Appraising chalk streams using citizen science

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Introduction

Citizen science plays an important role in providing invaluable data for research and nature conservation. Without the thousands of dedicated citizen scientists across the globe we would not have the knowledge that we do today. There are many different river citizen science projects which can aid in environmental assessment. The Riverfly Partnership is a dynamic network of organisations, representing anglers, conservationists, entomologists, scientists, water course managers and relevant authorities, working together to protect the water quality of our rivers; furthering the understanding of Riverfly populations and conserving Riverfly habitats. The Partnership's approach assesses Riverflies to provide a simple monitoring technique which can be used to assess river quality. The Modular River Survey (ModRS; England *et al.* 2017a, Gurnell *et al.*, 2016, Shuker *et al.* 2017) provides a means to assess the quality of physical habitat and functioning of rivers and streams. Within this study we explore how these two citizen science techniques can be used together to assess our rivers and whether the data can be combined to identify the habitat characteristics Riverfly populations require.

Study sites

The River Mimram, one of Hertfordshire's chalk streams, proved an ideal study site as along its length it provides a range of habitat types. Many sections are relatively natural but there is evidence of human modification in others, for example at Singler's Marsh in Welwyn where concrete banks have been installed

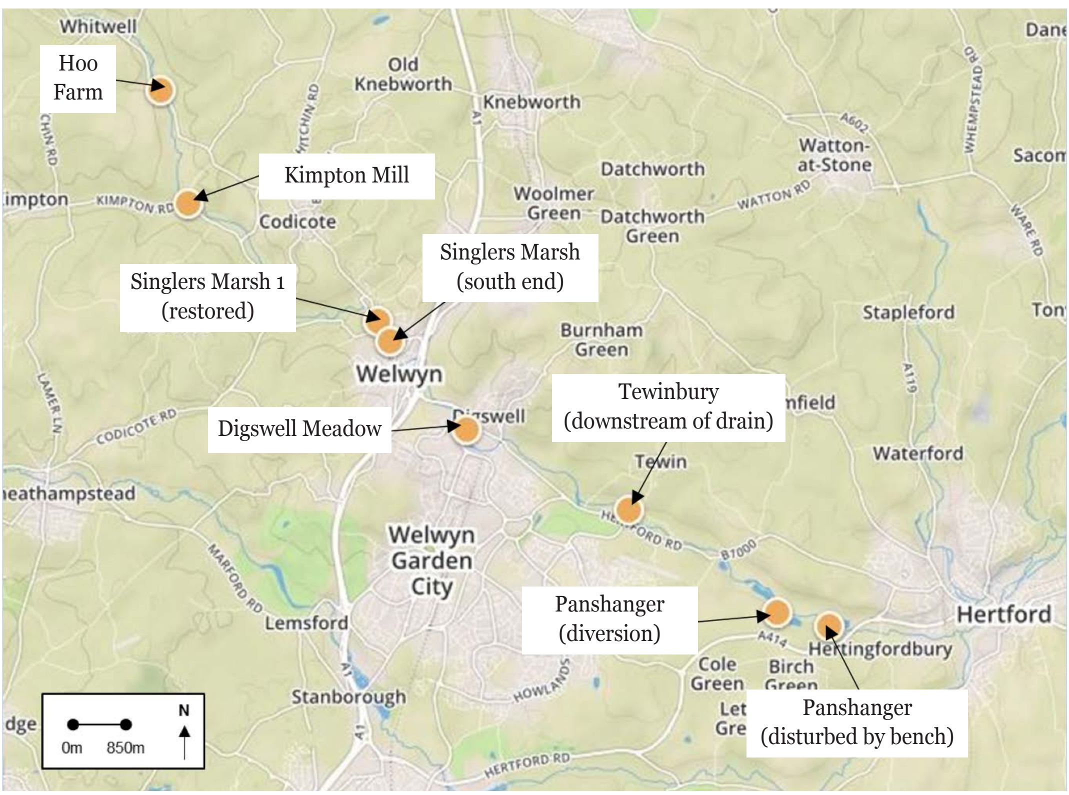


Figure 1. *Location of the eight survey sites along the River Mimram (adapted from Modular River Survey website).*

alongside the road. At this site, the channel was realigned from its original course, which has caused it to slow down and silt up. In places gravels have been reintroduced and deflectors installed to try and increase the velocity of flow, while increasing the physical diversity of the channel.

