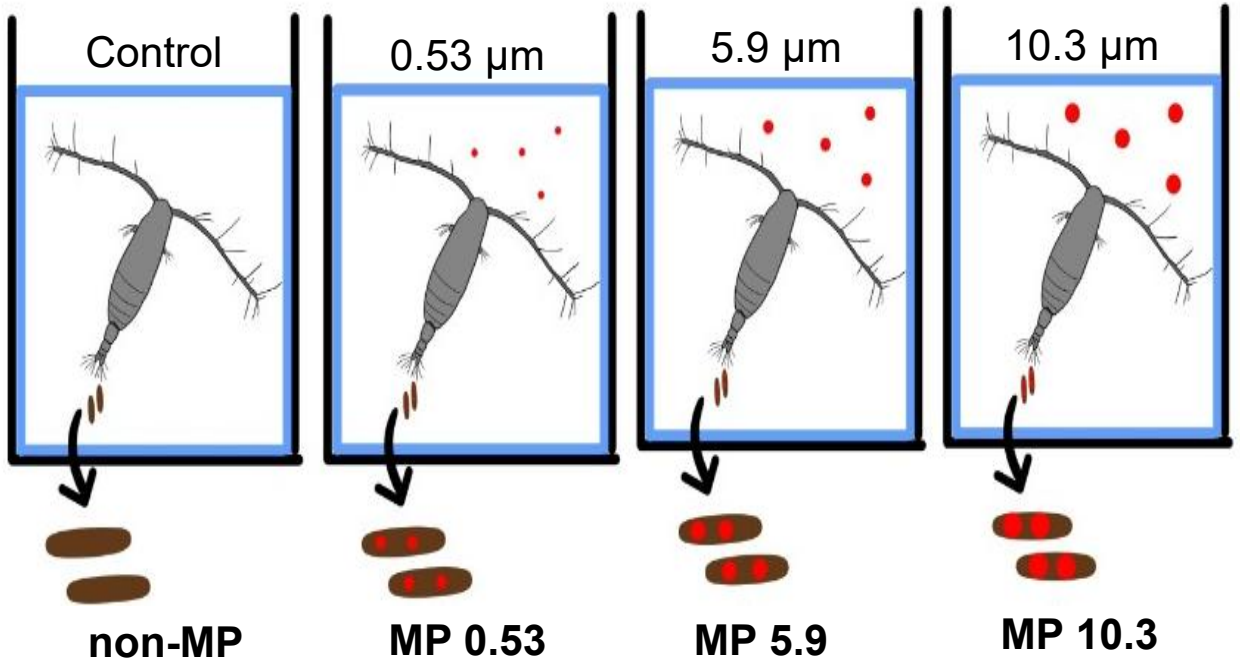
500 *μ*g C L^{-1}

+

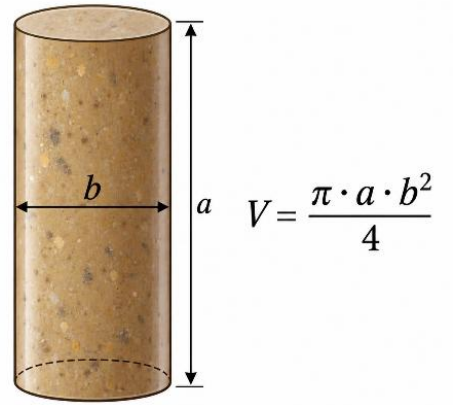
MP size
0.53, 5.9, 10.3 μm



1,000 particles mL^{-1}



- FP properties
  - Size: length, width, volume
  - MP content: number of MPs per pellet

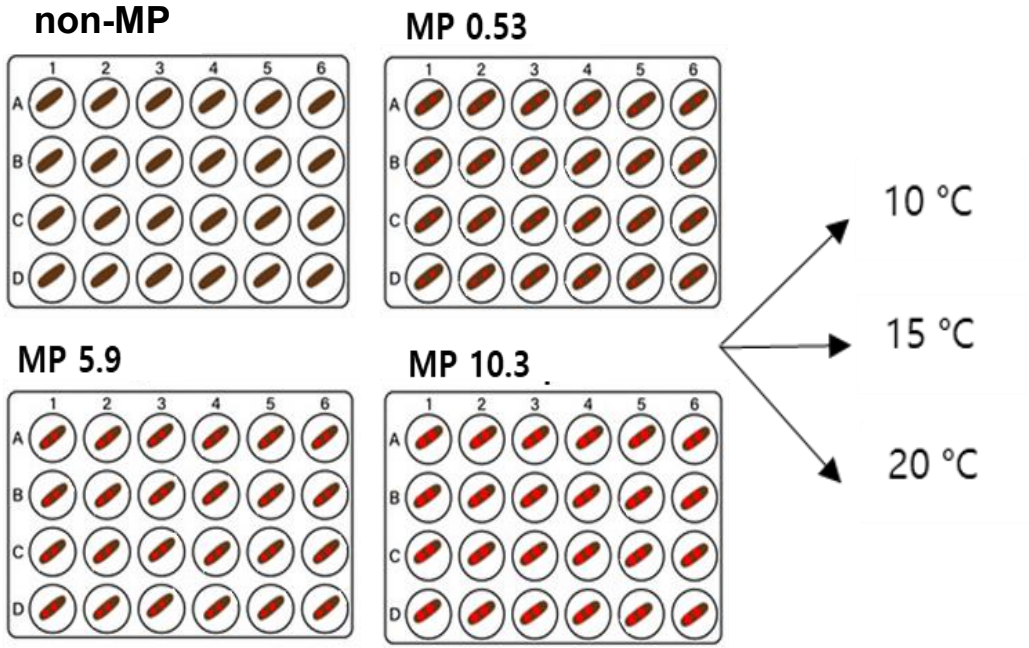


(Li et al., 2022)

