Ditching misconceptions:
Rare temporary stream specialists in artificial habitats

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Introduction

Ditches are among the most widespread aquatic habitats in the UK (Brown et al., 2006), providing drainage for the country's dense road infrastructure and extensive agricultural land. Despite their prevalence, ditches are often assumed to be species-poor due to their exposure to road runoff, pesticides and fertilisers. However, ditches can support high aquatic macroinvertebrate diversity (Hill et al., 2016), with some ditches rivalling the number of families recorded at unimpacted river 'reference' sites (Gething & Little, 2020). Thus, ditches may play a key role in increasing habitat provision for macroinvertebrates, and could prove particularly valuable in buffering local populations against disturbance events such as flash floods, drying or pollution incidents, which alter community structure and function.

Spatially isolated species with narrow environmental preferences, such as the temporary stream specialists in the chalk streams of southern England, may be particularly vulnerable to disturbance events (Macadam et al., 2021). These specialists, including the Nationally Scarce mayfly *Paraleptophlebia werneri* (Macadam, 2016), the Nationally Rare stonefly *Nemoura lacustris* (Macadam, 2015) and the IUCN Vulnerable diving beetle *Agabus brunneus* (Foster, 2010) are adapted to predictable flow cessation and drying events, which they may require to complete their life cycles (Tapia et al., 2018; Macadam et al., 2021). As such, these specialists are often thought to be restricted to drying headwater streams (often termed 'winterbournes'), leaving their populations with few sources of colonists to support recovery after disturbance events, such as abnormally wet years with no dry phase. However, the discovery of *P. werneri* juveniles in Suffolk ditches (Chalkley, 2006) suggests that winterbournes and ditches can both provide suitable habitat for such specialist species (Figure 1). Ditches increase the area and diversity of habitats within catchments (Armitage et al., 2003; Gething, 2021), and may thus represent a refuge from which specialists can repopulate winterbourne assemblages lost during disturbance events.

To determine whether ditches consistently provide suitable habitat, and thus have the potential to rescue nearby stream-based populations impacted by disturbance events, we undertook a field campaign to locate temporary stream specialists.

Method

We defined streams as the main watercourse within a sub-catchment, with their channels being predominantly groundwater-fed and ranging in form from heavily modified to semi-natural, while ditches were defined as channels engineered for surface water drainage. We sampled 21 stream and 22 ditch sites that experience flow cessation and/or drying across nine sub-catchments in southern England (Figure 2). Our survey identified one stream and at least one ditch in each sub-catchment, except the Candover Brook sub-catchment, where we found no ditches. We nonetheless surveyed Candover Brook—which supports *P. werneri* and *N. lacustris* populations (Bunting et al., 2021)—to characterise specialists in a temporary stream lacking nearby ditch-based populations. Samples were collected from each

Figure 1: The Candover Brook (left) and the River Lavant (right) winterbournes, which share similar habitat characteristics with nearby ditches (centre).

