

令和2年度海洋プラスチックごみ学術シンポジウム

セッションC：生態影響

C-4: メダカにおけるマイクロプラスチックの体内動態と生物濃縮および化学物質に対するベクター効果

大嶋 雄治(九州大学大学院)

MPの水生生物への影響

- 水生生物の体内動態は未解明
- 食物連鎖を介しての蓄積はあるのか？
- MPに吸着した有害化学物質の蓄積を介在するベクター効果はあるのか？
- 研究の殆どは新品の MPであり、劣化 MPでは化学物質の吸着特性と生物への蓄積と影響は大きく異なる可能性が高い

メダカ (*Oryzias latipes*) をモデルとして用いる

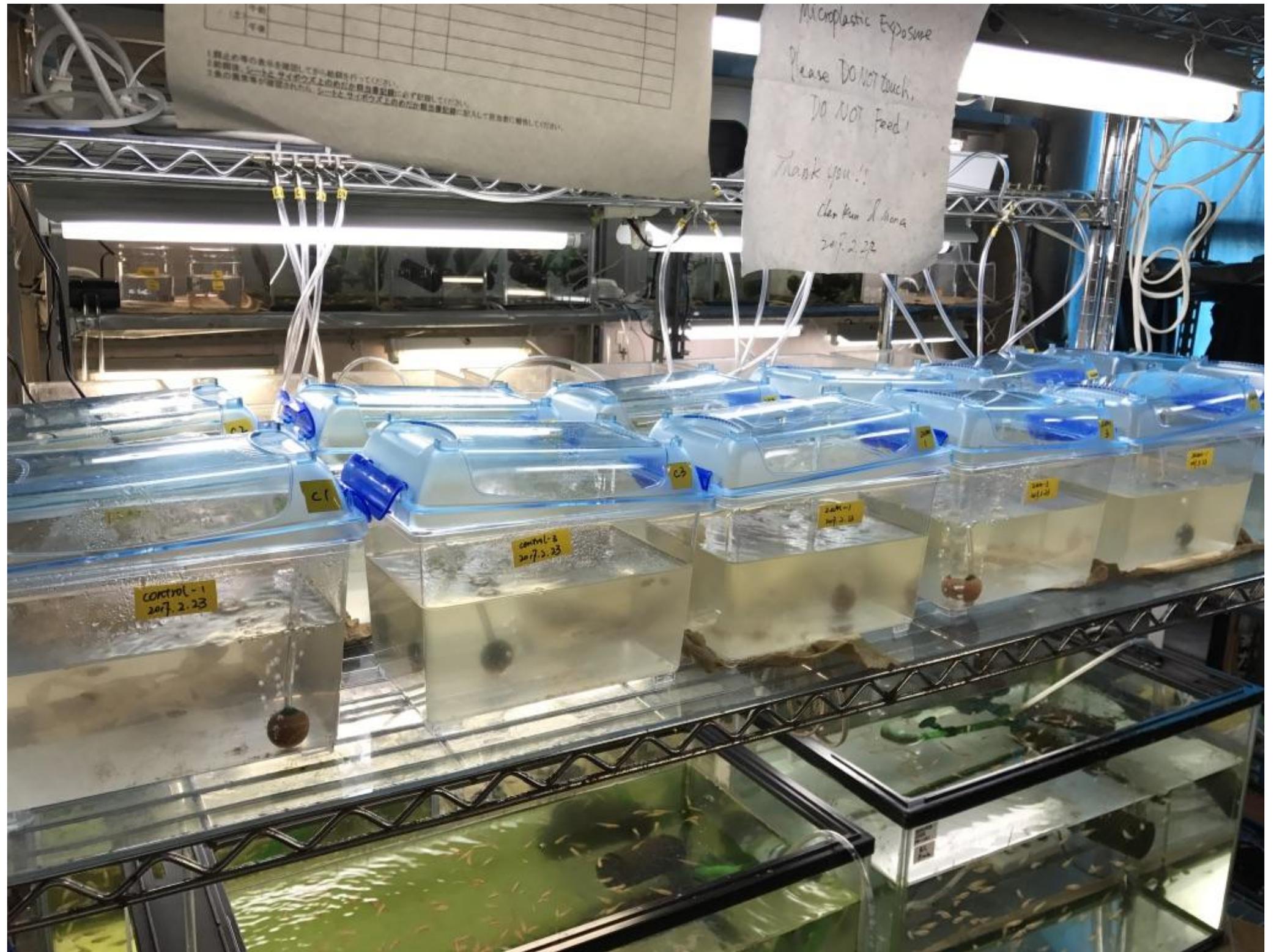
モデル生物として広く用いられている。

- 科学的バックグラウンドが充実している
- 生物試験の世界標準魚として用いられている
- 飼育が容易である。
- 卵の膜が透明なので、体ができる発生の過程が容易に観察できる。
- 交配の遺伝学的実験法が確立している。



実験の準備が整った状態で実験を行ってください。
実験中は、シートとマイクロプラスチックの割合を厳密に守ってください。
実験の終了後、シートとマイクロプラスチックの割合を厳密に守って回収してください。

Microplastic Exposure
Please DO NOT touch.
DO NOT Feed!
Thank you!!
Cher Kun A. Wong
2017.2.23



再生産への影響： 2um MPを暴露したメダカの産卵数と次世代の生存率



Bioaccumulation and reproductive effects of fluorescent microplastics in medaka fish

Mona Assas^{a,b}, Xuchun Qiu^{a,c}, Kun Chen^c, Hijiri Ogawa^a, Hai Xu^c, Yohei Shimasaki^a, Yuji Oshima^{a,d,*}