Sites were selected based on where Riverfly volunteers were conducting surveys between February and June 2017. These sites were easily accessible, provided a range of both physical habitats and hydromorphological features and were distributed along the length of the River Mimram. Eight sites (Figure 1 and Table 1) were chosen which met the criteria. Both Riverfly monitoring and Modular River Physical surveys were undertaken at the eight sites between February and June 2017.

Table 1. *Site descriptions of the survey sites along the River Mimram, listed upstream to downstream (adapted from: Beach, 2017).*

Hoo Farm Near Whitwell, Hertfordshire – Grid Reference: TL19365 20167 – Riverfly Site no: 1028	**Kimpton Mill** Kimpton, Hertfordshire – Grid Reference: TL19824 18453 – Riverfly Site no: 1029
 Near to the top of the catchment. Largely unshaded gravels with marginal and in-stream vegetation.	 Just downstream from the old water cress beds. Unshaded gravels with marginal and in-stream vegetation. Southern bank lightly horse grazed.
Singlers Marsh 1 (restored) Welwyn, Hertfordshire – Grid Reference: TL22813 16743 – Riverfly Site no: 1031	**Singlers Marsh** (south end) Welwyn, Hertfordshire – Grid Reference: TL23007 16435 – Riverfly Site no: 1033
 River displaced from its original course, slow moving and silted. The bank beside the road made of solid concrete with several inlet pipes from road, the other bank is natural. Small section re-gravelled.	 River displaced from its original course, slow moving and silted. Some evidence of attempted restoration works upstream to narrow the channel and increase flow. The bank beside the road is made of concrete (sand bag appearance) with several inlet pipes from road, the bank is starting to naturalise with brambles and nettles, the other bank is natural. A large amount of vegetation in the channel.

Digswell Meadow
Welwyn Garden City, Hertfordshire – Grid Reference: TL24213 15115 – Riverfly Site no: 1036

Gravel (re-gravelled?) site with good marginal vegetation. Evidence of old river narrowing works upstream of site. Low intensity sheep grazing on southern bank, few horses grazing on site but no access to the river at the survey site.

Tewinbury (downstream of drain)
Near Tewin, Hertfordshire – Grid Reference: TL26760 13947 – Riverfly Site no: 1040

Wide shaded channel with gravels and limited marginal and in-stream vegetation. Evidence of periodic sheep and cattle grazing but not recently at the survey site.

Panshanger (diversion channel)
Near Hertford, Hertfordshire – Grid Reference: TL29095 12452 – Riverfly Site no: 2393

The diversion channel is a 'replica chalk stream' created 10-15 years ago, to facilitate gravel extraction. Fast flowing, rather narrow, unshaded channel with gravel and some marginal/in-stream vegetation. Evidence that some areas are now beginning to silt up. Low intensity grazing on southern bank.

Panshanger (disturbed by bench)
Near Hertford, Hertfordshire – Grid Reference: TL29908 12270 – Riverfly Site no: 1043

Heavily shaded site with gravel bed. Over wide channel with small island. Opposite an installed bench with extensive damage to bank with no vegetation (stripped bare) and badly eroded (caused by people/dogs).

Methods

Riverfly monitoring

Angler's Riverfly Monitoring Initiative (ARMI) or Riverfly monitoring is now a widely recognised citizen science project undertaken by trained volunteers. Riverfly monitoring involves carrying out kick samples along a stretch of river over a timed period, the samples are sorted at the bankside and invertebrates identified to eight main target groups (Table 2). The abundance of these groups will naturally vary throughout the year and some groups will not be present at all sites.

Once identified the abundance of animals in each group is counted/estimated on a log scale (Table 3) and scores allocated for each group present. The sum of these scores provides the AMRI score which is compared against the site's minimum healthy level (trigger level) set in collaboration with the Environment Agency, and any breaches of the level

Table 2. *Eight main target groups for Riverfly monitoring (The Riverfly Partnership, n.d.).*

Target groups	
Caddisflies (or Sedgeflies)	Cased caddis
	Uncased caddis
Mayflies	Mayfly (*Ephemeridae*)
	Blue-winged olive (*Ephemerellidae*)
	Flat-bodied (*Heptageniidae*)
	Olives (*Baetidae*)
Stoneflies	
Freshwater shrimp	*Gammarus* spp.