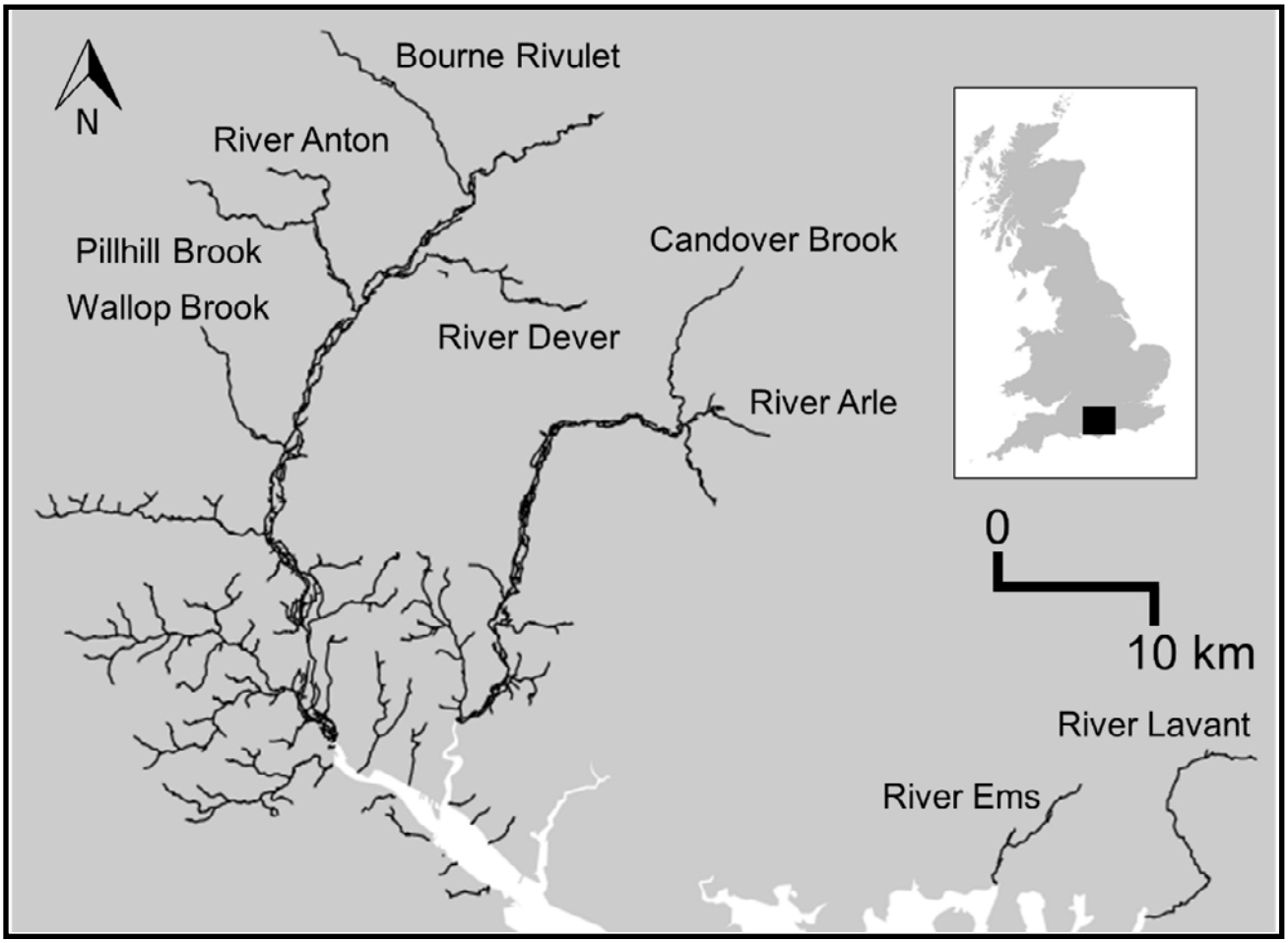

Figure 2: The study area in southern England, indicating the nine sub-catchments.

site in March, May and June using a 1-minute kick sampling method, and temporary stream specialists were identified. We used iRecord to compare our results with previous records of temporary stream specialists in the study area.

Results and Discussion

We recorded two specialists, *Paraleptophlebia werneri* and/or *N. lacustris* (Figure 3), in streams in five of the nine sub-catchments. In three of these sub-catchments (i.e. those of the Bourne Rivulet and Rivers Ems and Lavant: Figure 2), at least one specialist was also recorded in a ditch. These occurrences show that ditches can provide suitable habitats for specialists—which are therefore not restricted to winterbournes, as previously thought (Tapia et al., 2018).

One of the two sub-catchments in which specialists were identified in the stream but not in ditches was the Candover Brook, in which no ditch sites were identified. The second (Pillhill Brook) contained a single ditch site with "flashy", ephemeral flow, which is only wet in the hours–to–days after heavy rainfall (Figure 4), and supported only true fly larvae and oligochaete worms. The erratic hydrology of this ditch contrasts with the seasonal wet–dry cycle of many winterbournes (Berrie, 1992), which likely prevented specialists from sustaining populations.

In sub-catchments that supported specialists, *P. werneri* and *N. lacustris* were frequently the most abundant insects in ditches and were often the only representatives of their respective orders. Ditches supported lower abundances of the specialists than streams (mean ± SE: 17 ± 10 and 45 ± 13 individuals per sample, respectively). Additionally, sub-catchments with ditch populations supported a higher abundance of specialists in their stream than those lacking ditch populations (69 ± 21 and 3 ± 2 individuals per sample, respectively). The higher abundance of specialists in sub-catchments with nearby ditch-based populations suggests that ditches help to maintain stream populations, and in particular may act as refuges that provide colonists which enable rapid recovery of stream populations after disturbance events (see the concept of "rescue effects" in Sarremejane et al., 2021).

Nemoura lacustris have previously been reported from 17 temporary streams in southern England (Tapia et al., 2018; Bunting et al., 2021). We found *N. lacustris* in five streams, two of which (Bourne Rivulet and Pillhill Brook) we believe are new records. In contrast, our *P. werneri* records are not new additions to the fauna of any sub-catchments, but do extend the species' known range within some streams. For example, our observations extend records of *P. werneri* from

Figure 3: Temporary stream specialist mayfly *Paraleptophlebia werneri* (left) and stonefly *Nemoura lacustris* (right) specimens from ditches.