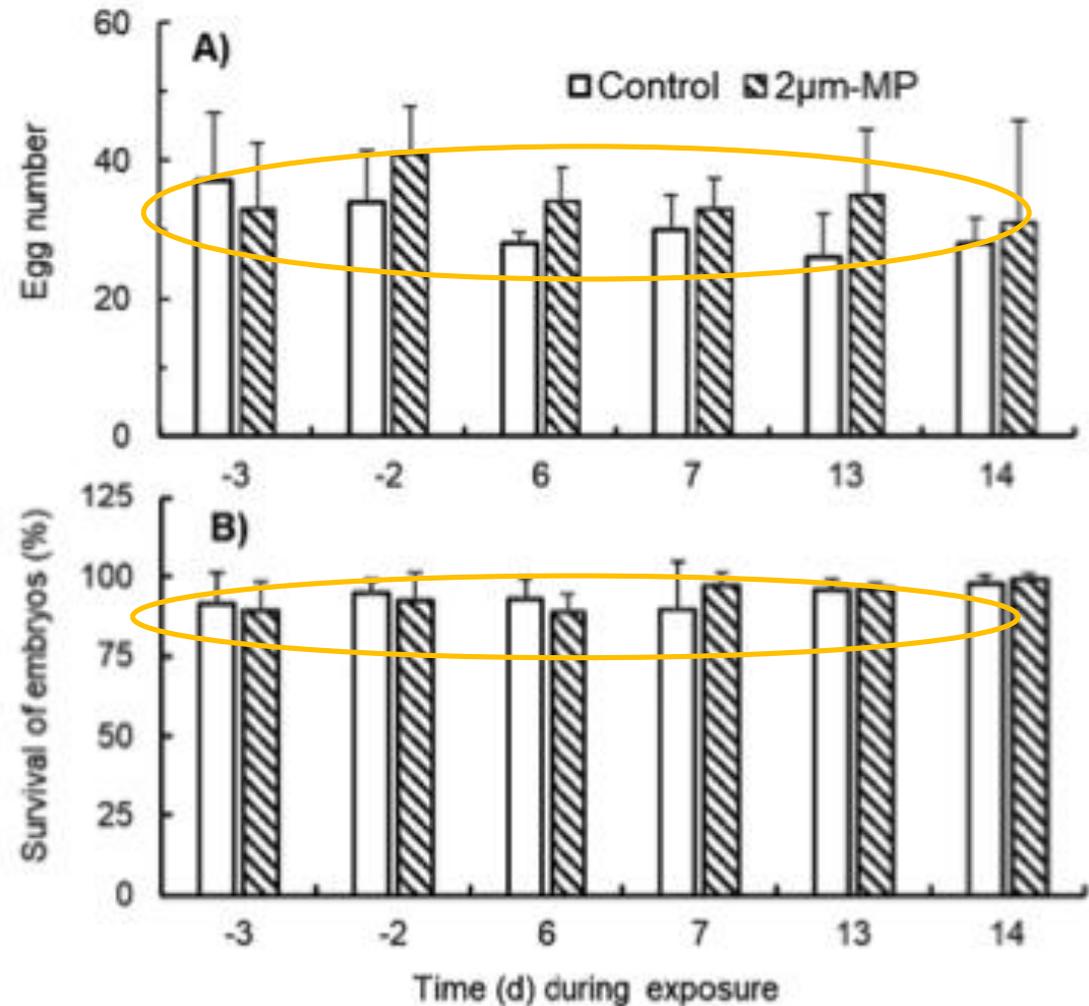
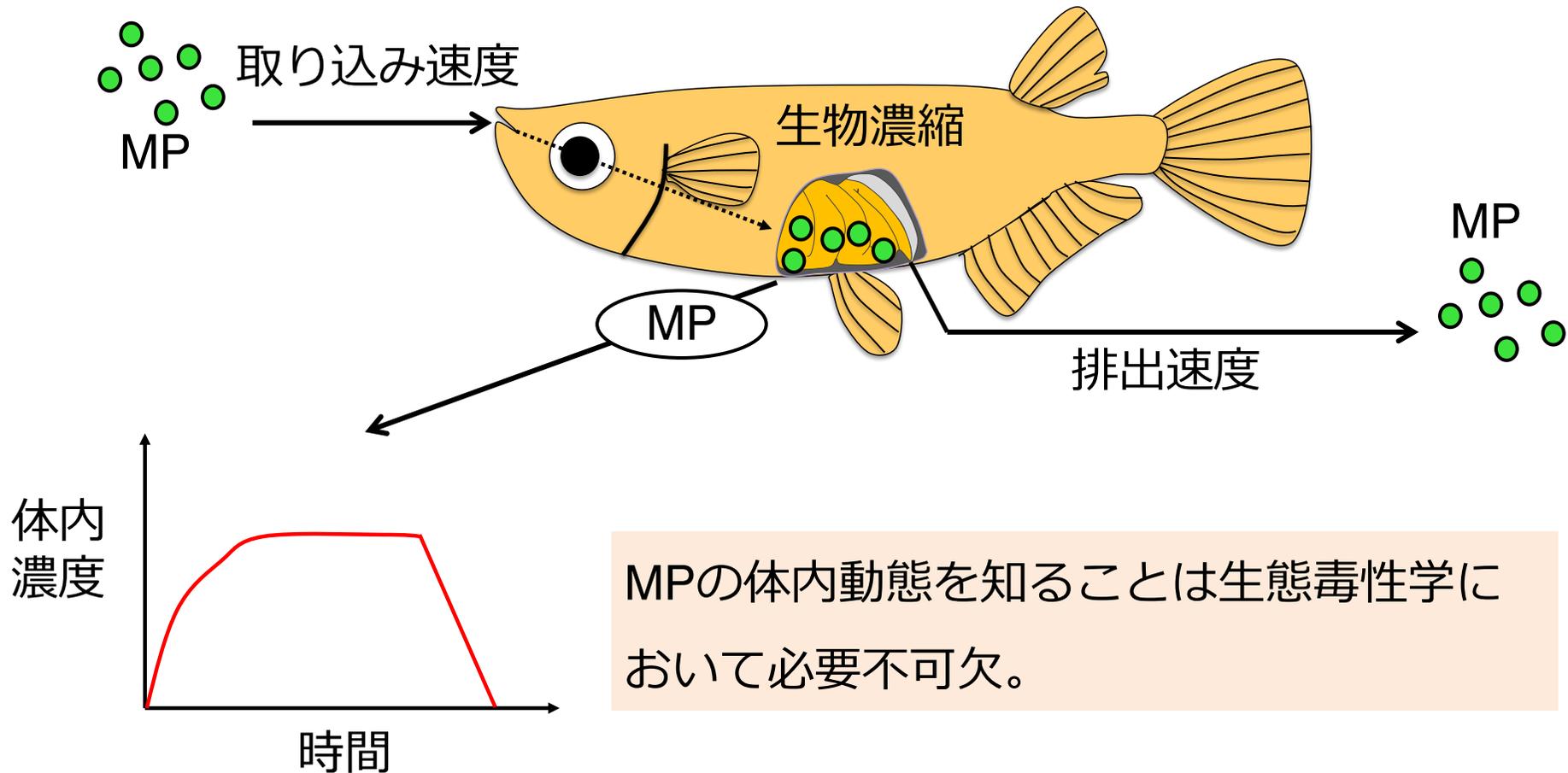


Fig. 3. Effect of microplastics (MPs) exposure on reproduction of Japanese medaka (*Oryzias latipes*). (A) Number of embryos collected; (B) survival of embryos to hatching.

