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Assessment of man-made leaky dams' contribution to macro-invertebrate ecology in a West Dorset stream.

Abstract

An assessment of how a man-made leaky dam can contribute to better macro-invertebrate ecology in the river Asker, Dorset was made in 2020-2022. Six dams of both natural (leaky) and constructed types were studied and they were spread evenly across the two tributaries. In five sampling periods across a year, kick-samples provided information on species diversity and abundance, which was also used in an Extended Riverfly Index. Having conducted comparisons of macro-invertebrate communities, between the area around the dams and within, it can be seen that the populations are similar. The dams would appear slightly better than downstream areas (P=0.005). Assessment of woody structures revealed no traits with macro-invertebrates. Overall, this shows potential ecological benefits of leaky woody dams to small streams.

Aim

To assess how a man-made leaky dam can contribute to better macro-invertebrate ecology in the river Asker.

Outcomes

The benefits of this study are in building community involvement in understanding the benefits of their survey work and habitat improvements on the river Asker, which in turn will add to the broader national understanding of the function of leaky dam structures. This can provide the basis for wide role out of leaky dams and improved ecology, alongside flood alleviation (Lockwood *et al.* 2020).

Background

The river Asker has a local community group keen to study and help improve the river and adjacent habitats. Boyer *et al.* 2003 describes the importance of river and land management for woody debris in rivers. Leaky dams were constructed (using woody material) over a range of small tributaries of the River Asker, Dorset in January, February and March 2020 and 2021. There were also some existing natural log dams, as is common in throughout rural UK (Linstead & Gurnell 1999), and they all collect natural debris consisting of lots of leaf matter that provides shelter and food for freshwater invertebrates.

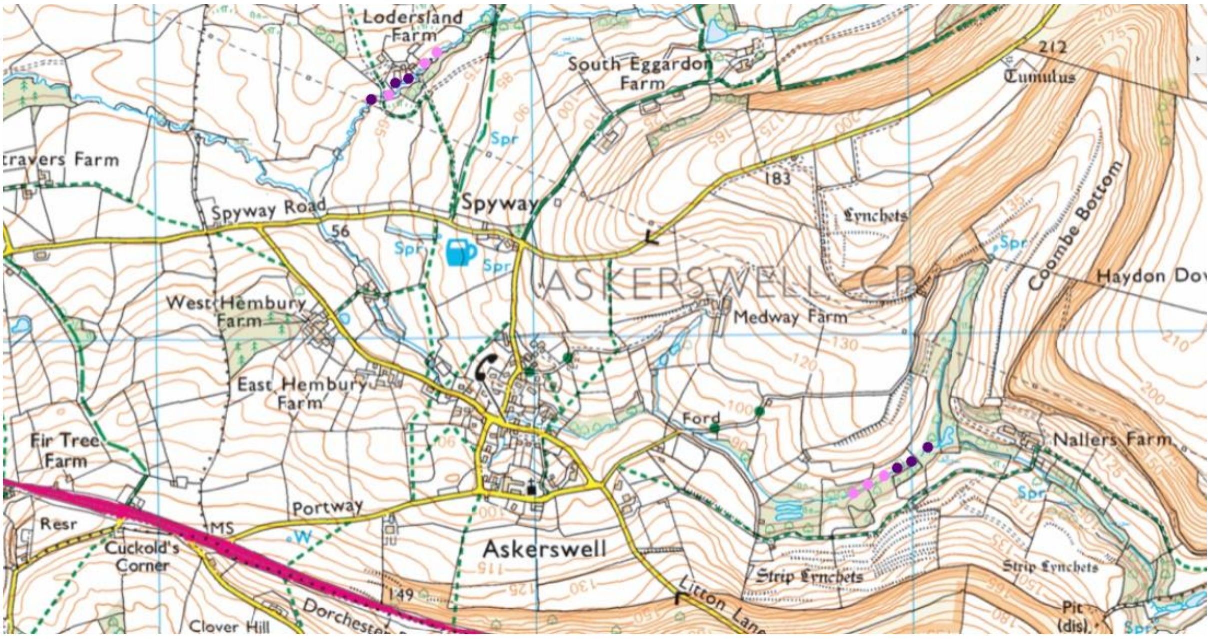
Godfrey 2003 describes how there are even numbers of wood dependant and non-wood dependant macro invertebrate species. Gurnell *et al.* 2005 shows the importance of islands and ponds, associated to woody debris, to amphibians and macro-invertebrates. Opperman *et al.* 2006 describes importance to river ecology especially fish populations.

The community group are monitoring invertebrate for the Riverfly partnership. All part of Dorset AONB project. This study is to extend the Riverfly study onto the dam areas to assess benefits.

<u>Approach</u>

The study sites are on two tributaries of the river Asker. The southerly tributary is upstream of Askerswell and the northerly tributary is at Lodersland Farm. The sites are shown in Map 1 as pink for sites with natural dams and purple for those with man-made leaky dams.

Map 1



Six dams of both natural and constructed types were selected for assessment and measurements of debris including leaf matter accumulation (photo 1) together with the associated invertebrates present. They were split evenly across the two tributaries. The man-made dams were full of debris and one to two years old.

Sampling was once approximately every 2 months from August 2021 to June 2022 giving five sample periods.