Materials & Methods

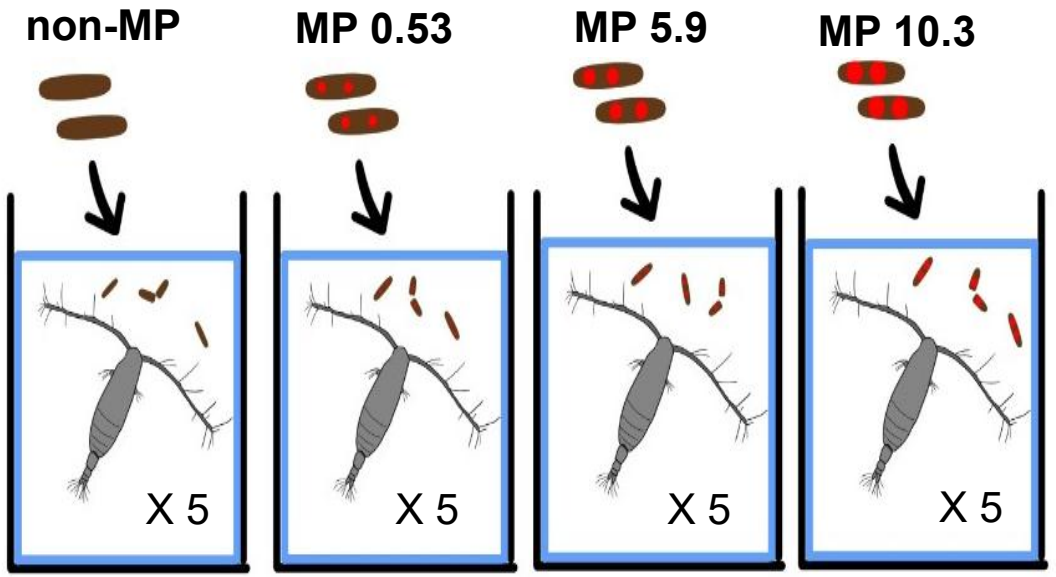
- **Faecal pellet degradation** experiment

1) **Temperature-dependent** degradation



- 20 FPs collected from each group were incubated at 10, 15, and 20°C.
- Observation times: 0, 3, 6, 9, 12, 24, 36, 48 h

2) **Copepod-mediated** degradation



- 50 FPs collected from each group were incubated with *A. omorii* at 15°C for 24 h.

Materials & Methods

- **Faecal pellet degradation** metrics

(1) **Fragmentation percentage** (%)

- Proportion of fragmented FPs

$$F = \frac{fragments}{intact + fragments} \times 100\%$$

F: fragmentation percentage (%)

fragments : total number of fragmented FPs

Intact : total number of intact FPs

(2) **Degradation rate** (d^{-1})

- Rate of FP disappearance

$$N_t = N_0 e^{-rt}$$

N_t : total number of FPs at the end

N_0 : total number of FPs at start

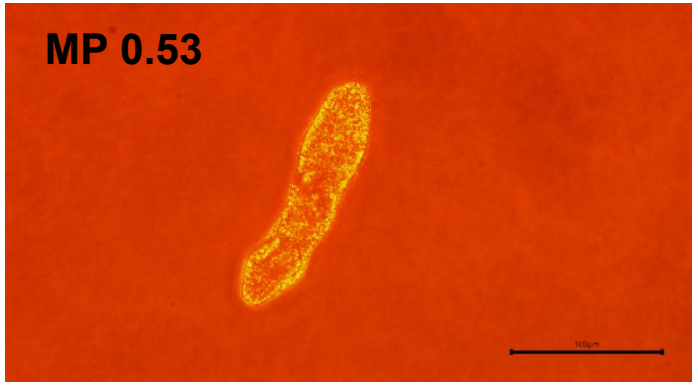
r : degradation rate (d^{-1})

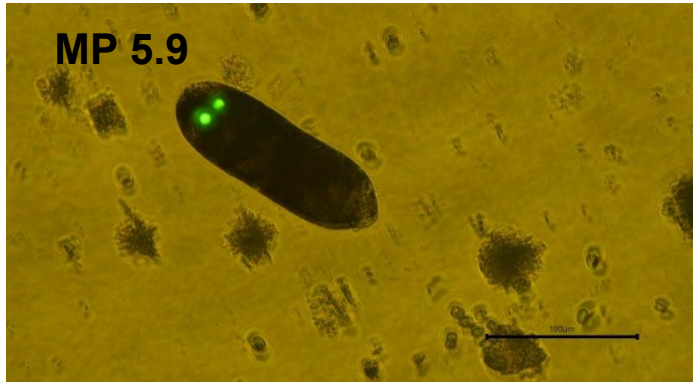
t : incubation time (days)

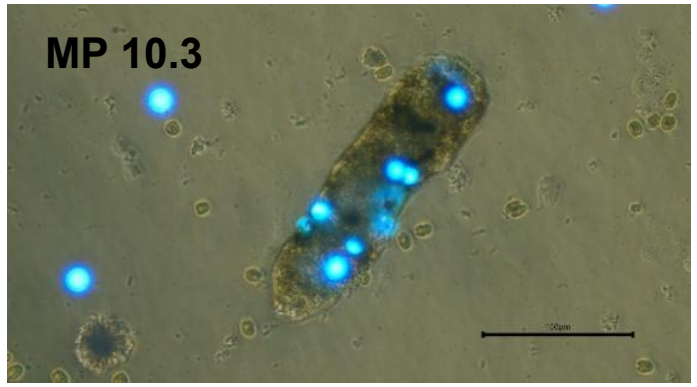
(Poulsen & Iversen, 2008)

