

Water Quality of four Wyre Forest Streams containing White-clawed Crayfish.

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Introduction

Four streams in the Wyre Forest have populations of White-clawed Crayfish (*Austropotamobius pallipes*) although population size differs; the reason for this is not immediately clear. White-clawed Crayfish require good quality water which contains high levels of calcium, and high levels dissolved oxygen levels (Holditch 2003). Crayfish are susceptible to spills of organic material with a high Biological Oxygen Demand (BOD) which reduce dissolved oxygen levels; to high levels of ammonia associated with sewage or farm effluents and to pesticides.

Methods

During 2015, water quality data was collected from Bell Brook, Forest Lodge Stream, Longdon Stream and Kingswood stream, at four weekly intervals between February and July. A range of parameters were measured/assessed – Temperature, Dissolved Oxygen (%), Specific Conductance (a measure of dissolved solids) and pH using a Horiba multi-parameter Water Quality Meter. Water samples were taken and Suspended Sediment load, Nitrate, Phosphate and Ammonia concentrations were subsequently measured in the laboratory. The percentage of streambed visible was assessed in each stream during crayfish surveys. For each stream catchment the percentage of land-

use types were calculated using Aerial Photographs (Google 2015) and 2007 Land Cover data (Centre for Ecology and Hydrology, 2011), using Woodland, Grassland, Arable and Suburban categories.

Kruskall-Wallis ANOVA was used to identify any significant differences in variables between the four streams.

Results

Water Quality

Temperature ranged from 3.1°C in Bell Brook in January to 15.4°C in Forest Lodge stream in July (Figure 1), there was little variation between values recorded in the four streams. Dissolved Oxygen levels ranged from 72% in Bell Brook in June to 105.5% in Kingswood Stream in March (Figure 2), Bell Brook and Forest Lodge stream both recorded low values in June although there is little variation between the streams. Specific Conductance ranged from 155.4 (µs/cm) in Bell Brook in March to 486.7(µs/cm) in Longdon stream in July (Figure 3) Bell Brook had a low range with Longdon stream showing higher values.

Water pH ranged from 6.7 in Forest Lodge stream in February to 8.22 in Bell Brook in May (Figure 4), the range of values is not large, although Bell Brook shows a slightly higher mean value (there was one low outlying value). Suspended sediment ranged from 0.43 (mg/l)