Photo 1

Based on initial trials the assessment of trapped leaves (photo 1) and substrate (Photo 2) alongside a 1-minute invertebrate kick-sample would provide enough information on species diversity and abundance. Analysis and recording was undertaken at the riverside as initial test samples revealed manageable numbers for this.

Photo 2

Analysis

The dam debris, substrate below and above individual dams was sampled to reveal the localised effects of the small impoundments. A sample of loose leaf material in the surrounding areas to the dams was also sampled in August sampling.

For dam debris present, the invertebrate analyses compared results from dams made of different wood types. Also, it compared constructed dams plus existing natural dams. Additionally, this data was assessed for correlation with dam size, debris leaf composition and flow at dam.

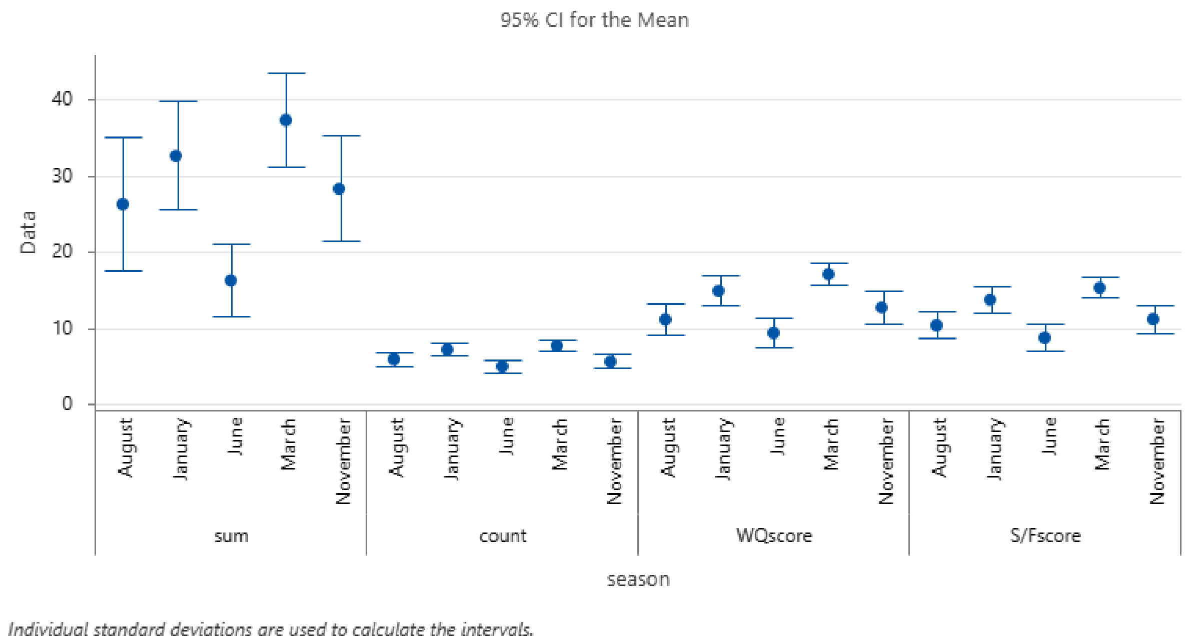
Excel files contain all the site measurements for the day of sampling and the macro-invertebrates counts for each family. The sum of individuals was also looked at. Riverfly extended scoring system was used for both Water Quality (WQ), and Silt and Flow (S/F) (Davy-Bowker 2020). Statistics was done in Mini-tab.

Results

Normality tests were completed on the four variables for all samples collected. Variables tested failed with count at (AD = 1.162, n = 180, P < 0.005), sum at (AD = 3.708, n = 180, P < 0.005), but not Riverfly WQ Score at (AD = 0.655, n = 180, P = 0.086) and Riverfly S/F Score at (AD = 0.628, n = 180, P = 0.100). Count and sum data was log10 transformed for use in further tests.