Results

- **Faecal pellet properties** by **microplastic size**





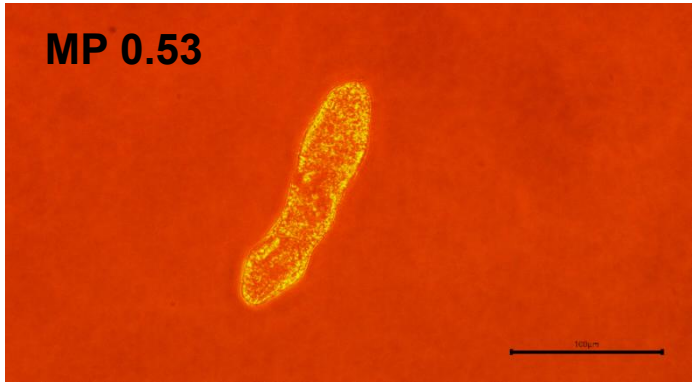


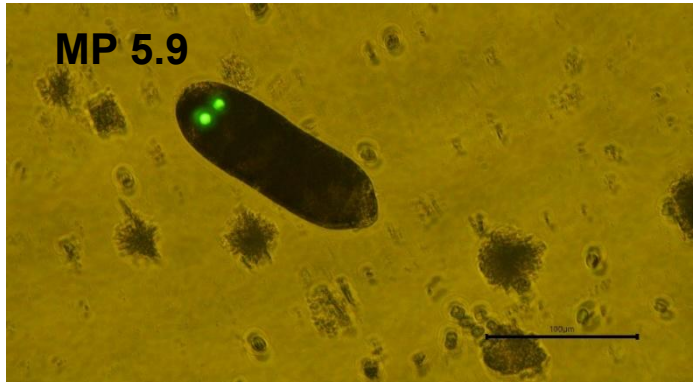
	Length (㎛)	Width (㎛)	Volume (x10^5 ㎛^{3})	Number of MPs (particles pellet^{-1})
non-MP	144.2±38.1	38.6±7.7	1.86±1.20	0
MP 0.53	143.7±41.6	40.2±14.2	1.93±1.16	-
MP 5.9	156.1±35.1	40.3±7.5	2.10±0.96	3.6±2.8
MP 10.3	154.1±39.2	40.0±8.1	2.09±1.15	21.7±16.3

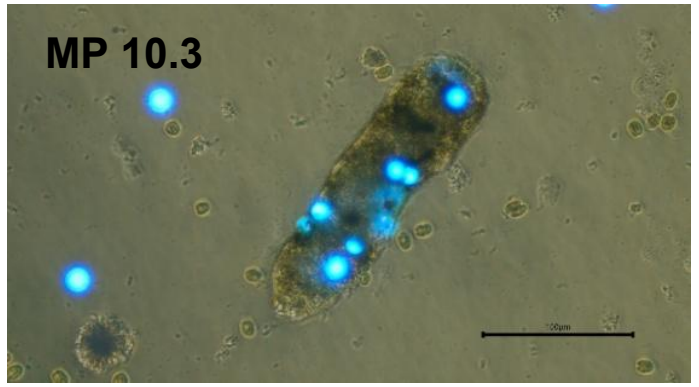
└ FP length differed significantly among groups ($p < 0.05$), while width and volume did not.

Results

- **Faecal pellet properties** by **microplastic size**







	Length (㎛)	Width (㎛)	Volume (x10^5 ㎛^{3})	Number of MPs (particles pellet^{-1})
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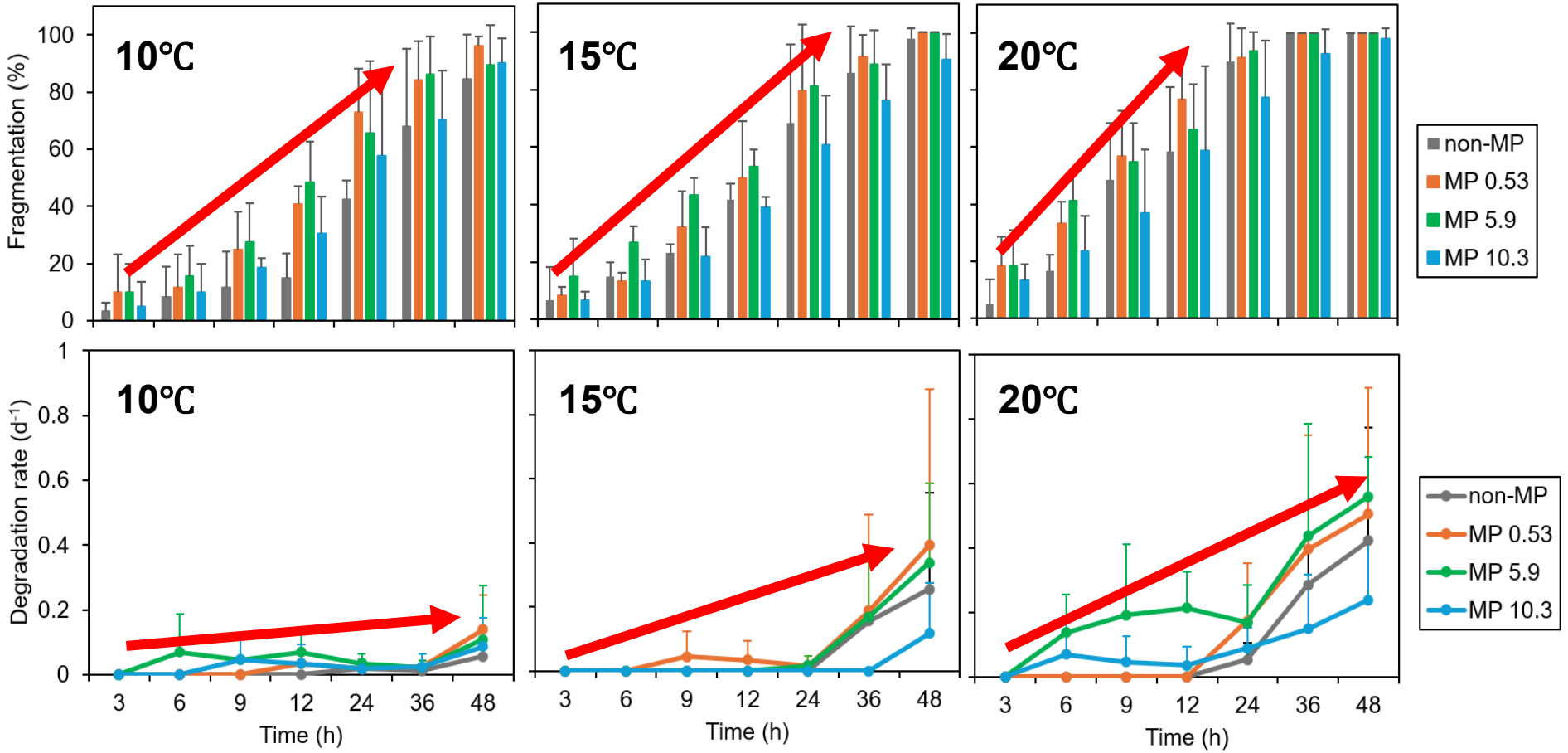
MP 10.3	154.1±39.2	40.0±8.1	2.09±1.15	21.7±16.3

- MP 10.3 showed significantly more particles per FP than MP 5.9 ($p < 0.001$).
- Particles in the MP 0.53 were too small to count individually.