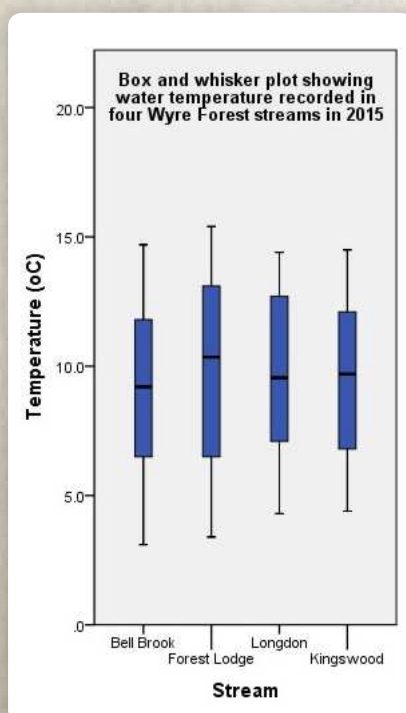


Figure 1 – Temperature

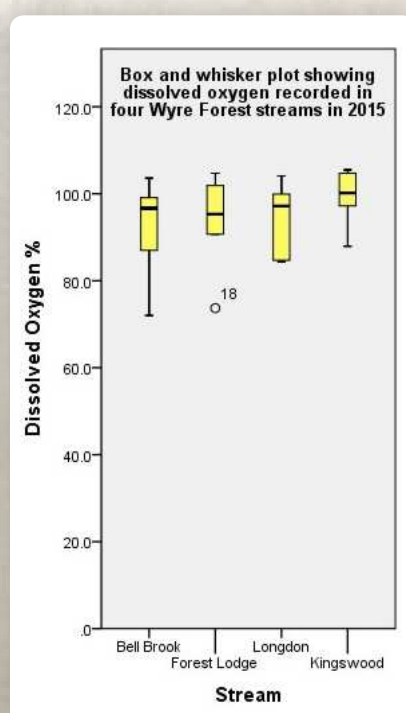


Figure 2 – Dissolved Oxygen

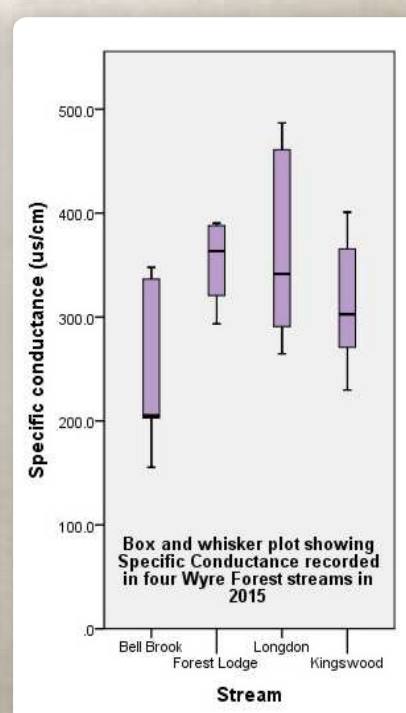


Figure 3 – Specific Conductance

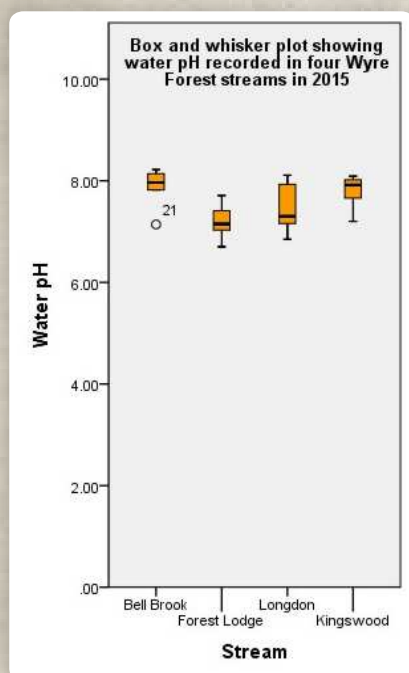


Figure 4 – Water pH

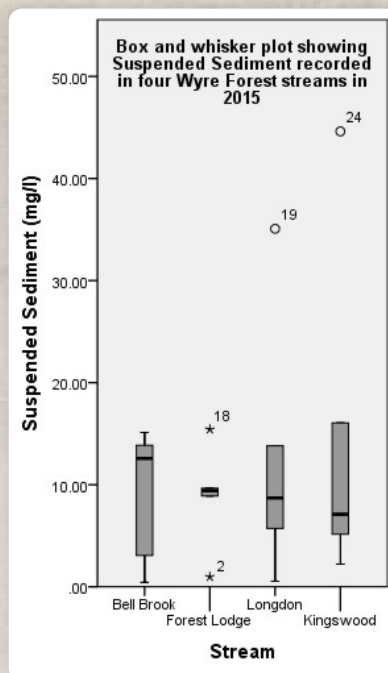


Figure 5 – Suspended sediment

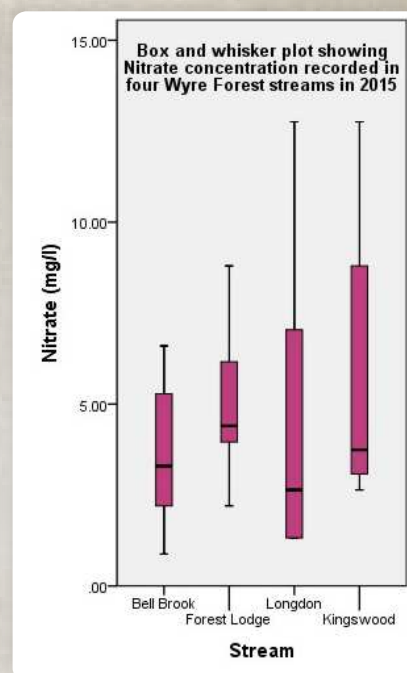


Figure 6 – Nitrate

in Bell Brook in March to 44.62 (mg/l) in Kingswood stream in July (Figure 5), Bell Brook and Forest Lodge stream show a consistently low range of values, with Longdon and Kingswood streams showing some high values in July and June respectively. Nitrate ranged from 0.88 (mg/l) in Bell Brook in July to 12.76 (mg/l) in Kingswood in February (Figure 6), Bell Brook and Longdon have low mean values, although Longdon and Kingswood streams both show much higher values in February.

Phosphate concentration ranged from 0.12 (mg/l) in Longdon stream in May to 2.13 (mg/l) in Kingswood stream in April (Figure 7), mean values for all streams are low although there are spikes in both Longdon and Kingswood streams in March and April respectively. Ammonia ranged from 0.02 (mg/l) in Forest Lodge stream in February to 0.43 (mg/l) in Kingswood in February (Figure 8), there appears to be little variation in ammonia content between the four streams.