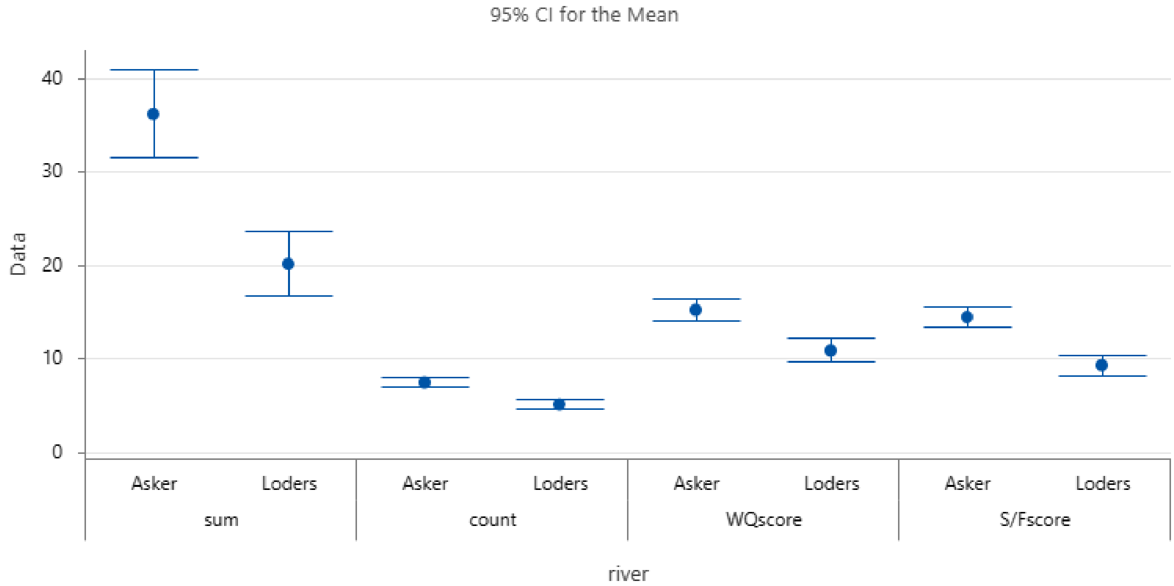
In the counts, sum, WQ and S/F score there appeared to be a lot of seasonally variation. This would be expected and count was ($F = 6.65$, $n = 179$, $P = 0.000$), sum at ($F = 8.07$, $n = 179$, $P = 0.000$), Riverfly WQ Score at ($F = 9.93$, $n = 179$, $P = 0.000$) and Riverfly S/F Score at ($F = 9.48$, $n = 179$, $P = 0.000$). Summer seasons were found to be slightly lower, which is typically due to the recent mass hatches (graph 1). This is considered part of the populations life cycle and so part of a true measure.

Graph 1. Measures of macro-invertebrate counts, sum, WQ and S/F score across seasons on the river Asker, Dorset (2021-2022). August and November 2021. January, March and June 2022.



Rivers were different in the counts, sum and S/F score; count being ($T = 6.32$, $n = 146$, $P = 0.000$), sum at ($T = 5.96$, $n = 160$, $P = 0.000$), WQ Score at ($T = 4.89$, $n = 177$, $P = 0.000$) and Riverfly S/F Score at ($T = 6.95$, $n = 177$, $P = 0.000$) so river would be put into the further tests as explanatory random factor. Riverfly were different between rivers and this could be expected (graph 2).

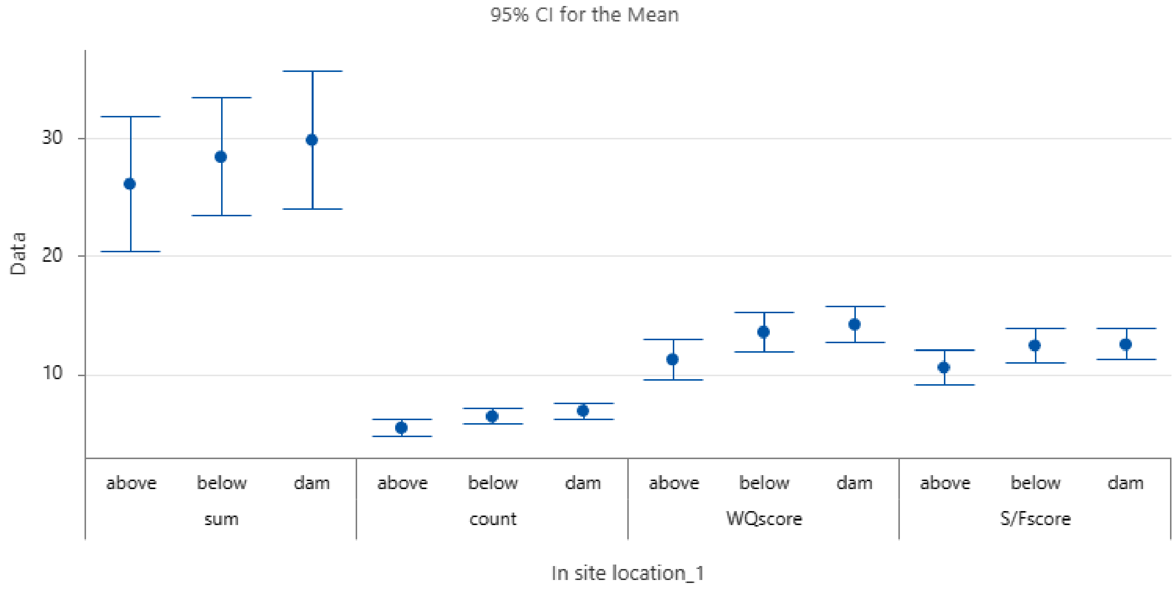
Graph 2. Measures of macro-invertebrate counts, sum, WQ and S/F score across tributaries of the river Asker, Dorset (2021-2022).



Individual standard deviations are used to calculate the intervals.

Analysis was now done grouping all rivers and seasons, although they were included as a random factor in the mixed models. It does appear that there is tendency for higher values in dams, but it is slight and not significant for sum at (F = 2.43, n = 172, P = 0.091), but is for count at (F = 7.42, n = 172, P = 0.001), Riverfly WQ Score at (F = 5.32, n = 172, P = 0.006) and Riverfly S/F Score at (F = 3.84, n = 172, P = 0.023). The differences looked at with interest are between dam, upstream substrate and downstream substrate populations. The dams would appear slightly better than downstream areas (graph 3). It's worth noting these differences are mostly significant and variation was contributed by the different rivers count at (31%), sum at (27%), Riverfly WQ Score at (20%) and Riverfly S/F Score at (34%). Interestingly, there is a contribution by season count at (13%), sum at (15%), Riverfly WQ Score at (19%) and Riverfly S/F Score at (17%).