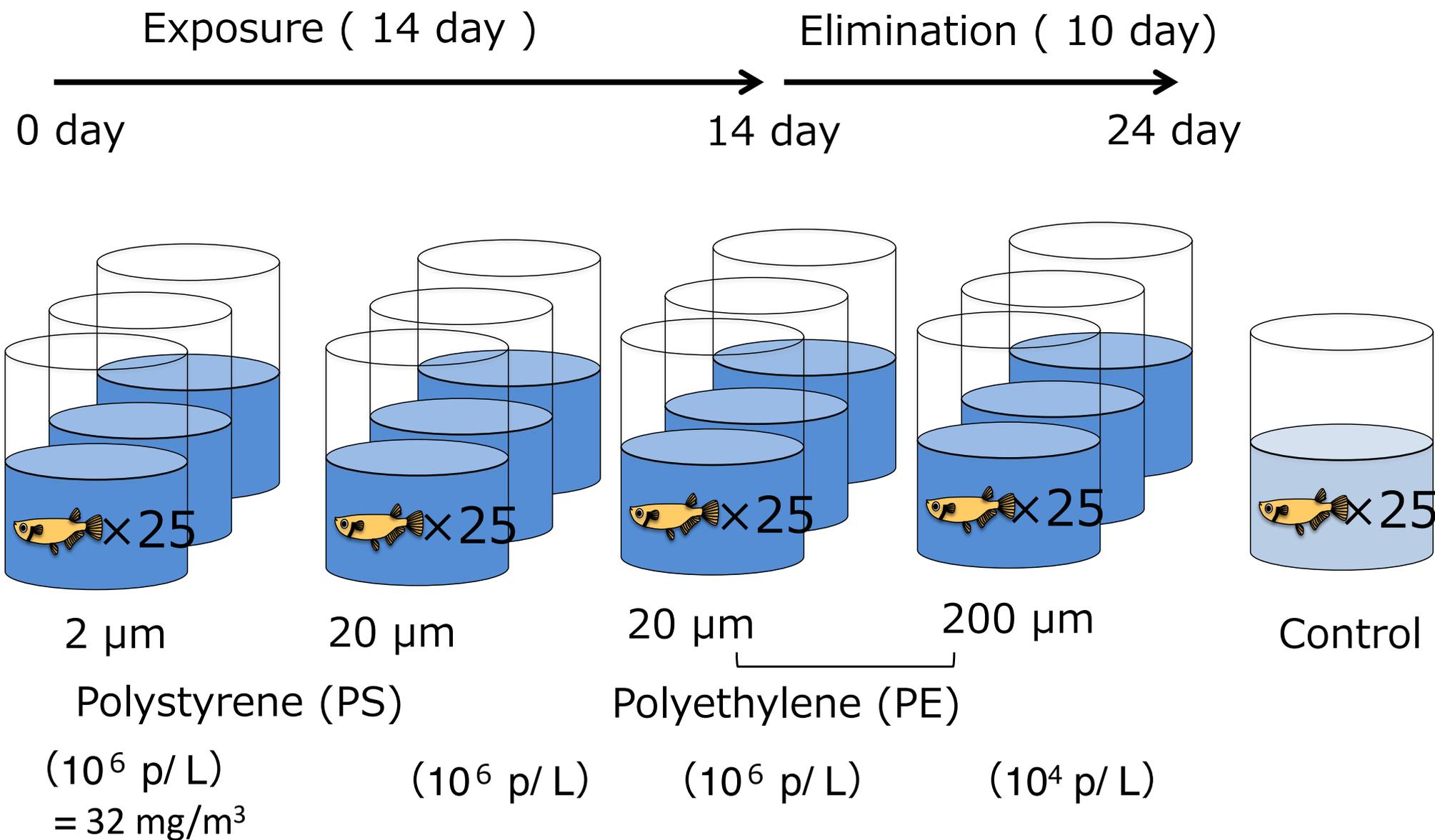
再生産へ影響はなかった

体に入ったプラスチックの蓄積・体内動態

MPの取り込み・蓄積・排出等の挙動についてはほとんど分かっていない。



2, 20, 200 μ mMPの暴露試験





Uptake and depuration kinetics of microplastics with different polymer types and particle sizes in Japanese medaka (*Oryzias latipes*)

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Y. Liu et al.