Some results are flagged as extreme or outlying, in Water pH (Figure 4) one result (flagged - O) is determined to be outside the expected range for the results and is not used in the analysis. In Suspended Sediment (Figure 5) high values from Longdon and Kingswood streams are outliers (O) and excluded from the analysis whilst two results from Forest Lodge are considered extreme values (*) and also excluded from the analysis. One phosphate result from Longdon stream (Figure 7) is also considered extreme (*) and one from Kingswood stream is considered an outlier

(O) – both are excluded from analysis. The reason for these outlying or extreme values is unclear, whilst the result may be correct it may also result from equipment errors or in the laboratory analysis.

A Kruskal-Wallis ANOVA test was undertaken of each of the water quality variables with the Null Hypothesis in each case being the there is no significant difference between the mean values in each stream. The results are shown in Table 1, where only pH values have any significant difference.

The Kruskal-Wallis ANOVA analysis suggests that water pH is significantly different between streams, Figure 4 shows that the mean pH value from Bell Brook is likely to be the driver of this significant difference, because pH is higher in Bell Brook than the other three streams.

	Significance
Water Temp (°C)	0.967
Dissolved Oxygen %	0.601
Specific Conductance (us/cm)	0.73
Water pH	0.045
Suspended Sediment (mg/l)	0.989
Nitrate concentration (mg/l)	0.562
Phosphate concentration (mg/l)	0.842
Ammonia Concentration (mg/l)	0.683

Table 1. Table showing the significance of Kruskal-Wallis ANOVA test of differences between the means of several water quality parameters in four catchments in the Wyre Forest.