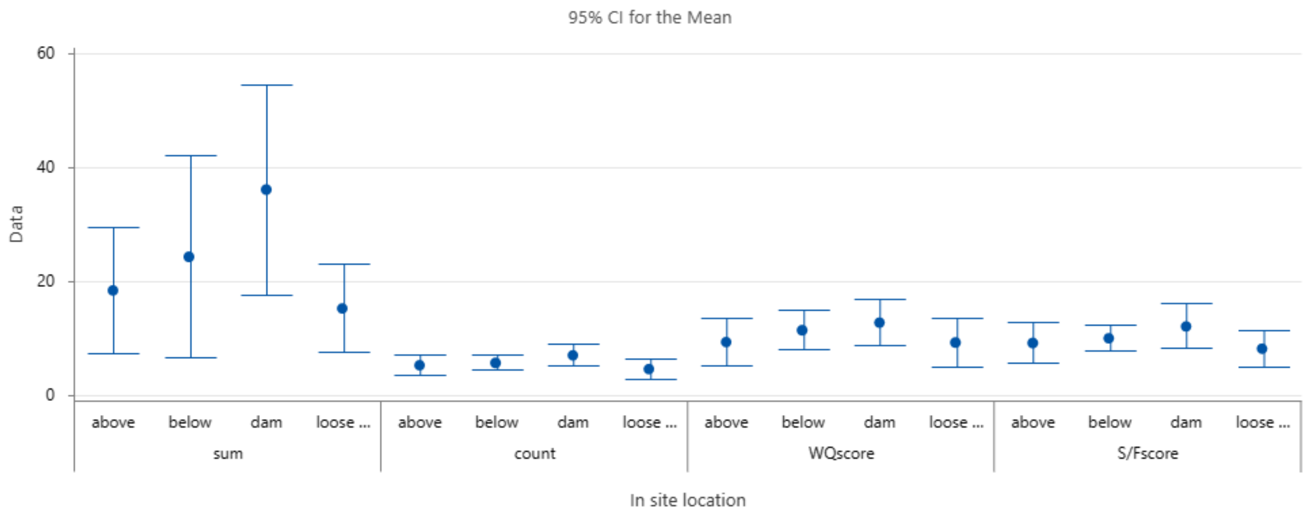
Graph 3. Measures of macro-invertebrate counts, sum, WQ and S/F score in and around woody dams on the river Asker, Dorset (2021-2022).



Individual standard deviations are used to calculate the intervals.

The side values represent invertebrates on loose organic materials on the riverside, but it was only present in August and significant differences were count at (F = 3.96, n = 43, P = 0.014), sum at (F = 3.87, n = 43, P = 0.016) and Riverfly S/F Score at (F = 3.02, n = 43, P = 0.040). Riverfly WQ Score at (F = 1.54, n = 43, P = 0.219) was not. However, as there is small amounts for material in the side samples, the actually numbers of individuals shows the values significantly lower (graph 4).

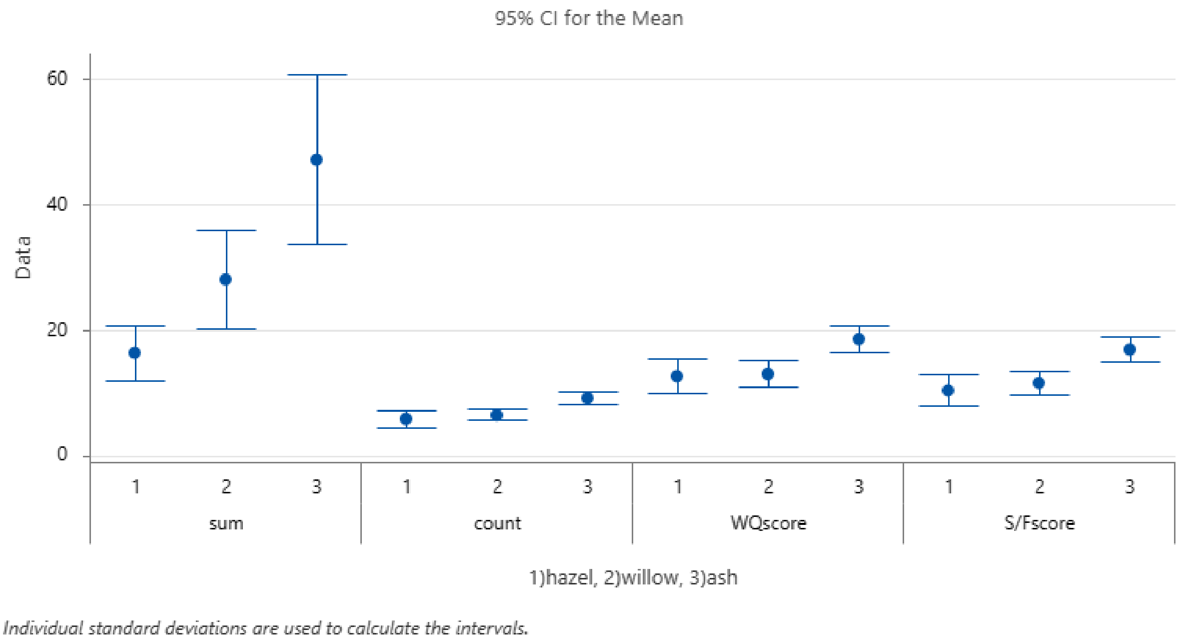
Graph 4. Measures of macro-invertebrate counts, sum, WQ and S/F score on loose material, and in and around woody dams on the river Asker, Dorset (August 2021).