Table 3. *Abundance of Riverflies, category and scores (FSC/Riverfly Partnership, 2015).*

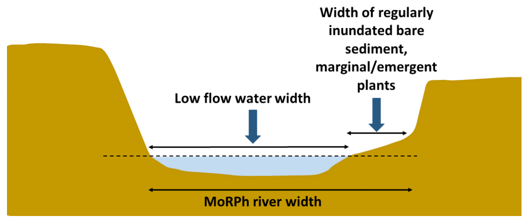
Category	**Abundance**	**Estimated number**	**Score**
A	1-9	Quick count	1
B	10-99	Nearest 10	2
C	100-999	Nearest 100	3
D	Over 1,000	Nearest 1,000	4

are reported. The data are held on a national database (www.riverflies.org) and overseen by the Riverfly catchment coordinator. Scores and raw counts can be freely obtained from the database under the Open Government Licence v3.0.

Modular River Physical (MoRPh) Survey

Modular River Physical (MoRPh) module survey is the smallest survey unit within the multi-scale Modular River Survey and provides a habitat-scale assessment that characterises the local physical structure of a river channel, and its margins, relevant to ecological indicators such as Riverfly (macroinvertebrates), fish or aquatic plants (macrophytes).

The length of the MoRPh module is approximately double the width of the river channel up to a maximum



MoRPh river width (m)	**River length for each module survey** (m)
<5m	10m
5 to <10m	20m
10 to <20m	30m
20 to <30m	40m
≥ to 30m	River channel too wide for this type of survey

Figure 2. *How to calculate the MoRPh module length (Gurnell* et al. *2016).*

40m length. The survey is not suitable for application to larger rivers (Figure 2). The survey module extends 10m back from the bank tops on both sides of the river (Figure 3) to characterise the riparian zone. By limiting the module length using the channel width, the survey covers a sufficient area to place a Riverfly monitoring point into its physical habitat context.

To complete the survey the surveyor systematically records physical features and vegetation properties for (a) the bank tops/floodplain within 10m of the channel, (b) the bank faces and channel edges, and (c) the channel bed (see England *et al.* 2017a for more details). Within these areas, natural features are recorded in addition to human-modified ones. The key to recording the information is *'record WHAT YOU SEE not what you know'*.

MoRPh survey data and accompanying photographs are entered into a database via the Modular River Survey website (www.modularriversurvey.org). The survey data are reviewed for completeness and data quality before being approved. Once the data have

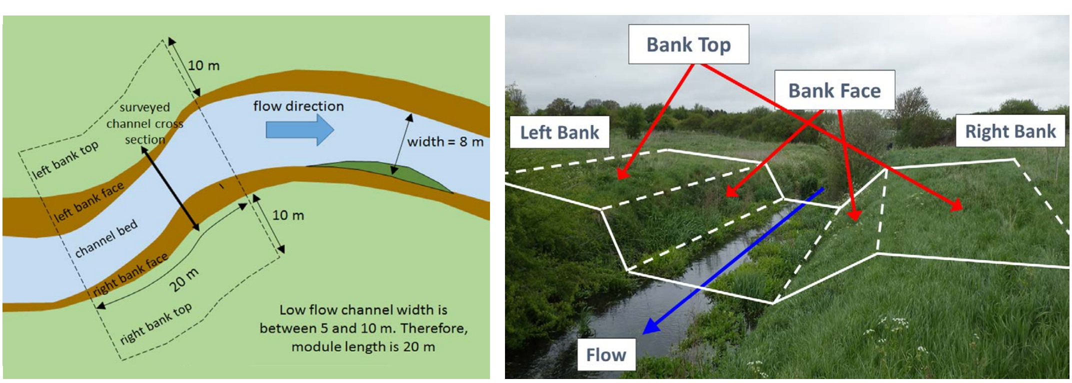


Figure 3. *Typical layout of a MoRPh survey site (Gurnell* et al. *2016).*

Table 4. *The 14 indices estimated from each MoRPh survey (Shuker* et al.*, 2017).*

