A comparison of ground beetle assemblages around temporary and perennial streams

Kieran J. Gething
School of Science and Technology, Nottingham Trent University; kieran.gething@ntu.ac.uk

Temporary streams provide opportunities for ground beetles (Carabidae), where novel resources such as dead/dying aquatic organisms and habitats with fewer competitors are exposed by receding water levels (Steward *et al*., 2022). However, the Carabidae assemblages supported by temporary streams, and how these assemblages differ from those supported by perennial streams, are infrequently studied.

Study area

This study was conducted on the Bourne Rivulet (SU396525, a tributary of the River Test) and the Candover Brook (SU566373, River Itchen), Hampshire, UK. The Bourne Rivulet and Candover Brook are approximately 16 km and 13 km long respectively, with 10.5 km and 6.5 km of these lengths experiencing temporary flow.

Data collection and interpretation

I sampled six sites in each catchment, with the lower two sites experiencing perennial flow and the upper four sites exhibiting temporary flow. At each site, I captured terrestrial invertebrates using six covered pitfall traps on each bank (Webb *et al*., 2022). I positioned pitfall traps 0.25-2 m from the water's edge and left them in place for two week prior to collection. I repeated this sampling on four occasions between May and August 2021. Thus, in this study, I report the captures of 576 individual pitfall traps (2 × catchments, 6 × sites per catchment, 12 × traps per site, 4 × sampling occasions).

In the laboratory, I identified adult Carabidae to the lowest practical taxonomic resolution, mostly species level (98.8% of individuals). I used *Pantheon* (see Webb *et al.* 2018) to determine species rarity and aid interpretation of the following comparisons.

Results and discussion

A total of 4,243 individuals from 83 Carabidae species were recorded. *Bembidion* Latreille and *Amara* Bonelli were the most species rich genera, with 12 and 11 species, respectively. *Pterostichus* Bonelli was the most frequently encountered genus, comprising 28% of individuals captured (see Chapter 5 of Gething, 2024 for more detail).

Perennial sites supported 51 taxa whereas temporary sites supported 77 taxa, possibly reflecting the greater number of pitfall traps set in temporary (384) than perennial (192) reaches. However, 32 species were unique to temporary reaches whereas six species were unique to perennial reaches (0.08 and 0.03 unique taxa per trap, respectively); suggesting temporary reaches contribute disproportionately to

intra-catchment diversity. This reflects that water is a resource around which Carabidae assemblages form (Lassau *et al*., 2005; Gething *et al*., 2022), and thus the spatiotemporally variable access to such a resource may cause greater variability in the assemblages supported by temporary relative to perennial reaches.

Bourne Rivulet and Candover Brook had 61 (73%) species in common, with the catchments supporting 73 and 71 species, respectively. Of the 12 and 10 species that were unique to the Bourne Rivulet and Candover Brook catchments respectively, nine (75%) and nine (90%) occurred only in temporary reaches. Headwater temporary streams can contribute disproportionately to regional aquatic invertebrate diversity (Finn *et al*., 2011), possibly because their geographic isolation promotes the establishment distinct communities (Sarremejane, *et al*., 2017) with taxa that occur infrequently (Aspin & House, 2022). Additionally, habitat heterogeneity among sites on the same and different streams promotes aquatic assemblage variability (Kabir *et al*., 2024). My results suggest the patterns observed among aquatic assemblages may be extend to riparian carabid assemblages, with temporary reaches contributing disproportionately to inter-catchment diversity.

Pantheon highlighted six Nationally Scarce (*Amara montivaga* Sturm, *Badister dilatatus* Chaudoir, *Badister unipustulatus* Bonelli, *Elaphrus uliginosus* Fabricius, *Panagaeus bipustulatus* Fabricius and *Pterostichus anthracinus* Panzer) and two Nationally Rare (*Amara nitida* Sturm and *Badister peltatus* Panzer) species (Table 1). Six of these species designated as Nationally Rare or Scarce occurred in both temporary and perennial reaches, whereas *B. peltatus* and *B. unipustulatus* occurred only in temporary reaches, further highlighting the potential value of temporary streams in supporting species of conservation interest.

Table 1 The Nationally Rare and Scarce species captured in perennial and temporary reaches of the Bourne Rivulet and Candover Brook.