Results

- **Faecal pellet degradation** by **microplastic size**

(1) **Temperature-dependent** degradation - Temporal changes over 48 h

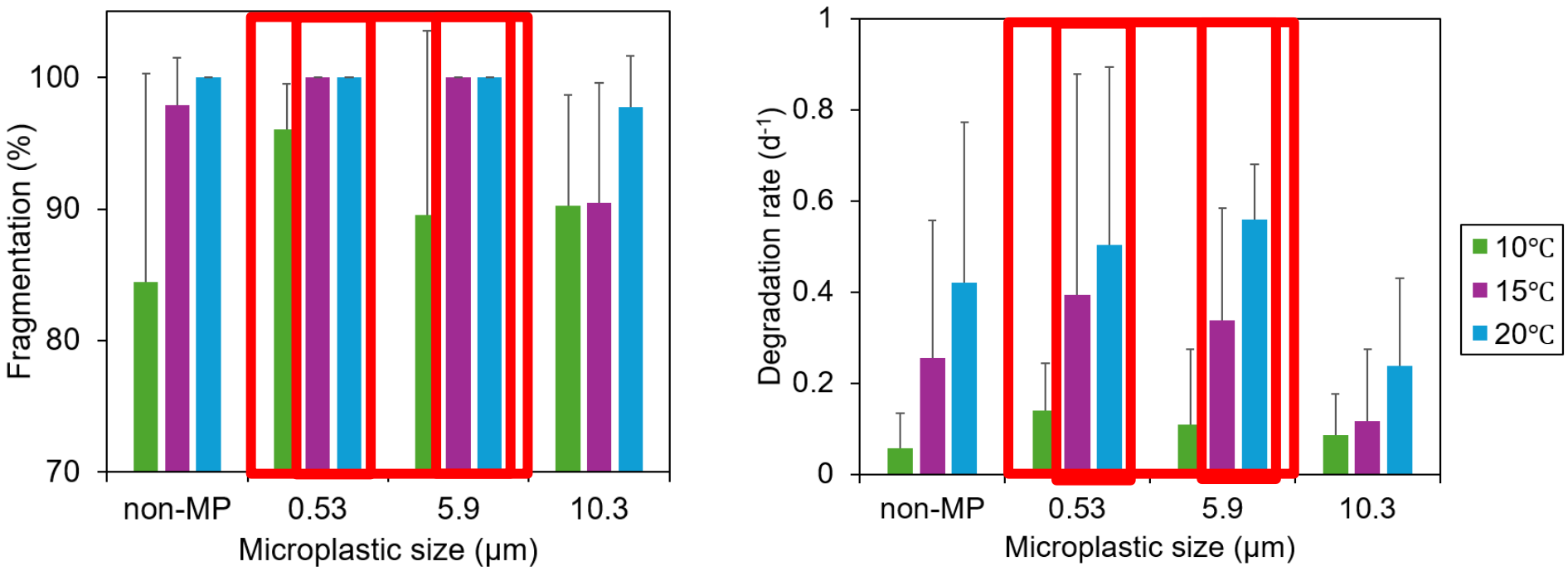


- Both fragmentation percentages and degradation rates increased with temperature ($p < 0.001$).

