

Food web transfer of plastics to an apex riverine predator

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A Plastic Planet

- Annual global plastic production 350 million tonnes and another 33 billion tonnes expected by 2050.
- Only a small proportion of plastics ever produced has been incinerated - most plastics still in use, in landfill or in the wider environment.
- Research largely focused on microplastics (particles <5mm) in our oceans.
- Increasing evidence has shown plastics frequently recorded in rivers and standing waters around the world.



Throwaway Living

DISPOSABLE ITEMS CUT DOWN HOUSEHOLD CHORES

The Story So Far

- Recent research increasingly shows plastics are ingested by a range of freshwater organisms, including macroinvertebrates, fishes and birds.
- Lab studies – lethal and sublethal effects from plastic consumption.
- Sources, fluxes, behaviour and effects of plastics in natural freshwater ecosystems poorly quantified.



The Story So Far

- Very little known on the transfer of plastics through freshwater food webs.
- White-throated dippers (*Cinclus cinclus*) recognised indicators of environmental quality, including the monitoring of organic pollutants.
- Plastics found in roughly half of aquatic invertebrates used as prey by dippers (Windsor et al. 2019).

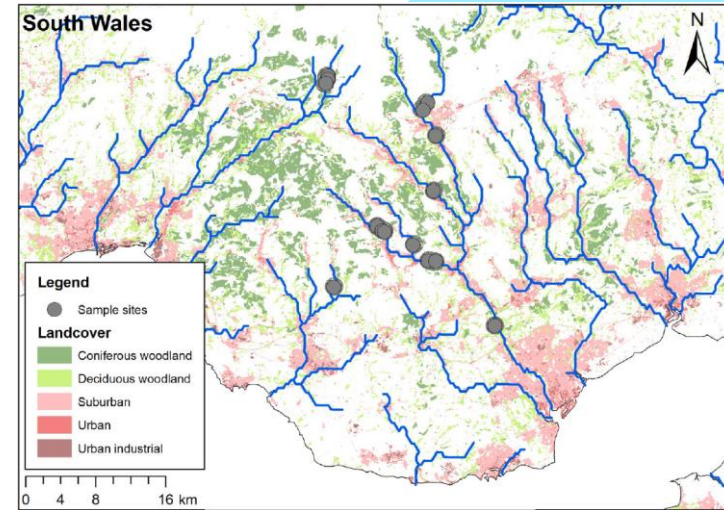


Hypotheses

- Using dippers as a model species to assess the occurrence of plastic debris, we tested three hypotheses:
 1. **Plastics are transferred from prey to predators in rivers.**
 2. **The concentration of plastic particles increases with urbanisation.**
 3. **Plastics contained in prey are transferred by adults to altricial offspring during nest provisioning.**

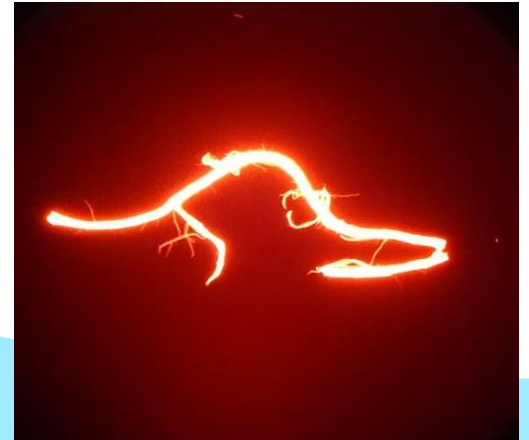
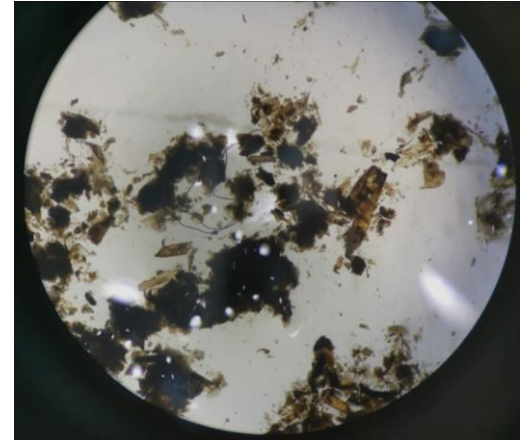
The Study

- 15 sample sites across South Wales – Rivers Cynon, Mellte, Ogmore, Rhondda and Taff.
- Surrounding land use a range of urban, woodland and grassland pasture.
- Fresh regurgitated and faecal pellets collected near to where dippers seen feeding.
- Samples (n=166) collected across seasons and a small number (n=14) from nestlings from two nests.



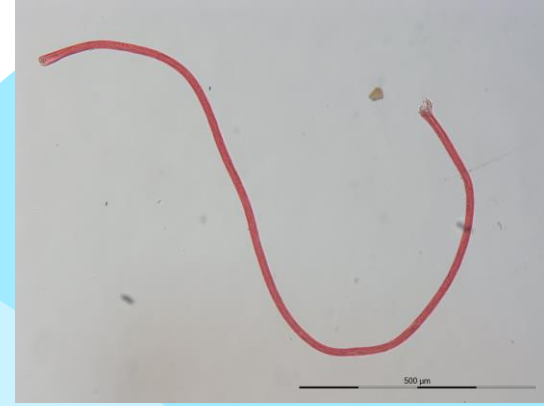
Lab Analysis

- Samples analysed under light microscopy, suspected plastics further analysed using infrared and bright- and dark-field illumination to distinguish plastics from natural materials.
- Sub-sample (n=72 of 151 suspected plastic particles) analysed using Fourier Transform Infrared Spectroscopy (FT-IR) at Greenspace Research Laboratories (University of Exeter).
- 85% of suspected particles revealed to be plastic polymers.