Ecotoxicology and Environmental Safety 212 (2021) 112007

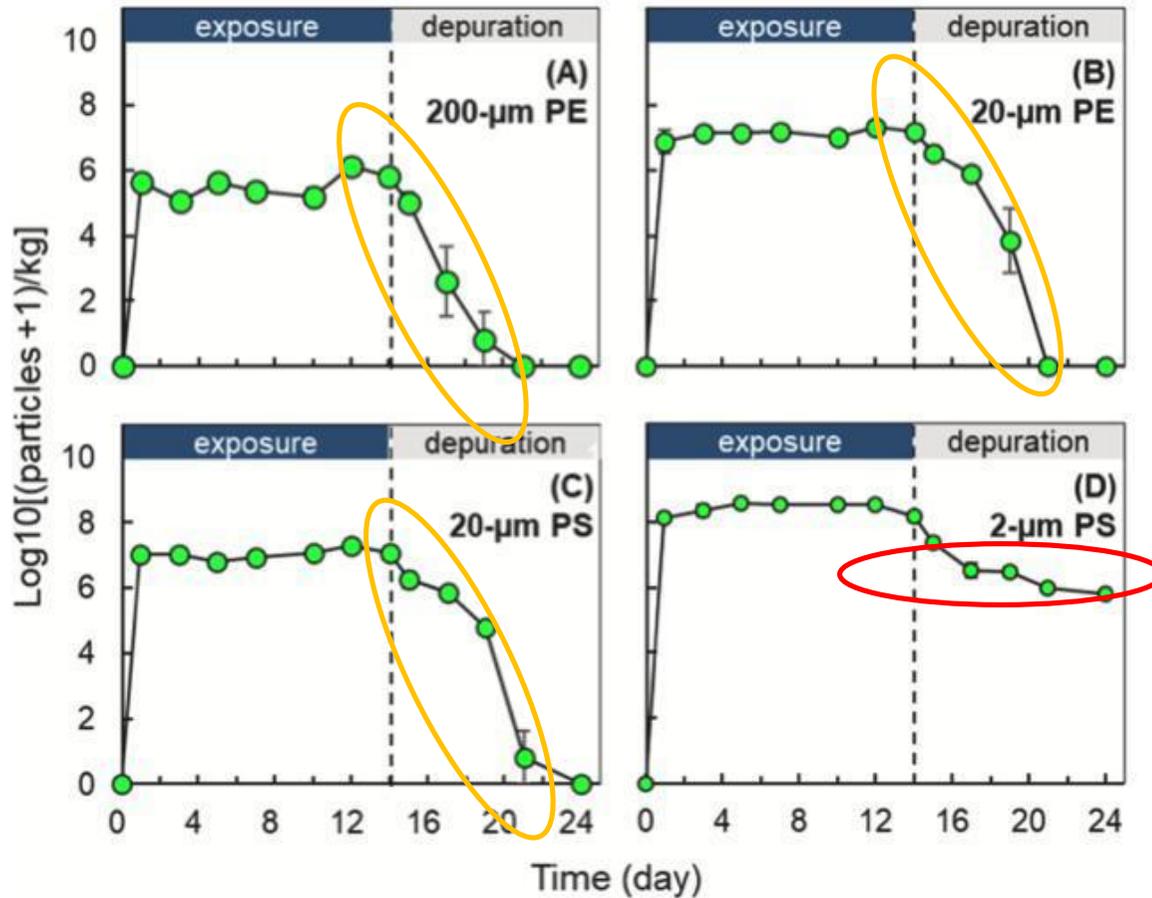


Fig. 5. The concentration of microplastics (MPs) in the Japanese medaka (*Oryzias latipes*). (A) PE-MPs with a diameter of 200 µm; (B) PE-MPs with a diameter of 20 µm; (C) PS-MPs with a diameter of 20 µm; (D) PS-MPs with a diameter of 2 µm. Data are shown as mean ± SD (n = 5). The experiment consisted of a 14-day

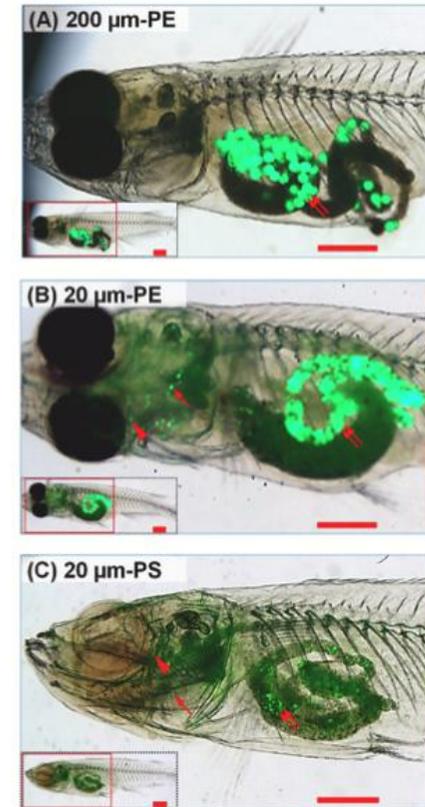


Fig. 3. Representative images of medaka (*Oryzias latipes*) collected during the exposure phase under the visual field of a GFP filter ($\lambda_{em} = 525/50$ nm and $\lambda_{ex} = 470/40$ nm). (A) PE-MPs with a diameter of 200 µm; (B) PE-MPs with a diameter of 20 µm; (C) PS-MPs with a diameter of 20 µm. The inner figure shows whole-body images. The typical fluorescent signals of MPs are indicated by the double arrow (gastrointestinal tract), single arrow (gill), and arrowhead (head). Bar = 1.0 mm.

MPは急速に体から出て行く . . .



Uptake and depuration kinetics of microplastics with different polymer types and particle sizes in Japanese medaka (*Oryzias latipes*)

Yangqing Liu^a, Xuchun Qiu^{a,b}, Xinning Xu^a, Yuki Takai^a, Hijiri Ogawa^a, Yohei Shimasaki^a, Yuji Oshima^{a,c,*}

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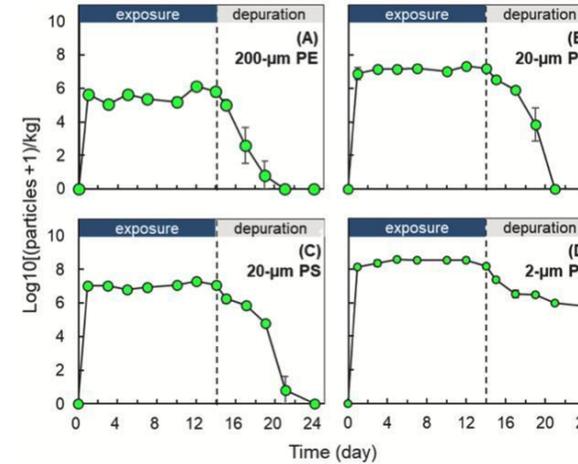


Fig. 5. The concentration of microplastics (MPs) in the Japanese medaka (*Oryzias latipes*). (A) PE-MPs with a diameter of 200 µm; (B) PE-MPs with a diameter of 20 µm; (C) PS-MPs with a diameter of 20 µm; (D) PS-MPs with a diameter of 2 µm.

Table 2

Pharmacokinetic parameters of microplastics (MPs) in Japanese medaka (*Oryzias latipes*)^a.

Parameter (unit)	200 µm PE	20 µm PE	20 µm PS	2 µm PS
BCF (L/kg)	74.4	25.7	16.8	139.9
k_u (L/kg/day)	83.7	26.7	15.8	106.1
k_e (/day)	1.13	1.04	0.94	0.76
$T_{1/2}$ (/day)	0.62	0.67	0.74	0.91
MRT (/day)	0.90	1.00	1.12	1.33

^a PE: Polyethylene MPs; PS: Polystyrene MPs; BCF: bioconcentration factor; k_u : uptake rate constant; k_e : elimination rate constant (estimated from day 14–19); $t_{1/2}$: biological half-life; MRT: mean residence time.