Individual standard deviations are used to calculate the intervals.

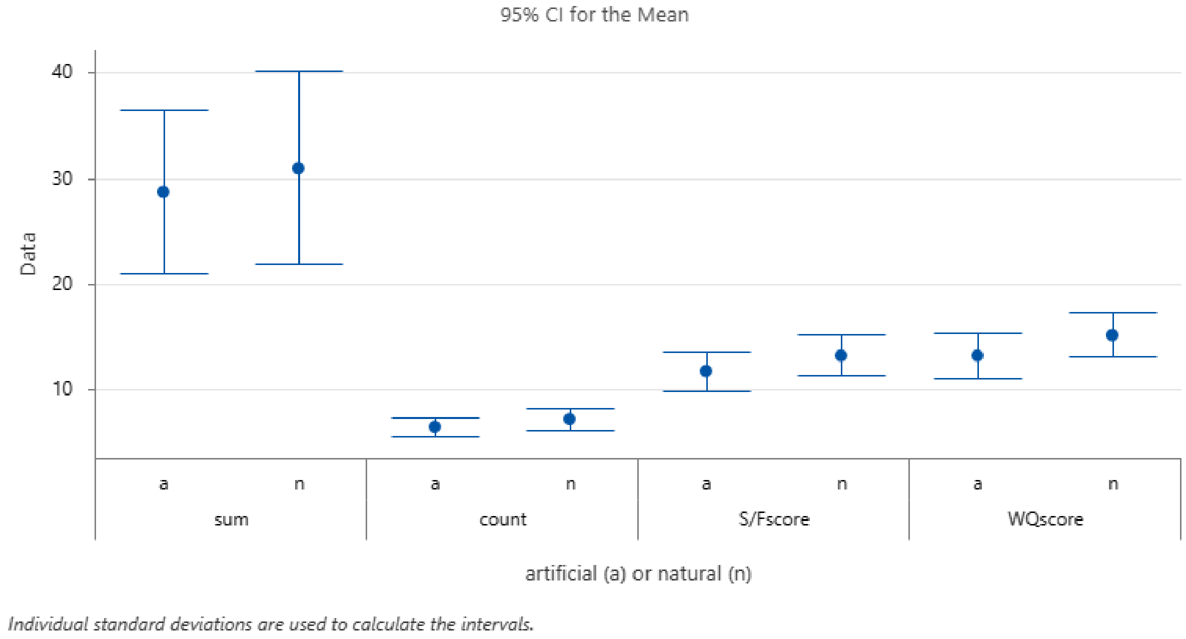
In graph 5 there are ccomparisons for wood type in the dams and there were no differences count at (F = 2.68, n = 49, P = 0.079), sum at (F = 1.24, n = 52, P = 0.299), Riverfly WQ Score at (F = 2.94, n = 46, P = 0.063) and Riverfly S/F Score at (F = 3.01, n = 49, P = 0.058).

Graph 5. Measures of macro-invertebrate counts, sum, WQ and S/F score of dams made of different woody material on the river Asker, Dorset (2021-2022).