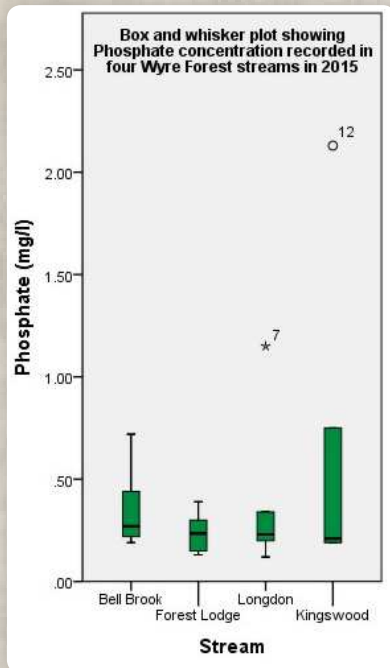


Figure 7 – Phosphate

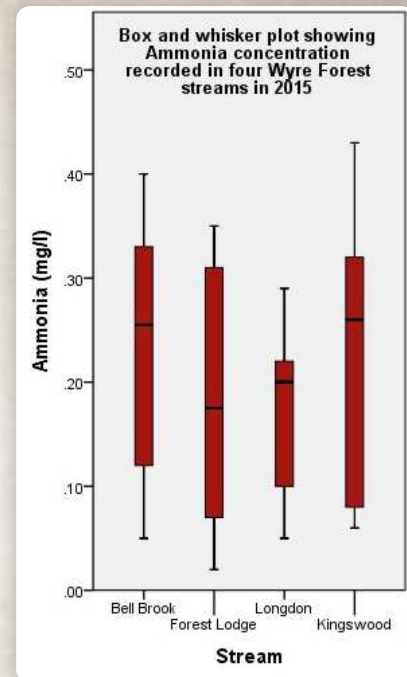


Figure 8 – Ammonia

Bed visibility

Bed visibility was assessed during crayfish surveys in the summer by estimating the percentage of bed that was clearly visible to the surveyor. Table 2 shows that only Kingswood stream had less than 100% bed visibility, where, in the upper reaches of the stream, the bed was rarely visible although this improved with increasing distance downstream.

Land use

Woodland accounted for 52.6% by area, Grassland 16.9%, Arable 30.3% and Suburban (farmyard and housing) to 0.3%. Table 3 and Figure 9 breaks down the land use by catchment for each of the four catchments, Bell Brook and Forest Lodge contained only Woodland and Grassland (the small footprint of the few houses was too small to measure). Kingswood and Longdon both have areas of Arable land use, 3.4% and 35.9%

Stream	Visibility
Bell Brook	100%
Forest Lodge	100%
Longdon	100%
Kingswood	20 – 90%

Table 2. Table showing the percentage of stream bed that was visible during crayfish surveys, 2015.

respectively together with a small amount of suburban development – 0.7 and 0.3% respectively.

Discussion

There are clear differences between the White-clawed Crayfish populations in the four streams where they are known in the Wyre Forest. Bell Brook and Forest Lodge stream have good populations whilst in Longdon and Kingswood streams the populations are low and in some years no crayfish have been detected during surveys (see Hill and Hill 2015 on page 18). Physical habitat quality in all streams is abundant, so this investigation aimed to investigate any effects caused by water quality.

Of the nine parameters recorded, only water pH was significantly different between the four streams although all streams are within the suitable range for crayfish. Water pH is closely linked to the presence

	Bell Brook	Forest Lodge	Longdon	Kingswood
Woodland	81.3%	15.7%	68.7%	41.8%
Arable	0.0%	0.0%	3.4%	35.9%
Grassland	18.7%	84.3%	27.2%	22.0%
Suburban	0.0%	0.0%	0.7%	0.3%

Table 3. Percentages of catchment land-use for four streams in the Wyre Forest.