Results

- **Faecal pellet degradation** by **microplastic size**

(1) **Temperature-dependent** degradation - Comparison at 48 h

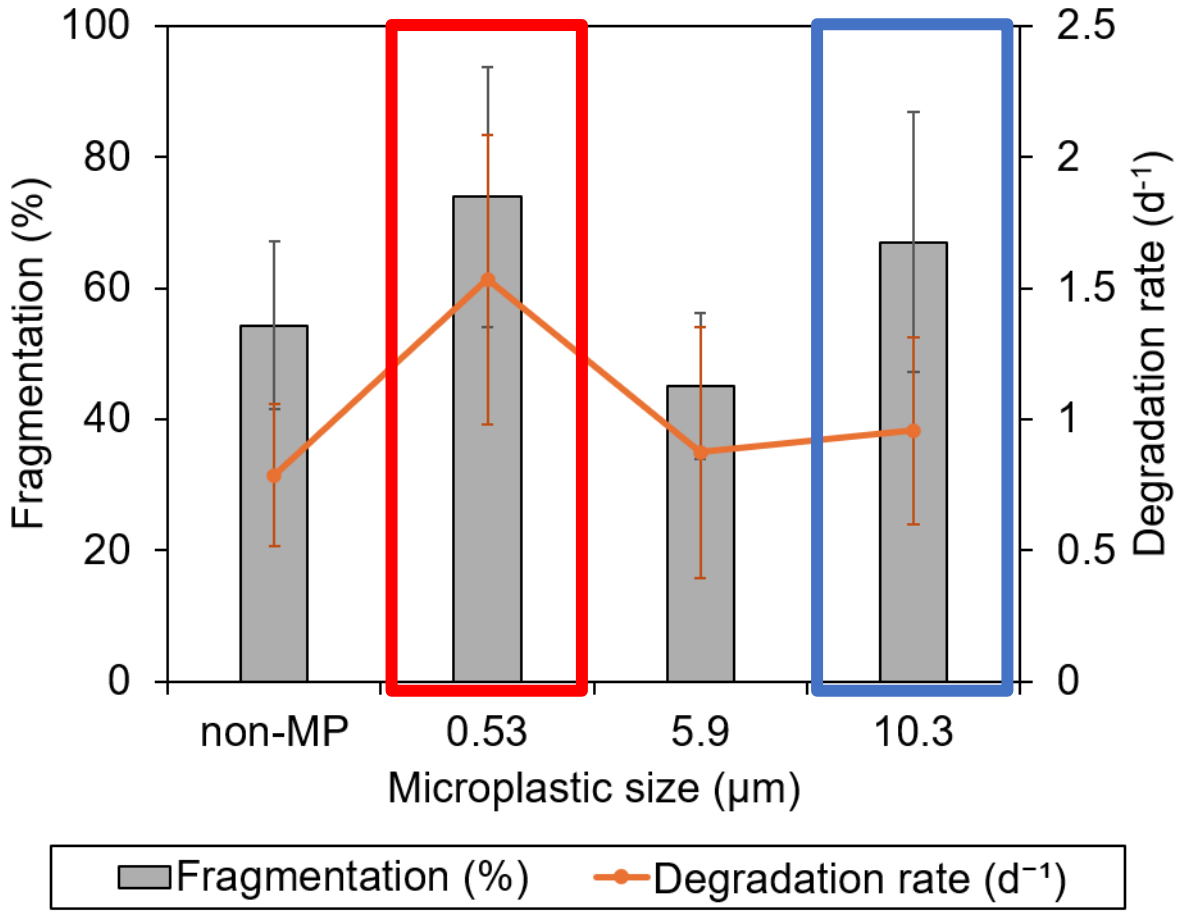


- **MP 0.53** and **MP 5.9** showed higher fragmentation percentages ($p < 0.001$), degradation rates (significant only for MP 5.9, $p < 0.05$), at higher temperatures.

Results

- **Faecal pellet degradation** by **microplastic size**

  (2) **Copepod-mediated** degradation after 24 h



- **MP 0.53** showed the highest FP fragmentation percentage ($p < 0.05$), degradation rate ($p < 0.001$).

- Unlike the temperature-dependent degradation, **MP 10.3** showed higher fragmentation than non-MP and MP 5.9.

Discussion

- **Microplastic ingestion** by **particle size**
  - Selective ingestion

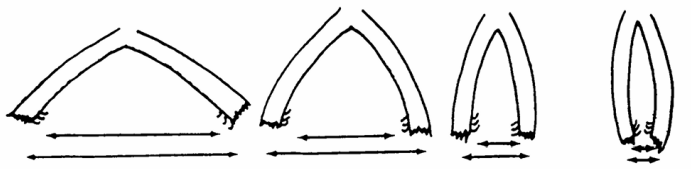
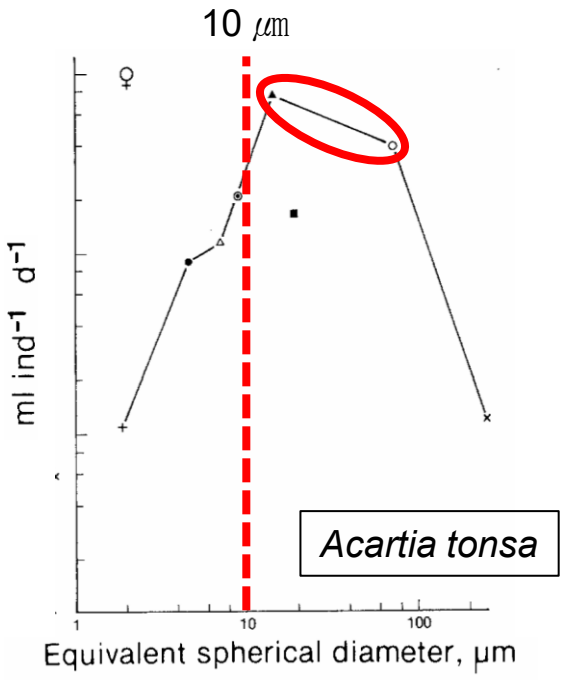


FIG. 6. Generalized "grasping appendages" showing that, while a wide size range of particles may be caught, any one posture can efficiently catch only a smaller sub-range.

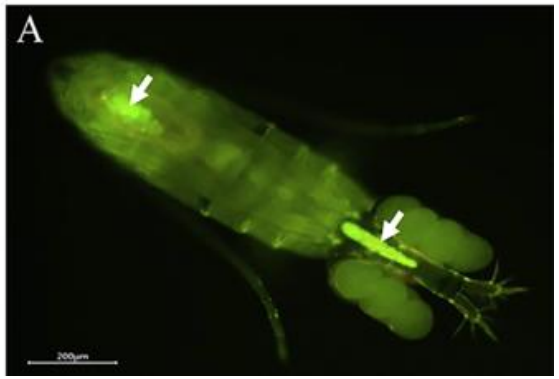
(Wilson, 1973)



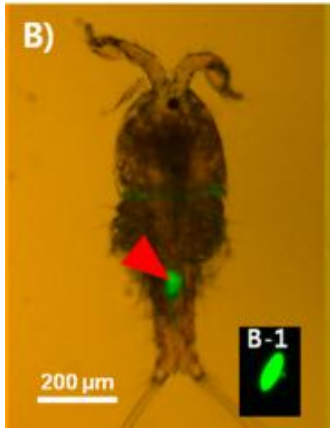
(Berggreen et al., 1988)

- Copepods can selectively ingest MPs based on size, particularly within the size range of their natural prey (Fibbe et al., 2023).