Index type	Index number and name
River channel characteristics	**Index 1:** Number of flow types
	Index 2: Highest energy extensive flow type
	Index 3: Number of bed material types
	Index 4: Coarsest extensive bed material particle size
	Index 5: Average bed material size
	Index 6: Average bed material particle size class
	Index 7: Extent of bed siltation
	Index 8: Channel physical habitat complexity
	Index 9: Number of aquatic vegetation morphotypes
Riparian (bank face and top) character	**Index 10:** Riparian physical habitat complexity
	Index 11: Riparian vegetation complexity
Human pressures and impacts	**Index 12:** Degree of human pressure imposed by land cover on the bank tops
	Index 13: Channel reinforcemen
	Index 14: Extent of non-native invasive plants

been approved, fourteen indices are calculated from the uploaded data to summarize the flow patterns, sediments, physical habitats, vegetation, human interventions and pressures within each surveyed module (Table 4). MoRPh indices represent the weighted sum of the abundances and types of groups of surveyed features or characteristics. Each index increases in value with an increase in the magnitude, complexity or severity of the property being indicated, and the potential minimum and maximum values of each index provide a basis for interpreting individual values from particular modules.

Results

To investigate the relationship between Riverfly groups and MoRPh indices with numerical values, correlations were calculated.

Figure 4 shows there is a positive significant (Spearman's rank; r_s=0.32, p<0.05) correlation between the number of Ephemeridae Mayflies and index 8 which measures Channel Physical Habitat Complexity. This indicates that the more complex the channel's physical habitat, the greater the number of Mayflies supported. Importantly, the highest abundances of Ephemeridae Mayflies are associated with the highest recorded values of index 8.

Figures 5 and 6 show a significant positive correlation between both Mayfly (Ephemeridae) (r_s=0.57, p<0.05) and Cased Caddis (r_s=0.49, p<0.05) and index 10 for Riparian Physical Habitat Complexity suggesting that more taxa are found associated with a more varied riparian physical habitat. This may reflect the importance of the riparian zone in providing sheltered areas for flies to rest following emergence. Riparian conditions are also important in the breeding cycle of caddis species who swarm under trees to mate. The importance of the riparian structure is also reflected in the positive correlation (r_s=0.47, p<0.05) between the overall ARMI score and index 10 Riparian Physical Habitat Complexity (Figure 7).

Olive Mayflies (Baetidae) exhibited a negative correlation (r_s=0.47, p<0.05) with index 12 degree of

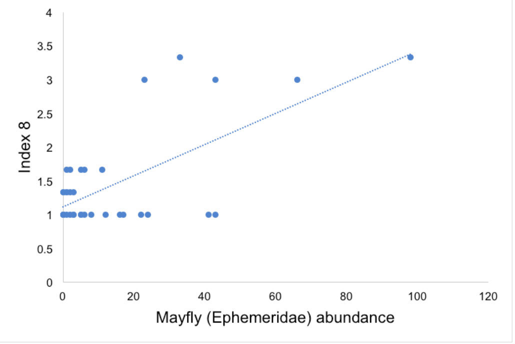


Figure 4. *Correlation between the number of Mayflies (Ephemeridae) recorded and Index 8 Channel Physical Habitat Complexity.*

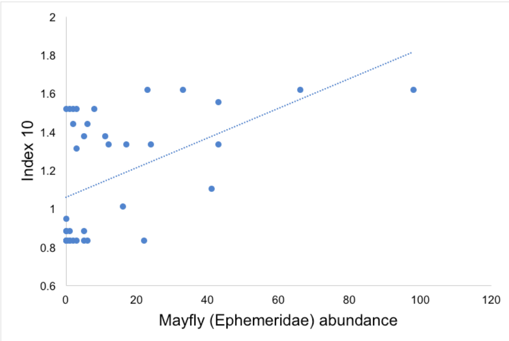


Figure 5. *Correlations between Mayfly (Ephemeridae) and Index 10 Riparian Physical Habitat Complexity.*

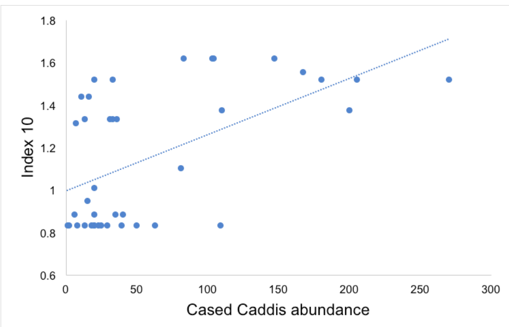


Figure 6. *Correlation between Cased Caddis and Index 10 Riparian Physical Habitat Complexity.*