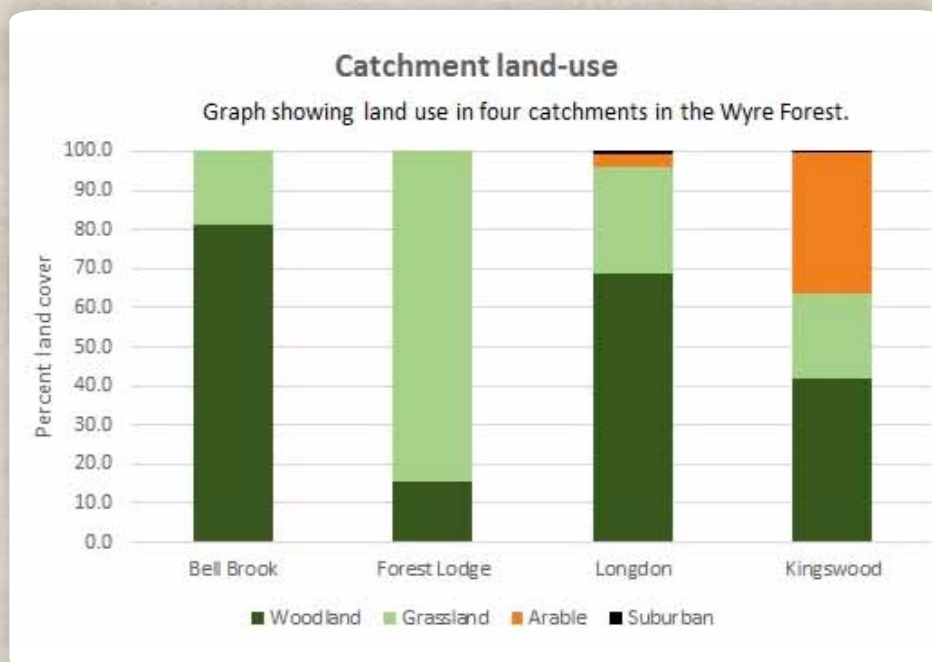


Figure 9. Percentages of catchment land-use for four streams in the Wyre Forest.

or absence of calcium, within the Wyre Forest there are calcareous flushes within the largely sandstone geology, suggesting that in Bell Brook catchment there is a source of calcium sufficient to raise pH above the levels of the other streams. Ammonia concentration was included in the investigation because it was thought that in Kingswood stream it may be higher because of the large waterfowl population in ponds adjacent to the stream. However, although ammonia levels in Kingswood stream are slightly higher than other streams, this is not statistically significant. Levels of Nitrate and Phosphate, which are high in relation to desired standards, are broadly similar across the streams investigated.

The arable farming in both Kingswood and Longdon stream catchments is likely to be adding to suspended sediment, nitrate and phosphate concentrations in these streams. Arable farming practices frequently involve adding fertiliser and spraying with pesticides of various types. High nitrate and phosphate levels can result from fertiliser applications, although both are also available in the natural system too. Pesticide residue can be flushed off crops and land into the stream as a short-lived pollution event – these are difficult to record unless continuous monitoring is used. It is possible that such events are responsible for the low crayfish numbers in the two streams with arable land use, although more work would be needed to determine this.

During this study turbidity was not measured although the percentage of visible stream bed was estimated

during crayfish surveys. High turbidity (caused by suspended sediment) has a negative impact on crayfish with fine sediment clogging the crayfish's gills, it also hampers survey efficiency because both hand-searching and torching relies on the surveyor being able to see crayfish on the stream bed. The water in Bell Brook, Forest Lodge stream and Longdon stream is very clear, the bottom of the stream can be seen, almost, in its entirety, whereas in Kingswood stream a greater proportion of the streambed is not visible – it may be that in this stream there are more crayfish than have been recorded, simply because they cannot be seen. Interestingly, during the first survey of Kingswood stream in 2011, crayfish were observed on the bed of a scour-pool below a culvert under the farm track at the upper limit of the survey, in subsequent years the bed of this pool has not been visible.

Water chemistry is affected by the types of land use within the catchment. Arable farming leaves the soil un-protected at some times of the year allowing sediment mobilisation into water courses. Both fertilisers and pesticides can leach from the soil into the streams following rainfall.

Conclusions

Measure water quality did not reveal any clear reason for differences in crayfish population size between streams containing White-clawed Crayfish in the Wyre Forest. However, it did show that – of the parameters assessed – only pH is significantly different between the catchments.

Turbidity is an issue, both for the crayfish and for surveys. Large quantities of suspended sediment increase turbidity although there is no significant difference in suspended sediment between the four streams. Discolouration of the water due to other factors affects visibility of the bed which hampers survey effort with subsequent low numbers recorded. The presence of crayfish can be detected by recently developed Environmental DNA techniques (see Troth 2015 presented elsewhere in this publication), and may provide a way to overcome some of the visibility issues affecting surveys.

The presence of leached pesticides and nutrients from arable land in the catchments with low populations of native crayfish could be a significant issue, however, recording short-term changes in these concentrations would require more intensive, or continuous, monitoring.

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References

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Dowles Brook

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