20, 200 µmMPのBCFは<100と推定された



Uptake and depuration kinetics of microplastics with different polymer types and particle sizes in Japanese medaka (*Oryzias latipes*)

Yangqing Liu^a, Xuchun Qiu^{a,b}, Xinning Xu^a, Yuki Takai^a, Hijiri Ogawa^a, Yohei Shimasaki^a, Yuji Oshima^{a,c,*}

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Ecotoxicology and Environmental Safety 212 (2021) 11200

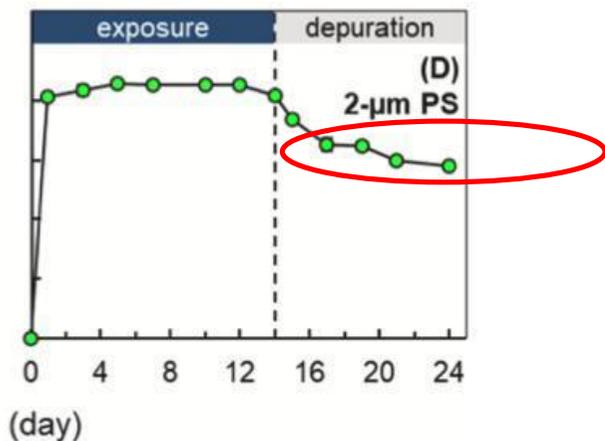


Fig. 4. Typical fluorescent signal in the head and gastrointestinal tract of medaka (*Oryzias latipes*) exposed to 2 µm polystyrene microplastics (MPs) under the visual field of a GFP lens ($\lambda_{em} = 525/50$ nm and $\lambda_{ex} = 470/40$ nm). (A) representative whole-body image; (B) MPs in the head of fish sampled on day 1; (C) MPs in gastrointestinal tract of fish sampled on day 7; (D) MPs in the gastrointestinal tract of fish sampled on day 24 (the last day of the depuration phase). The typical fluorescent signal is indicated by an arrowhead. Bar = 1.0 mm.

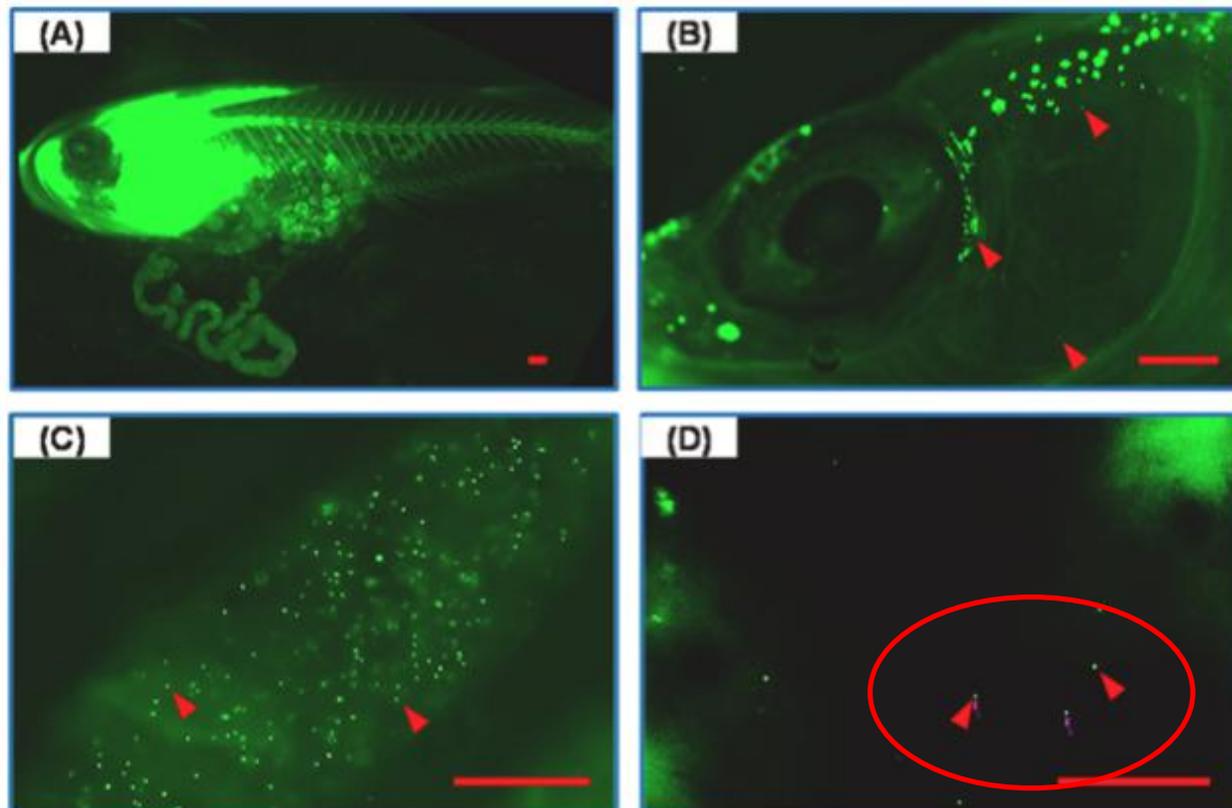
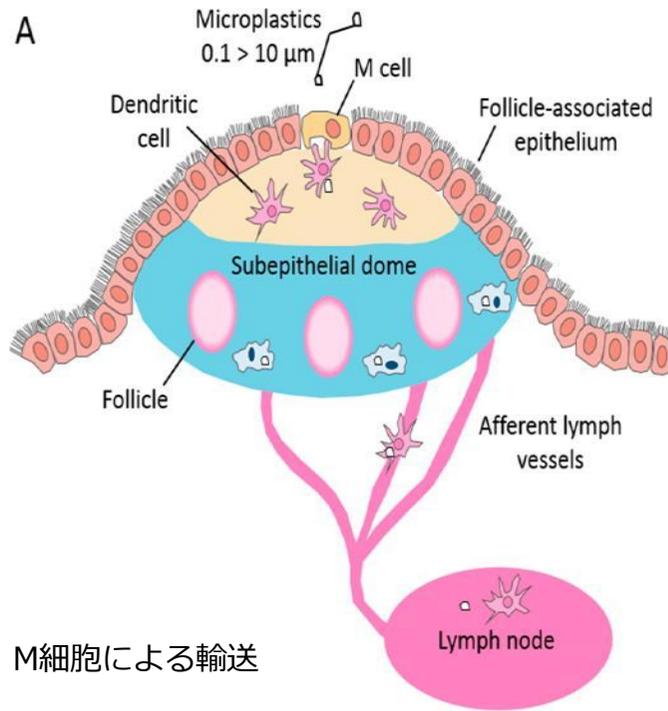