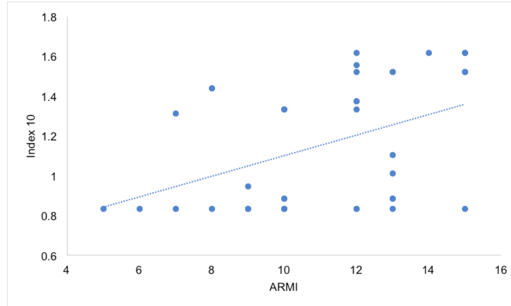


Figure 7. *Correlation between ARMI Score and Index 10 Riparian Physical Habitat Complexity.*

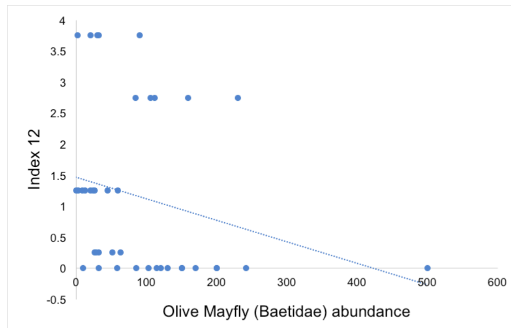


Figure 8. *Correlation between Index 12 Degree of Human Pressure Imposed by Land Cover on the Bank Tops and Olive Mayfly (Baetidae).*

Human Pressure Imposed by Land Cover on the Bank Tops (Figure 8). Index 13: Channel Reinforcement, was negatively correlated with ARMI (r_s= -0.58, p<0.05), Cased Caddis (r_s= -0.42, p<0.05), Caseless Caddis (r_s= -0.48, p<0.05), Olives (r_s= -0.58, p<0.05), Stoneflies (r_s= -0.36, p<0.05) and Shrimps (r_s= -0.34, p<0.05). These results demonstrate the negative impact which channel reinforcement and changes in land cover can have on in-stream biota.

Discussion

The results of this study show relationships between Riverfly groups and physical habitat. A more diverse Riparian Physical Habitat (index 10) favoured Cased Caddis, Mayfly and provided greater ARMI scores, showing the importance of a varied riparian structure (Harrison *et al*., 2004; Harrison & Harris, 2002), which relates to a better ecological status of the river (Solari *et al*., 2016; Peligro & Jumawan, 2015; Hussain & Pandit, 2012). Vegetation actively interacts with river hydromorphology by trapping and retaining sediment and thus changes the bed sediment composition, for example by exposing gravels, to changing the river bed topography and river planform (shape as viewed from above), and eventually changing the abundance and distribution of vegetation (Gurnell, 2014).

Riverfly groups are also affected by activities within and alongside the immediate channel as can be seen by the decline in the number of Olives as the bank top pressures as a result of increased human activity increase and the decline of many invertebrate groups with channel reinforcement. This supports research indicating that more natural channels are important for richer in-stream biota (Harrison *et al*., 2004; Harrison & Harris, 2002).

Linking species to habitat data is always difficult, even when both data sets give very detailed information. It is typical to find a lot of scatter in such data as found in the citizen science observations reported here. Against this background it is remarkable that significant associations have been found between Riverfly groups and habitat information which also illustrates the enormous potential value for the wider use of these citizen science surveys.

Our findings also demonstrate, that even with this small dataset from a short length of a single stream, how combined Riverfly monitoring and MoRPh surveys may be used to determine where restoration work is required or has been successful. This information and these insights can have a major part to play in helping to characterise the rivers across Hertfordshire, by assessing their in-stream and riparian habitat complexity (Beach 2017; England *et al*. 2017b).

Using MoRPh and Riverfly monitoring techniques has illustrated the usefulness of citizen science in the assessment of chalk river restoration. Reconnecting people to their local river environments (Shuker *et al*., 2017) though projects like Riverfly monitoring (www.riverflies.org) and MoRPh surveying (modularriversurvey.org) will also help foster the next generation of citizen scientists. These projects provide vast amounts of data it would not normally be possible to collect. The more citizen scientists who are trained in these survey techniques the larger the data sets collected will be, thus providing invaluable information on the health of the nation's rivers and ultimately where we need to undertake restoration work to safe guard this precious habitat.

An ideal opportunity to link MoRPh surveys to monitoring river habitats would be via the catchment partnerships, as they are the ones who are developing action plans and restoration schemes across their catchments. Most of the partnerships have citizen scientists already involved with Riverfly monitoring along their rivers and MoRPh surveying would complement this. Furthermore, Riverfly monitors may even be interested in undertaking a MoRPh survey at their recording site.

Acknowledgements

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