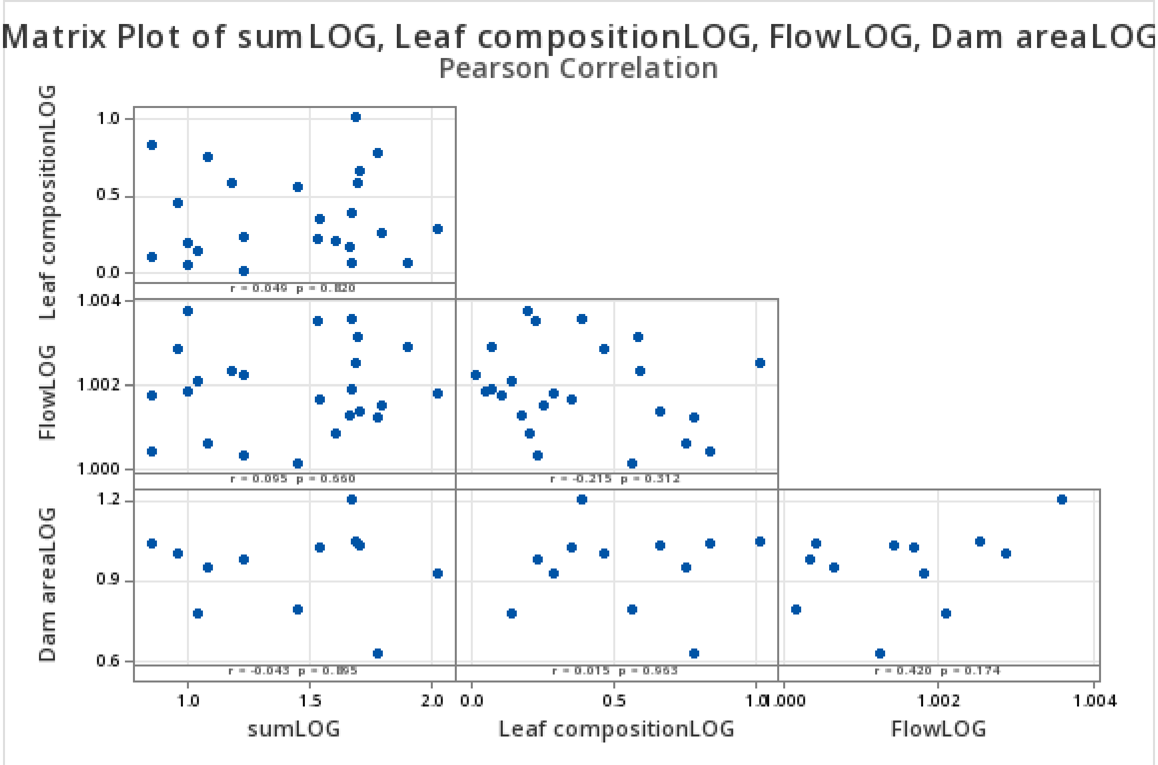
Graph 6 shows ccomparisons done for man-made dams and natural dams and there were no differences count at (F = 1.11, n = 53, P = 0.296), sum at (F = 0.05, n = 53, P = 0.831), Riverfly WQ Score at (F = 2.55, n = 53, P = 0.116) and Riverfly S/F Score at (F = 1.87, n = 53, P = 0.177).

Graph 6. Measures of macro-invertebrate counts, sum, WQ and S/F score between man-made leaky and natural dams on the river Asker, Dorset (2021-2022).

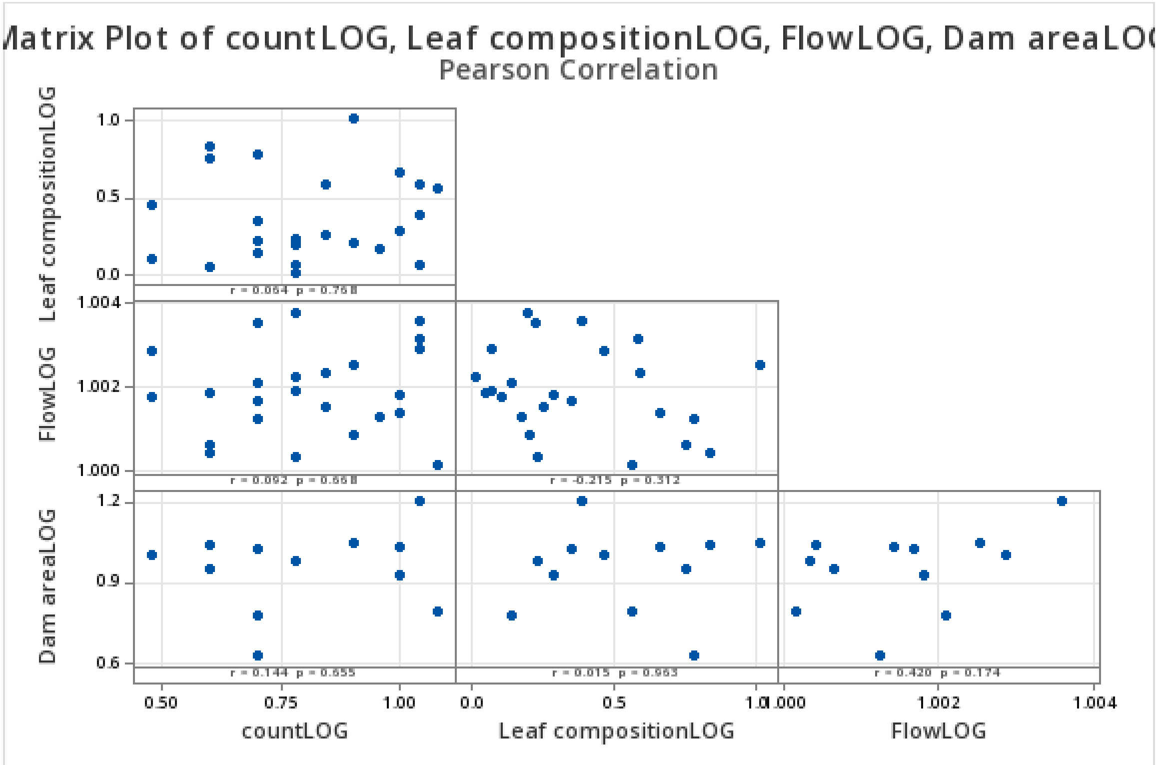


The dams were looked into in more detail. The interest is in highlighting any functional aspects that may have contributed to healthy populations. The factors looked at for influencing invertebrates were the percentage of leaf matter in debris, flow at the dam and dam area (graphs 7-10). However, no correlations were found (r and p values in charts, and with numbers at 24 per test except where dam area was involved where it was 12).