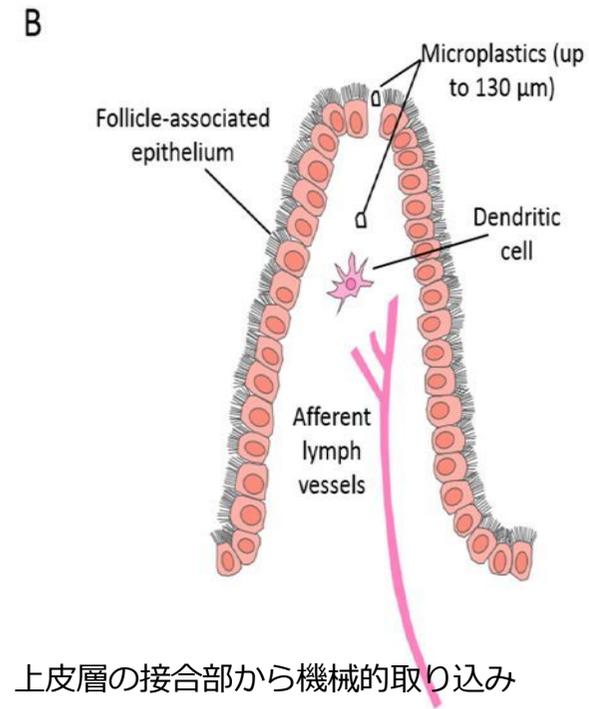
Fig. 4. Typical fluorescent signal in the head and gastrointestinal tract of medaka (*Oryzias latipes*) exposed to 2 µm polystyrene microplastics (MPs) under the visual field of a GFP lens ($\lambda_{em} = 525/50$ nm and $\lambda_{ex} = 470/40$ nm). (A) representative whole-body image; (B) MPs in the head of fish sampled on day 1; (C) MPs in gastrointestinal tract of fish sampled on day 7; (D) MPs in the gastrointestinal tract of fish sampled on day 24 (the last day of the depuration phase). The typical fluorescent signal is indicated by an arrowhead. Bar = 1.0 mm.

MPは急速に体から出て行くが 2µm MPは残留する

Predicted pathways of microplastic uptake from the gastrointestinal tract (GIT)



Endocytosis



(Wright and Kelly et al., 2017)

Persorption

消化管内壁にMPsが入り込んだ可能性が高い

MPは食物連鎖を介して濃縮するのか？

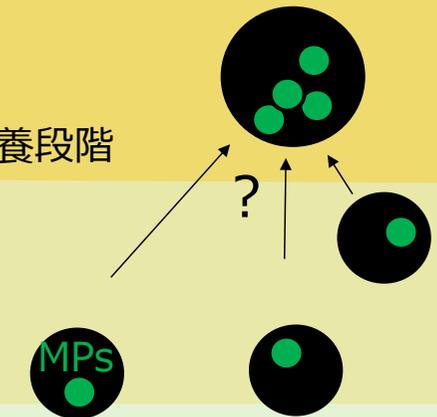
食物連鎖による生物濃縮の可能性は低い (BCFが<100)

低次栄養段階の生物への取り込みが報告されている

高次栄養段階

低次栄養段階

生態ピラミッド



ムラサキイガイ

(フィンランド環境研究所より)



ナンキョクオキアミ

(Dawson et al., 2018)



生産者

オキアミから魚へ食物連鎖
で移行する (Hasegawa
and Nakaoka, 2020)

T. Hasegawa and M. Nakaoka

Environmental Pollution 273 (2021) 116468

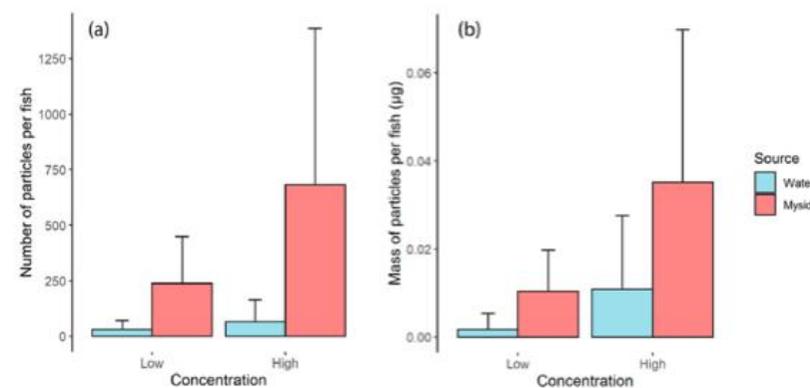
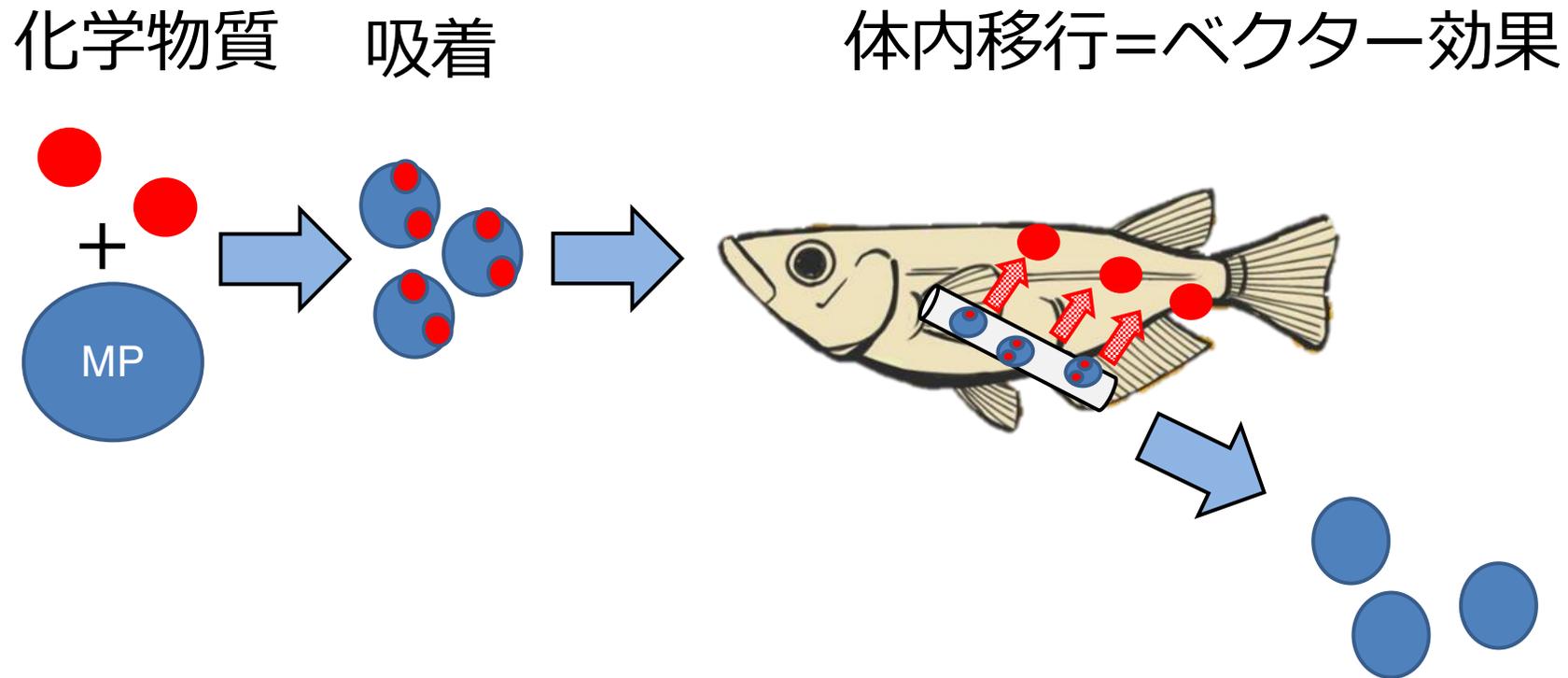


Fig. 3. Average number (a) and mass (b) of polyethylene beads ingested by fish (*Myoxocephalus brandti*) from the water column or through ingestion of bead-exposed mysids. Bead concentration was 200 µg/L (low) or 2000 µg/L (high). Error bars represent the standard deviation.