Species	No. captured	No. captured in perennial reaches	No. captured in temporary reaches	Status
Amara montivaga	46	12	34	Nationally Scarce
Amara nitida	53	13	40	Natioanlly Rare
Badister dilatatus	57	2	55	Nationally Scarce
Badister peltatus	2	0	2	Natioanlly Rare
Badister unipustulatus	42	0	42	Nationally Scarce
Elaphrus uliginosus	10	6	4	Nationally Scarce
Panagaeus bipustulatus	10	1	9	Nationally Scarce
Pterostichus anthracinus	116	3	113	Nationally Scarce

In 2019, Bunting *et al*. (2021) undertook hand searches and pitfall trapping on the dry bed of the Candover Brook. In the present study (samples collected from the banks of the channel during drying), I captured 85% of the Carabidae taxa captured by

Bunting *et al*., suggesting a high proportion of the in-channel assemblage may colonise from nearby banks during and after drying, consistent with Corti & Datry (2016).

Implications

Here, I highlight that temporary streams are capable of supporting diverse Carabidae assemblages, which include a number of rare species. I hope these findings will foster new interest in the assemblages supported by temporary streams and other drying waterbodies, so their terrestrial diversity may be recognised and valued alongside their more frequently studied aquatic assemblages.

Acknowledgements

I would like to thank Nottingham Trent University, the Environment Agency, Hampshire and Isle of Wight Wildlife Trust and the Vitacress Conservation Trust for funding this research. I am also grateful to Prof. Rachel Stubbington, Dr Christopher Terrell-Nield and Tim Sykes for field and laboratory assistance.

References

ASPIN, T. & HOUSE, A. 2022. Alpha and beta diversity and species co-occurrence patterns in headwaters supporting rare intermittent-stream specialists. *Freshwater Biology* **67**: 1188-1202. https://doi.org/10.1111/fwb.13910

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

CORTI, R. & DATRY, T. 2016. Terrestrial and aquatic invertebrates in the riverbed of an intermittent river: Parallels and contrasts in community organisation. *Freshwater Biology* **61**: 1308-1320. https://doi.org/10.1111/fwb.12692

FINN, D.S., BONADA, N., MÚRRIA, C. & HUGHES, J.M. 2011. Small but mighty: headwaters are vital to stream network biodiversity at two levels of organization. *Journal of the North American Benthological Society* **30**: 963-980. https://doi.org/10.1899/11-012.1

GETHING, K.J. 2024. Dry me a river: characterising and monitoring how aquatic and terrestrial invertebrates respond to drying and anthropogenic pressures in temporary streams. PhD Thesis. Nottingham: Nottingham Trent University. https://irep.ntu.ac.uk/id/eprint/51574/

GETHING, K.J., HAYES, C., WEBB, J., SYKES, T., ENGLAND, J. & STUBBINGTON, R. 2022. Living on the edge: predicting invertebrate richness and rarity in disturbance-prone aquatic–terrestrial habitats. *Ecological Solutions and Evidence*: **3**, e12196. https://doi.org/10.1002/2688-8319.12196

KABIR, J., BIONDI, G., GETHING, K.J., ASPIN, T., SYKES, T. & STUBBINGTON, R. 2024. Spring forth diversity: specialist species enhance the conservation value of headwater springs and streams at the landscape scale. *River Research and Applications* **40**: 863-874. https://doi.org/10.1002/rra.4275

LASSAU, S.A., HOCHULI, D.F., CASSIS, G. & REID, C.A.M. 2005. Effects of habitat complexity on forest beetle diversity: Do functional groups respond consistently? *Diversity and Distributions* **11**: 73-82. https://doi.org/10.1111/j.1366-9516.2005.00124.x

SARREMEJANE, R., MYKRÄ, H., BONADA, N., AROVIITA, J. & MUOTKA, T. 2017. Habitat connectivity and dispersal ability drive the assembly mechanisms of macroinvertebrate communities in river networks. *Freshwater Biology* **62**: 1073-1082. https://doi.org/10.1111/fwb.12926

STEWARD, A.L., DATRY, T. & LANGHANS, S.D. 2022. The terrestrial and semi-aquatic invertebrates of intermittent rivers and ephemeral streams. *Biological Reviews* **97**: 1408-1425. https://doi.org/10.1111/brv.12848

WEBB, J.R., GETHING, K.J., KRATZ, C.C., ENGLAND, J., DREWITT, A.L. & STUBBINGTON, R. 2022. A standardized multi-method survey to enhance characterization of riparian invertebrate communities. *Water and Environment Journal* **36**: 425-432. https://doi.org/10.1111/wej.12775

WEBB, J., HEAVER, D., LOTT, D., DEAN, H.J., VAN BREDA, J., CURSON, J., HARVEY, M.C., GURNEY, M., ROY, D.B., VAN BREDA, A., DRAKE, M., ALEXANDER, K.N.A. & FOSTER, G. 2018. Pantheon - database version 3.7.6 available at: https://pantheon.brc.ac.uk/