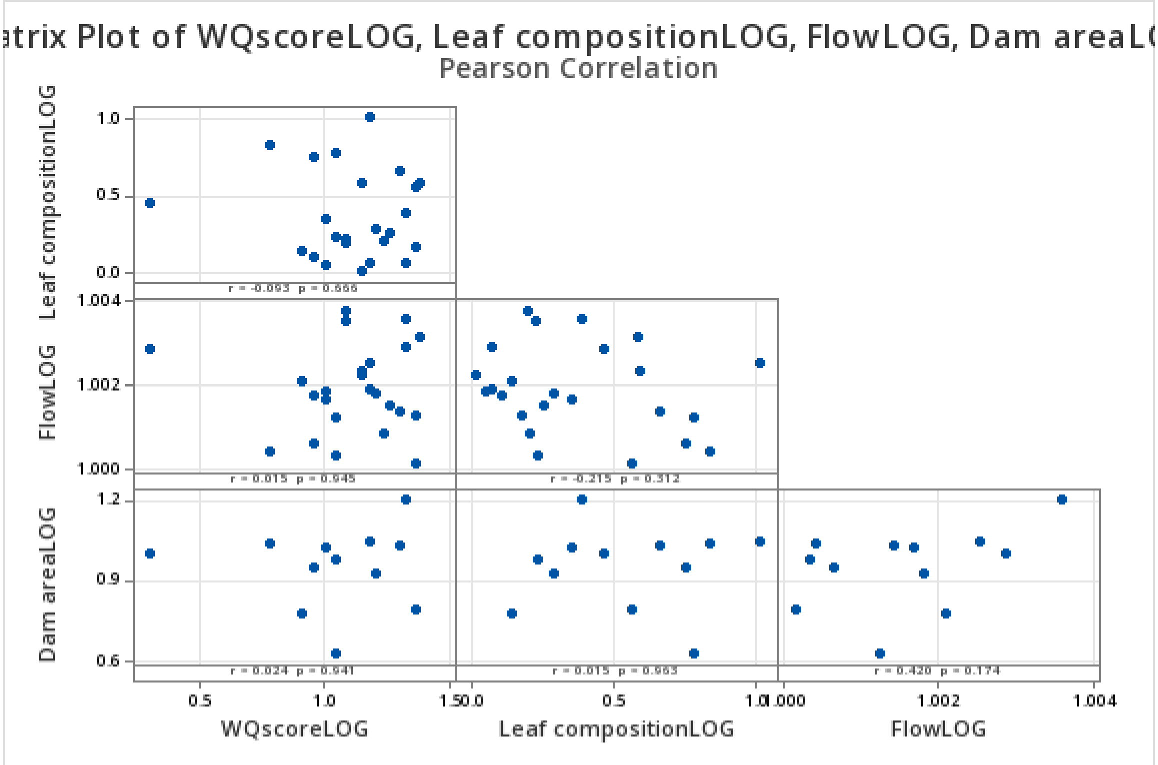
Graph 7. Correlations of macro-invertebrate sum with leaf composition, flow and dam area on the river Asker, Dorset (2021-2022).



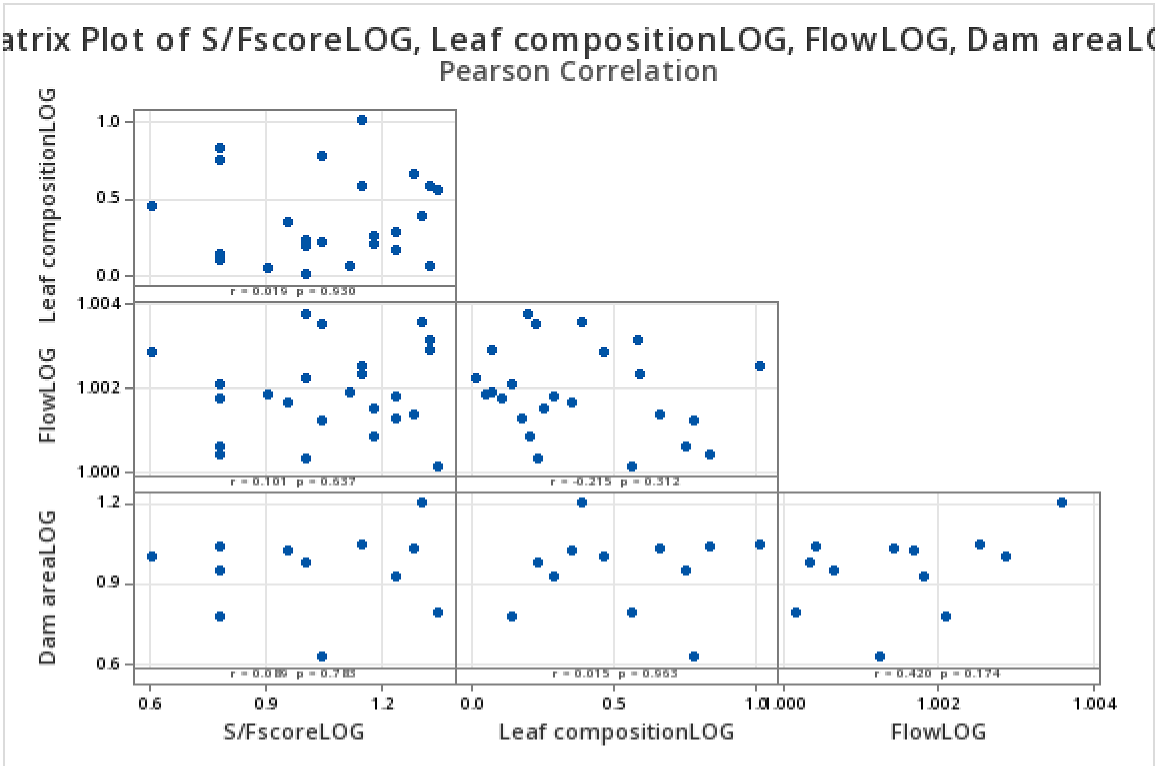
Graph 8. Correlations of macro-invertebrate counts with leaf composition, flow and dam area on the river Asker, Dorset (2021-2022).