Results

- Plastics in 47% of faecal and regurgitate samples and at 14 of the 15 sample sites (93%).
- Plastics in both adults and nestlings.
- 95% of plastics were fibres, with fragments and textile meshes only a small proportion.
- 75% categorized as microplastics (<5mm), longest was 30mm in length.



Results

- Composition of plastics – range of materials, predominantly polyester, polyvinyl alcohol mixtures and vinyl chloride/vinyl acetate copolymers.
- Urban land use near to sample sites had the strongest effect in increasing plastic concentrations ($t_{1,100} = 7.48, p = .007$; Gaussian GLMM)
- Distance from source had no effect when used as a sole predictor ($t_{1,108} = 1.33, p = .25$).

Findings



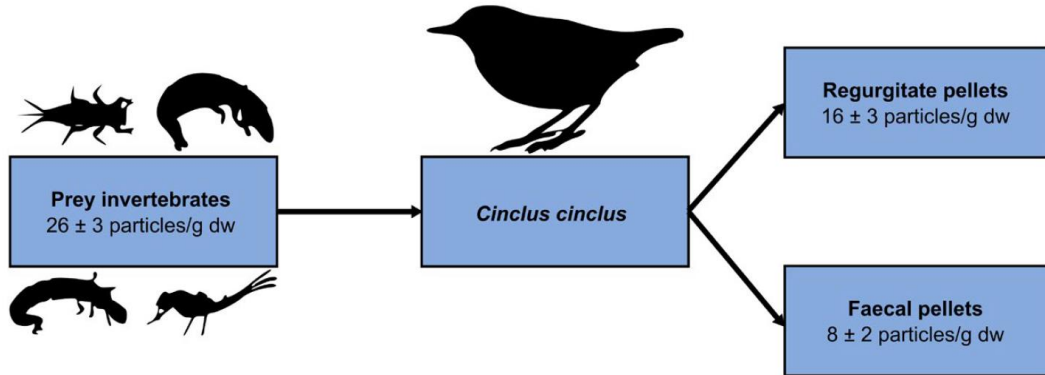
1. One of the first studies to illustrate how plastic is being transferred through food webs in natural freshwater ecosystems.

- Assumption of ingestion via prey supported – size of plastics in samples much smaller than the normal prey size of dippers.
- Mainly fibres detected (95%) and mainly either polyester, polyvinyl alcohol (PVA) mixtures or vinyl chloride/vinyl acetate copolymers.
- Potential sources of plastics – textile fibres, textile coatings, reinforced concrete and construction processes.

Findings

1. One of the first studies to illustrate how plastic is being transferred through food webs in natural freshwater ecosystems.

- Steady-state equation: estimated mean intake of around **200 plastic particles per day**.



Findings

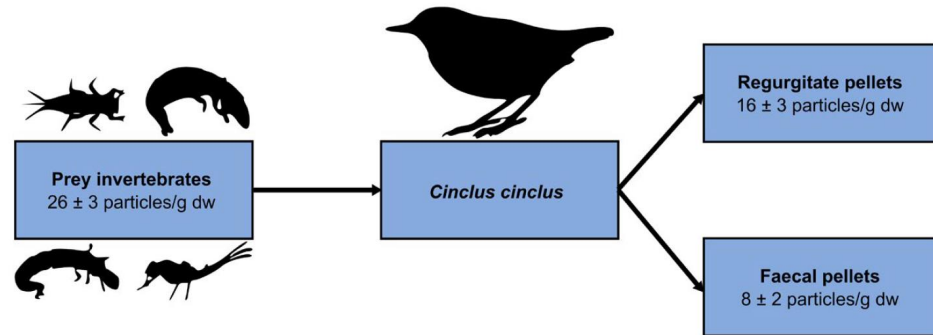
2. Concentration of plastics increased significantly along the most urbanised river reaches.

- Consistent with research linking environmental plastic occurrence with urban land cover and the amounts of plastics ingested by organisms.
- Urban areas likely to be considerable sources of plastic pollutants, such as:
 - Wastewater treatment,
 - Combined sewerage overflows,
 - Direct urban drainage,
 - Increased road density, and
 - Increased volume of plastic usage from a range of urban activities.

Findings

3. Plastics present in both adult and nestling samples, demonstrating intergenerational transfer of plastics.

- Nestlings entirely dependent on adults – again, plastics appear to be entering via the prey.
- Silver lining – plastics seem to be transient.



Future Directions

- Major unknowns remain and prevent effective management.
- Accurate source apportionment needs considerable development at whole catchment scales.
- Transfer of plastics within food webs have the potential to vector other pollutants (e.g. contaminants).
- As the ecotoxicological consequences of plastics remains unknown, this global pollutant continues to increase.

Future Directions

- Senedd Climate Change, Environment and Rural Affairs Committee
- 10-year strategy to reduce plastic use and pollution
- *'More research is needed to address knowledge gaps in relation to nano and microplastics in Welsh waters. The Welsh Government should explore how such research can be supported, so that its policy interventions are informed by the latest knowledge'*



Further Information

- Guardian Article (2020) – Microplastic pollution in oceans vastly underestimated – study
<https://www.theguardian.com/environment/2020/may/22/microplastic-pollution-in-oceans-vastly-underestimated-study>
- D'Souza et al. 2020 – Food web transfer of plastics to an apex riverine predator. <https://doi.org/10.1111/gcb.15139>
- Windsor et al. 2019 - A catchment-scale perspective of plastic pollution.
<https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14572>