MPによる化学物質蓄積へのベクター効果





Quantifying the vector effects of polyethylene microplastics on the accumulation of anthracene to Japanese medaka (*Oryzias latipes*)

Xuchun Qiu^{a,b}, Souvannasing Saovany^b, Yuki Takai^b, Aimi Akasaka^c, Yoshiyuki Inoue^c, Naoaki Yakata^c, Yangqing Liu^b, Mami Waseda^b, Yohei Shimasaki^b, Yuji Oshima^{b,d,*}

Table 1
Pharmacokinetic parameters of anthracene (ANT) in Japanese medaka (*Oryzias latipes*) in the ANT exposure and ANT-MPs co-exposure groups.

Parameters	ANT exposure	ANT-MPs co-exposure
ANT in water (on day 14; mg/L)	0.037	0.074 (containing MPs) 0.022 (water phase)
ANT in medaka (on day 14; mg/kg)	42.8	41.1
Bioconcentration factor (BCF; L/kg)	1170	556 (containing MPs)
Uptake rate constant (k_u ; L/kg ^{0.5} /day)	2432	1078
Depuration rate constant (k_e ; /day)	2.08	1.94

X. Qiu et al.

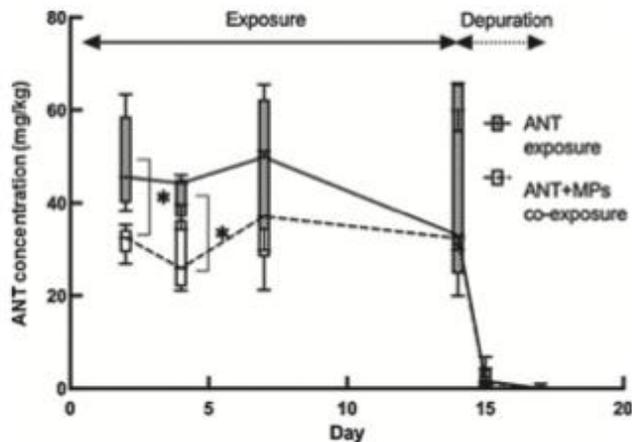


Fig. 2. The concentration of anthracene (ANT) in the Japanese medaka (*Oryzias latipes*) in the anthracene (ANT) exposure and ANT-MPs co-exposure groups. The experiment consisted of a 14-day uptake phase (solid arrow) and a 3-day depuration phase (dotted arrow).

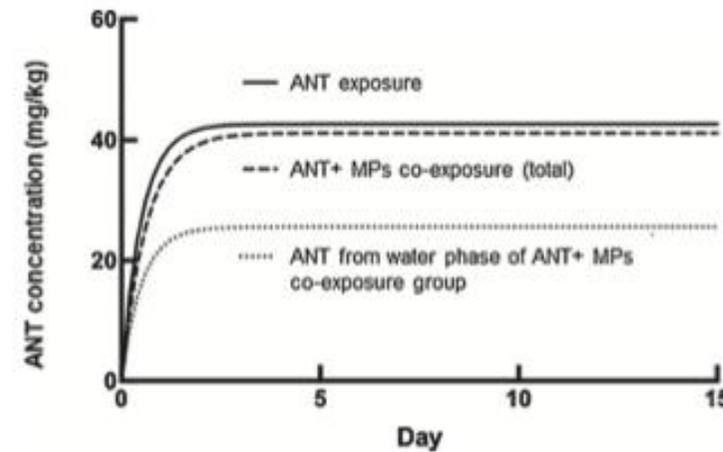


Fig. 3. The one compartment with first-order elimination model (formulas 3 and 4) fitted to time-dependent concentrations of anthracene (ANT) in Japanese medaka (*Oryzias latipes*) in the anthracene (ANT) exposure and ANT-MPs co-exposure groups.

PE-MPはアントラセン蓄積でベクター効果を持つ

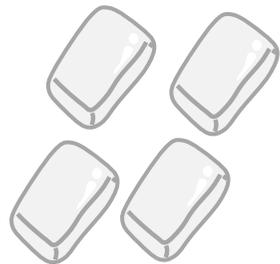
実験に使用したモデルPE粒子



一般に使用されているものと分子量、結晶度が大きく異なるので注意が必要

劣化MPの作製

約200 μm 粒状ポリエチレン (PE)、粉碎PE, PSのマイクロプラスチックを作製し、実環境中の1.5および5年に相当する紫外線を照射して劣化させた粒状及び粉碎PEを作製した結果、PEの劣化度は低かったが、PSは劣化が確認された。

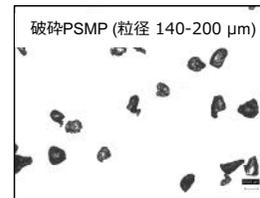
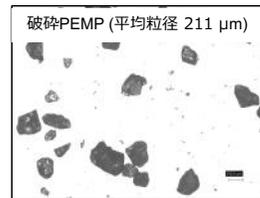