  - Non-selective ingestion



(Cheng et al., 2020)



(Lee et al., 2013)

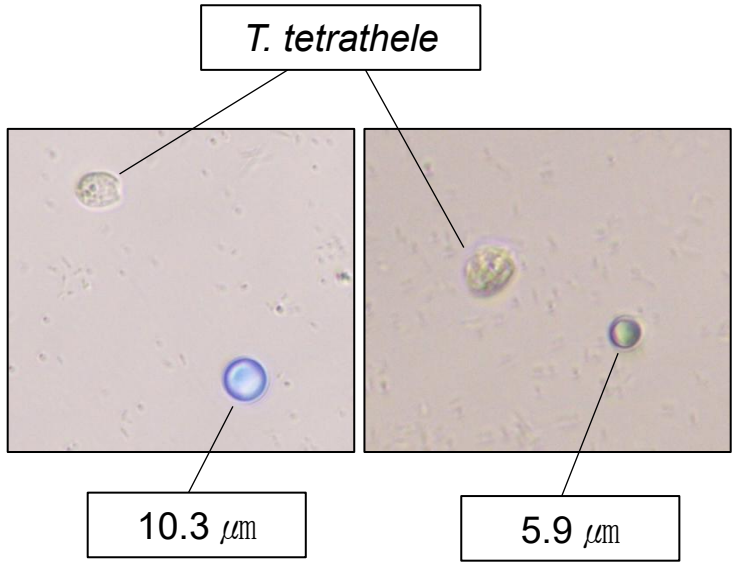
- Nanomaterials can aggregate with natural colloids in water, forming heteroaggregates (Quik et al., 2014).

- Submicron MPs (< 1 ㎛) can be ingested non-selectively by copepods.

Discussion

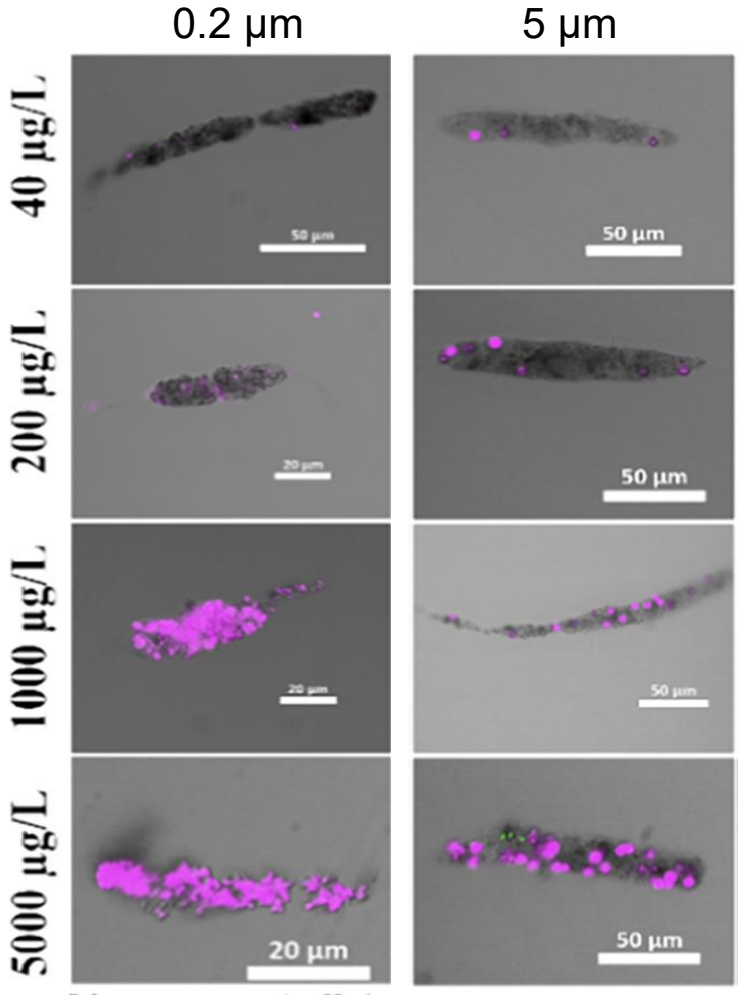
- In this study : MPs content in FPs
- **MP 10.3 > MP 5.9** : Higher MP content may be due to the **similarity in size between 10.3 ㎛ particles and *T. tetrathele*.**

- **MP 0.53 (not quantified)** : MPs may have been **ingested non-selectively through aggregation** with food particles.

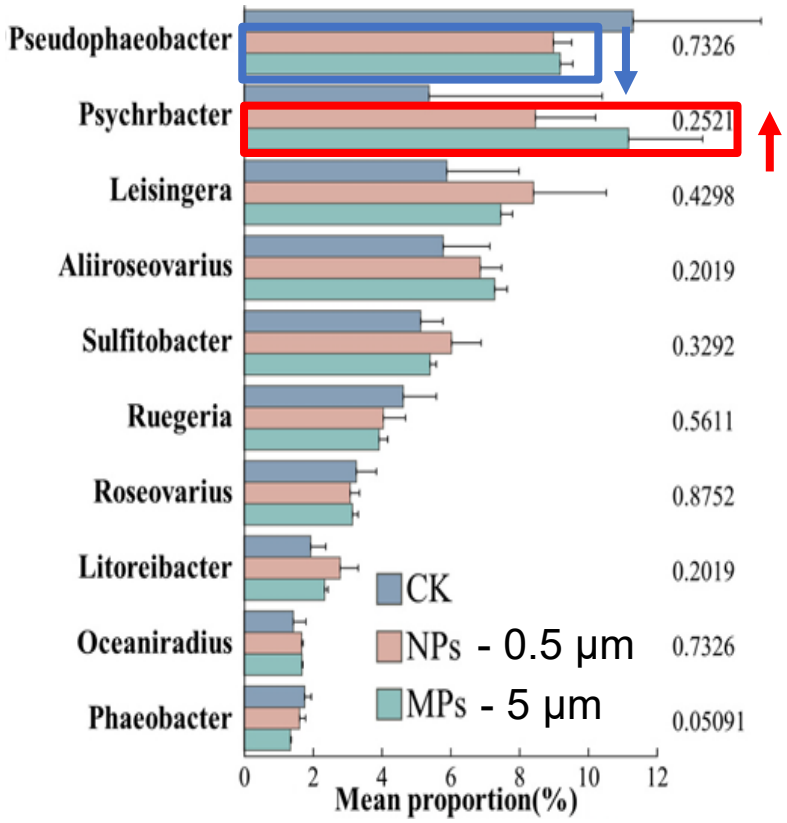


Discussion

- **Microplastic size** effects on **faecal pellet properties**



(Dong & Wang, 2025)