Figure 4: A ditch in the Pillhill Brook sub-catchment, which flowed in response to rainfall (left) but was otherwise dry (right).

Figure 5: The ditch-like winterbourne headwaters of the Candover Brook taking road run-off during a heavy rainfall event.

1 km to 6 km upstream of the perennial head on the Bourne Rivulet.

Our study demonstrates that ditches, although often perceived as sub-optimal aquatic habitats, play a role in supporting populations of Nationally Rare and Scarce temporary stream specialists. Given that many winterbournes now share physical characteristics with ditches, and that winterbournes and ditches are exposed to comparable human impacts (e.g. road run-off: Figure 5), it is perhaps unsurprising that specialists that tolerate winterbourne conditions can also survive in ditches. Thus, we call for further research to characterise the full range of within-catchment habitats that support populations of rare specialists, and for the biodiversity value of temporary waterbodies to be more broadly recognised during conservation and restoration initiatives.

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References

Armitage, P. D., Szoszkiewicz, K., Blackburn J. H. & Nesbitt, I. 2003. Ditch communities: a major contributor to floodplain biodiversity. *Aquatic Conservation: Marine and Freshwater Ecosystems* **13:** 165–185. https://doi.org/10.1002/aqc.549

Berrie, A. D. 1992. The chalk-stream environment. *Hydrobiologia*, **248**: 3–9. https://doi.org/10.1007/BF00008881

Brown, C. D., Turner, N., Hollis, J., Bellamy, P., Biggs, J., Williams, P., Arnold, D., Pepper, T. & Maund, S. 2006. Morphological and physico-chemical properties of British aquatic habitats potentially exposed to pesticides.Agriculture, *Ecosystems & Environment* **113:** 307–319. https://doi.org/10.1016/j.agee.2005.10.015

Bunting, G., England, J., Gething, K., Sykes, T., Webb, J. & Stubbington, R. 2021. Aquatic and terrestrial invertebrate community responses to drying in chalk streams. *Water and Environment Journal* **35**: 229–241. https://doi.org/10.1111/wej.12621

Chalkley, A. 2006. Paraleptophlebia werneri (Ulmer) (Ephemeroptera: Leptophlebiidae), an unexpected addition to the Suffolk List. *Transactions of the Suffolk Natural History Society* **42**: 62–64.

Foster, G. N. 2010. A review of the scarce and threatened Coleoptera of Great Britain Part (3): Water beetles of Great Britain. Species Status 1. Joint Nature Conservation Committee, Peterborough.

Gething, K. J. 2021. Physicochemical drivers of managed river and agricultural drainage channel macroinvertebrate communities. R*iver Research and Applications* **37**: 675– 680. https://doi.org/10.1002/rra.3779

Gething, K. J. & Little, S. 2020. The importance of artificial drains for macroinvertebrate biodiversity in reclaimed agricultural landscapes. *Hydrobiologia* **847**: 3129–3138. https://doi.org/10.1007/s10750-020-04325-8

Hill, M. J., Chadd, R. P., Morris, N., Swaine, J. D. & Wood, P. J. 2016. Aquatic macroinvertebrate biodiversity associated with artificial agricultural drainage ditches. *Hydrobiologia* **776**: 249–260. https://doi.org/10.1007/s10750-016-2757-z

Macadam, C.R. 2015. A review of the stoneflies (Plecoptera) of Great Britain – Species status no.20. Natural England Commissioned Report NECR174. http://publications.naturalengland.org.uk/publication/5404611030548480

Macadam, C.R. 2016. A review of the mayflies (Ephemeroptera) of Great Britain – Species status no. 28. Natural England Commissioned Report NECR193. http://publications.naturalengland.org.uk/publication/4635857668538368

Macadam, C., Stubbington, R. & Wallace I. 2021. The specialist insects that rely on the wet-dry habitats of temporary streams. *FBA News* **81**: 28–33.

Sarremejane, R., Stubbington, R., England, J., Sefton, C. E. M., Eastman, M., Parry, S. & Ruhi, A. 2021. Drought effects on invertebrate metapopulation dynamics and quasi-extinction risk in an intermittent river network. *Global Change Biology*, **27:** 4024– 4039. https://doi.org/10.1111/gcb.15720

Tapia, G., Bass, J.A.B. & House, A. 2018. Further occurrence records for the Winterbourne Stonefly Nemoura lacustris Pictet, 1865, (Plecoptera: Nemouridae).*Entomologist's Monthly Magazine* **154**:60–64. https://doi.org/10.31184/M00138908.1541.3915

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