PE、PS ペレット

破碎



ふるい分け



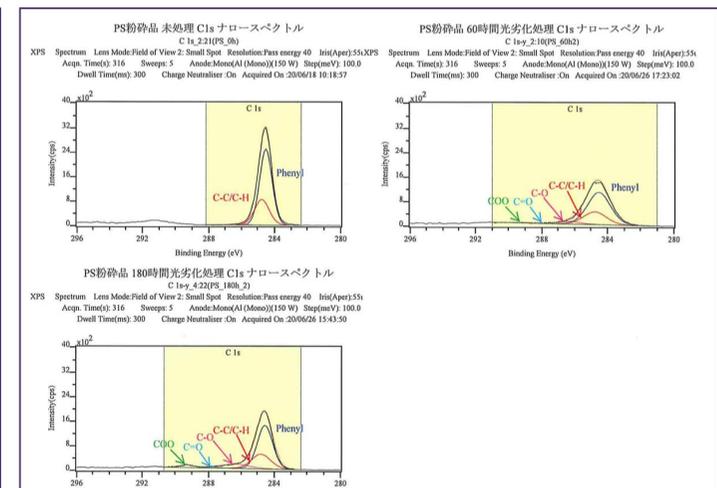
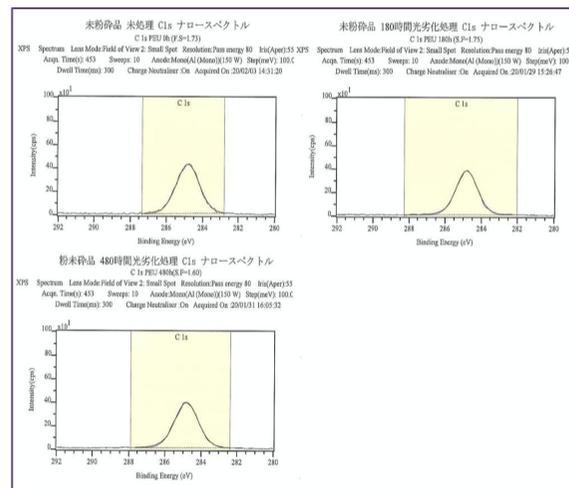
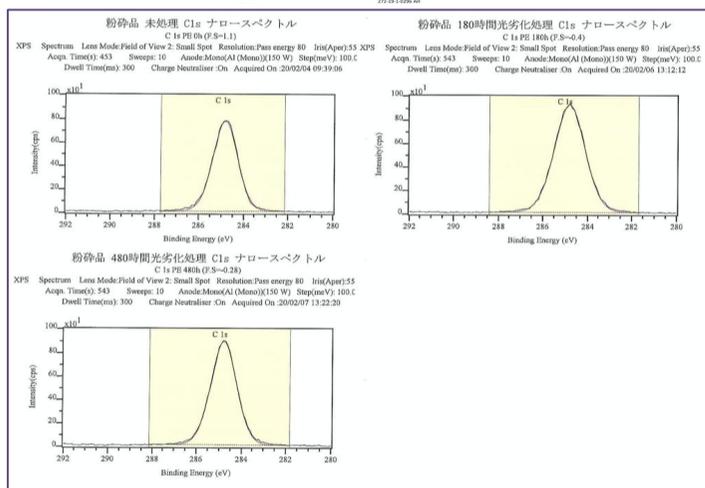
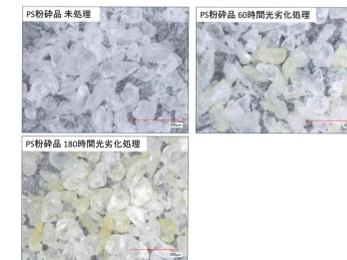
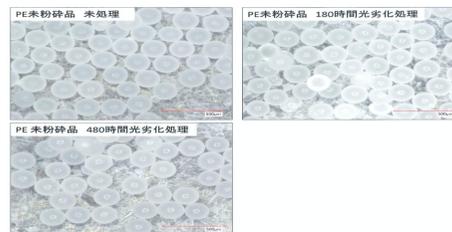
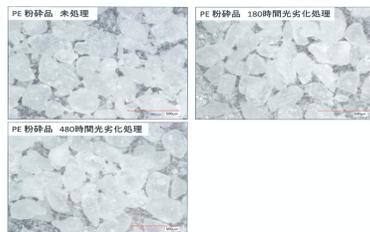
紫外線照射

劣化MPの作製

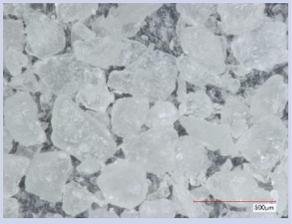
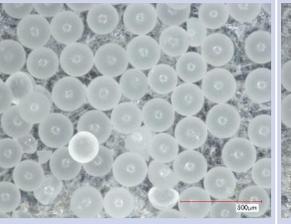
粉碎劣化PE紫外線照射
(1.5年、5年分)

粒状劣化PE紫外線照射
(1.5年、5年分)

粉碎劣化PS紫外線照射
(0.5年、1.5年分)



ポリエチレン粉砕品及び未粉砕品の劣化構造解析結果

試料	粉砕品			粒状未粉砕品		
	未処理	180時間光劣化処理	480時間光劣化処理	未処理	180時間光劣化処理	480時間光劣化処理
外観						
	色及び形状の変化は認められない			色及び形状の変化は認められない		
FT-IR (化学構造) ~1 μm	化学構造の変化は認められない			化学構造の変化は認められない		
XPS (結合状態) ~10 nm	炭素の結合状態に変化は認められない			480時間光劣化処理により極表面においてわずかに酸化劣化が進行		
GPC (分子量) バルク	光劣化処理の経過時間に伴いに分子鎖切断と分子間架橋がわずかに生じている			光劣化処理の経過時間に伴いに分子鎖切断と分子間架橋がわずかに生じている		

光劣化処理により極表面において、わずかに酸化劣化が進行している。

- 水生生物の体内動態は未解明

BCFはメダカでは 10^2 程度→ さらに検証が必要

- 食物連鎖を介しての蓄積はあるのか？

魚類では起こりにくい→ さらに検証が必要

- MPに吸着した有害化学物質の蓄積を介在するベクター効果はあるのか？

起こる→ さらに検証が必要

本研究の一部は以下の研究費支援により行われた

- 環境研究総合推進費(SII-2-2(2), JPMEERF18S20206)
- 日本化学工業協会LRI (19_R05-01)
- CERi 共同研究

- 1) Assas, M., Qiu, X., Chen, K., Ogawa, H., Xu, H., Shimasaki, Y., Oshima, Y., 2020. Bioaccumulation and reproductive effects of fluorescent microplastics in medaka fish. *Mar. Pollut. Bull.* 158, 111446.
- 2) Qiu, X., Saovany, S., Takai, Y., Akasaka, A., Inoue, Y., Yakata, N., Liu, Y., Waseda, M., Shimasaki, Y., Oshima, Y., 2020. Quantifying the vector effects of polyethylene microplastics on the accumulation of anthracene to Japanese medaka (*Oryzias latipes*). *Aquatic Toxicology* 228, 105643.
- 3) Liu, Y., Qiu, X., Xu, X., Takai, Y., Ogawa, H., Shimasaki, Y., Oshima, Y., 2021. Uptake and depuration kinetics of microplastics with different polymer types and particle sizes in Japanese medaka (*Oryzias latipes*). *Ecotoxicol. Environ. Saf.* 212, 112007.