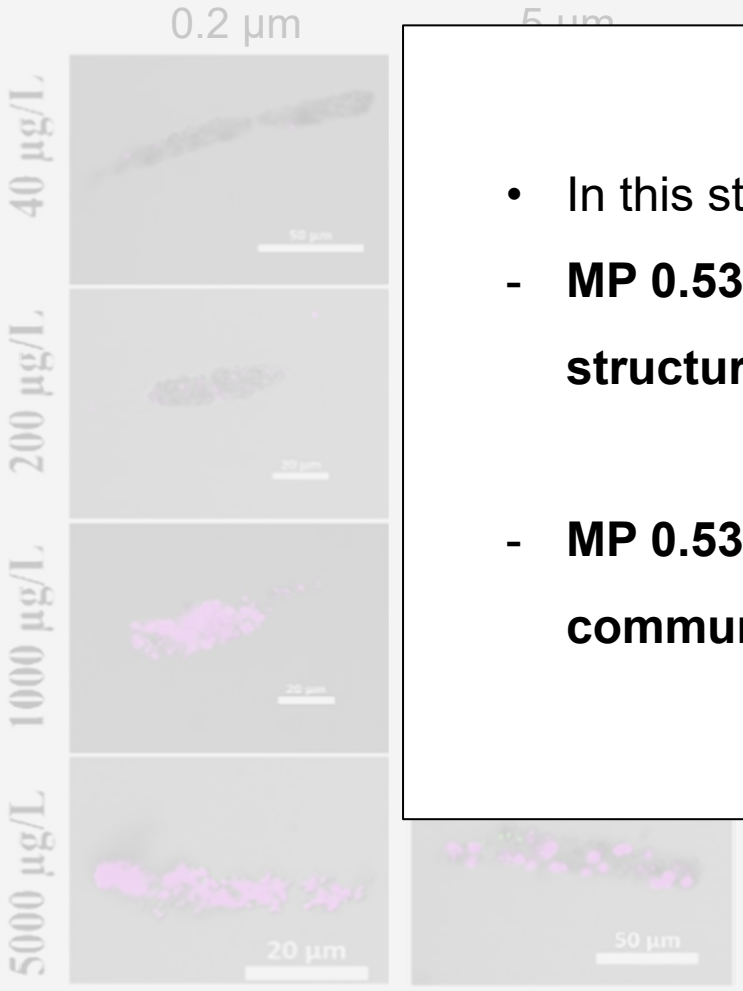
(Dong & Wang, 2026)

- Submicron MPs (< 1 ㎛) were more uniformly distributed within FPs (Dong & Wang, 2025).

- MPs altered FP microbial communities, reducing core taxa and increasing plastic-associated genera (Dong & Wang, 2026).

Discussion

- **Microplastic size** effects on **faecal pellet properties**



(Dong & Wang, 2025)

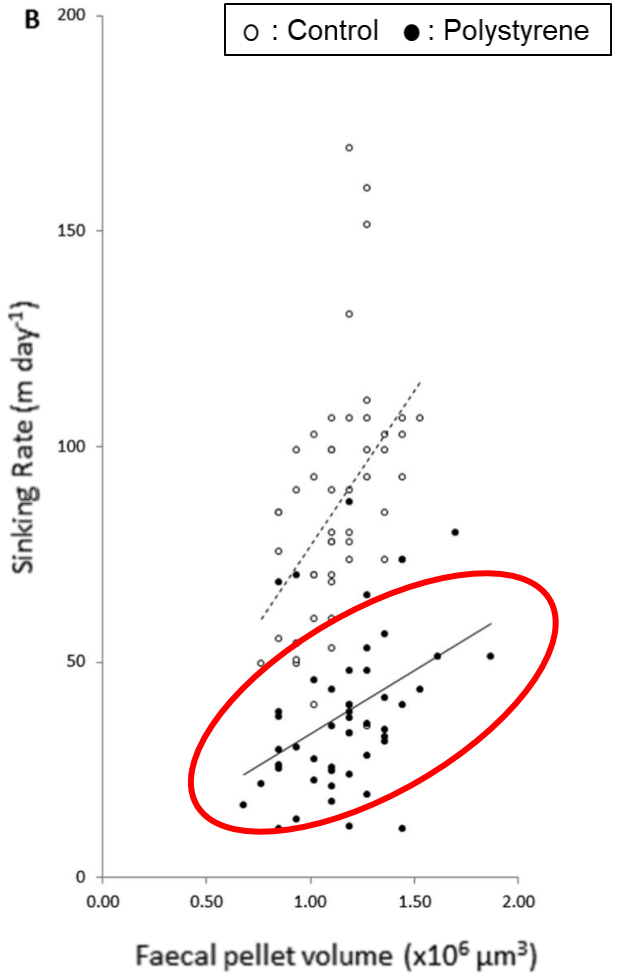
- In this study
- **MP 0.53**: Uniform MP distribution within FPs may **reduce structural stability**, leading to higher degradation.
- **MP 0.53 & MP 5.9**: MP-induced **shifts in microbial community** may enhance degradation at higher temperatures.

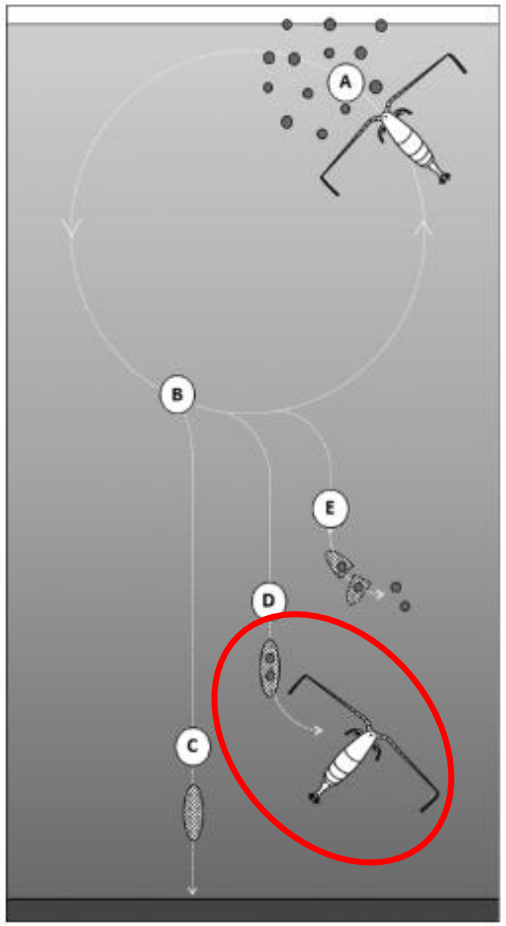
< 1 µm) were more
ed within FPs
icrobial
ucing core taxa
astic-associated
g, 2026).

(Dong & Wang, 2026)

Discussion

- **Faecal pellet sinking** and **interactions with degraders**





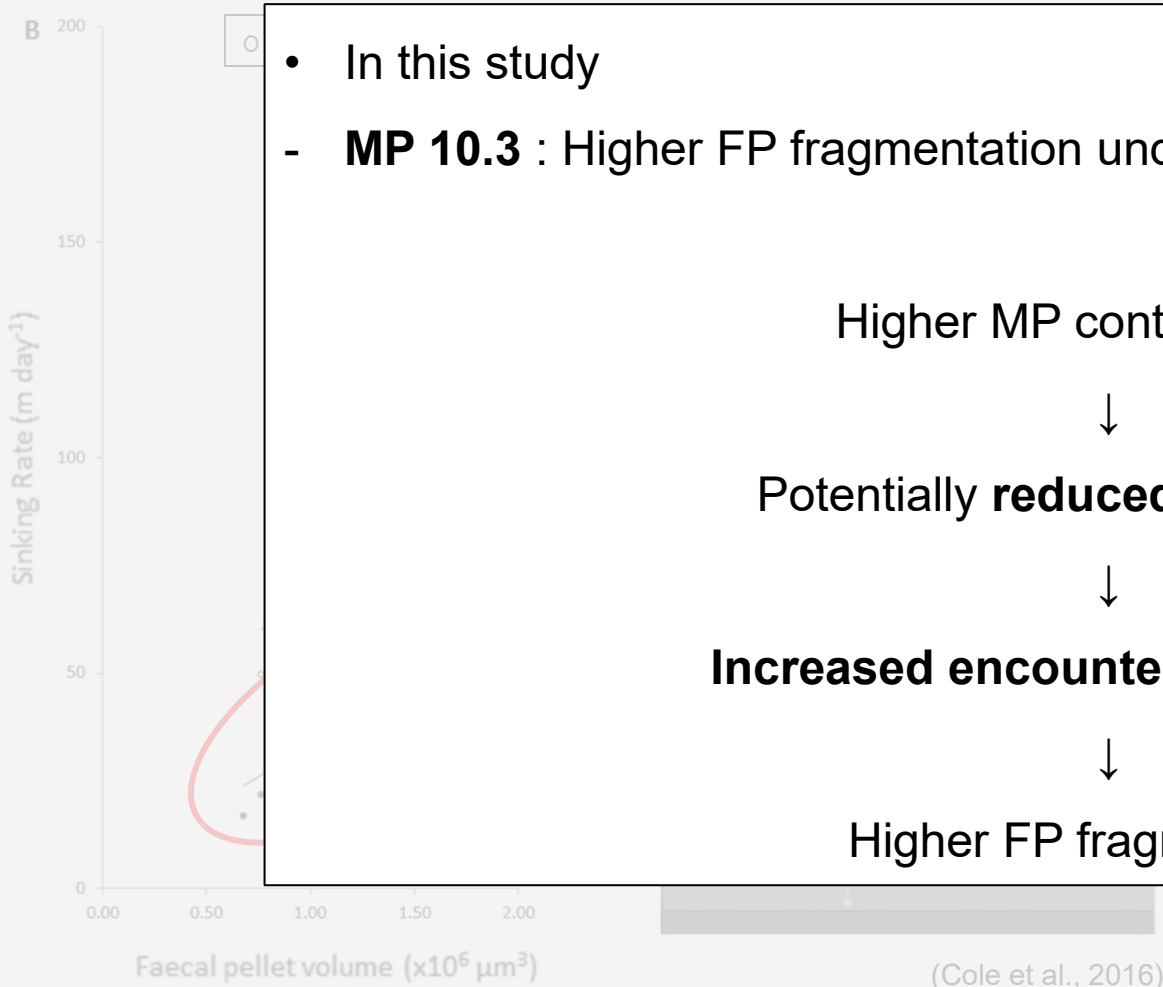
(Cole et al., 2016)

- MPs ingested by copepods can alter FP structural integrity, density, and sinking rates (Cole et al., 2016).

- Slower-sinking FPs may remain suspended longer, increasing encounters with other FP degraders (Noji et al., 1991; Iversen & Poulsen, 2007).

Discussion

- **Faecal pellet sinking** and **interactions with degraders**



(Cole et al., 2016)

- In this study

- **MP 10.3** : Higher FP fragmentation under copepod-mediated degradation

Higher MP content in FPs

↓

Potentially **reduced sinking rate**

↓

Increased encounters with *A. omorii*

↓

Higher FP fragmentation

alter FP

sinking rates

suspended

ith other FP

Poulsen, 2007).

Conclusion

❖ **Faecal pellet degradation** by **microplastic size**

- This study **quantified FP degradation based on MP sizes** under two different degradation processes.
  - **Temperature-dependent** degradation
  - **Copepod-mediated** degradation

MP 0.53	Temperature-dependent ↑ Copepod-mediated ↑	Reduced structural stability
MP 5.9	Temperature-dependent ↑ Copepod-mediated ↓	Shifts in FP microbial communities
MP 10.3	Temperature-dependent ↓ Copepod-mediated ↑	Reduced sinking rates and increased copepod encounters

1. FP fragmentation percentage and degradation rate varied with **MP sizes** and **degradation processes.**
2. Submicron MPs showed **higher FP degradation,** while larger MPs showed **different patterns between degradation processes**.
3. The **effects of MPs on FP carbon export** may vary with **MP sizes** and **degradation processes**.

Thank you

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