Graph 9. Correlations of macro-invertebrate WQ score with leaf composition, flow and dam area on the river Asker, Dorset (2021-2022).

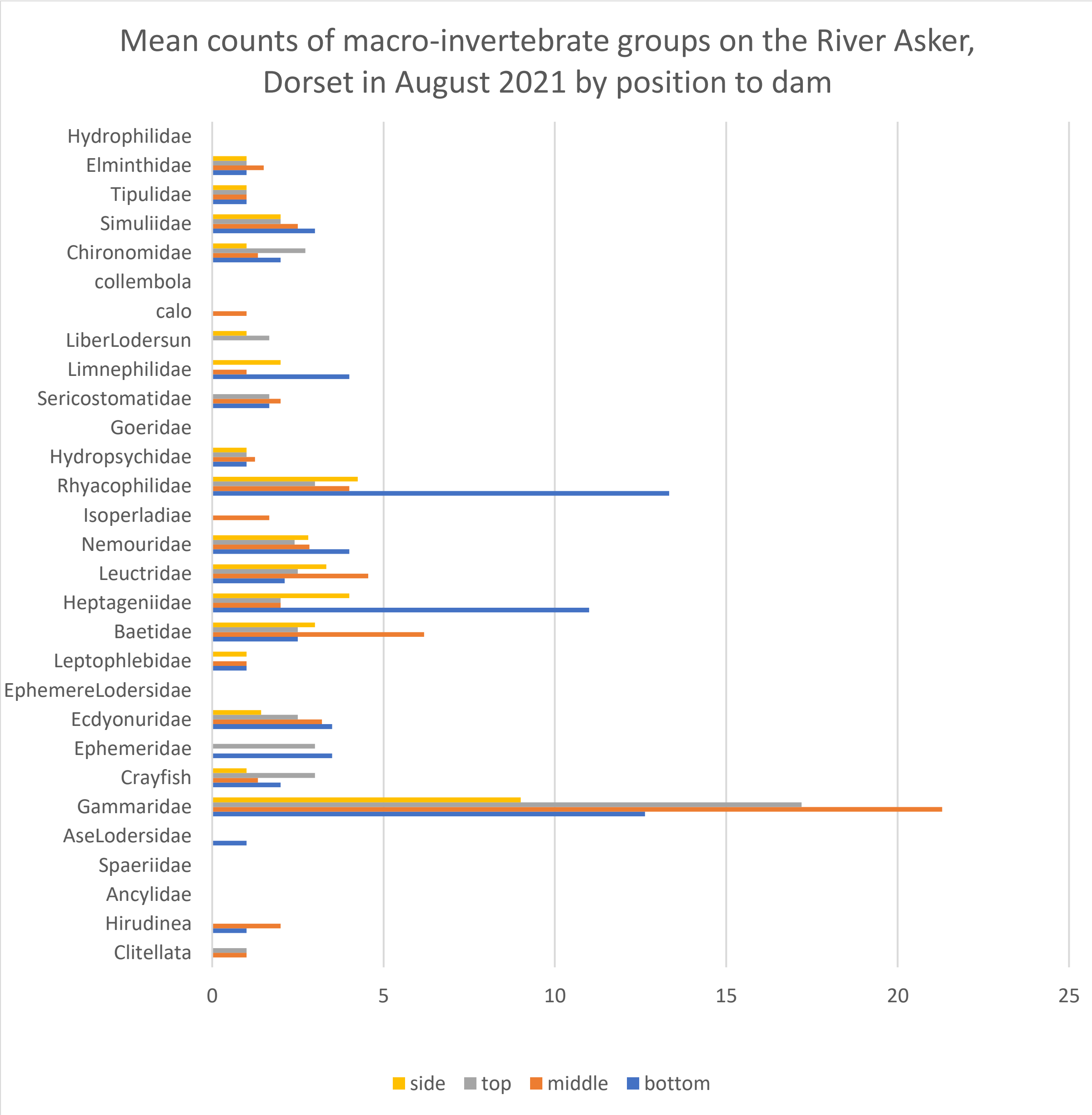


Graph 10. Correlations of macro-invertebrate S/F score with leaf composition, flow and dam area on the river Asker, Dorset (2021-2022).

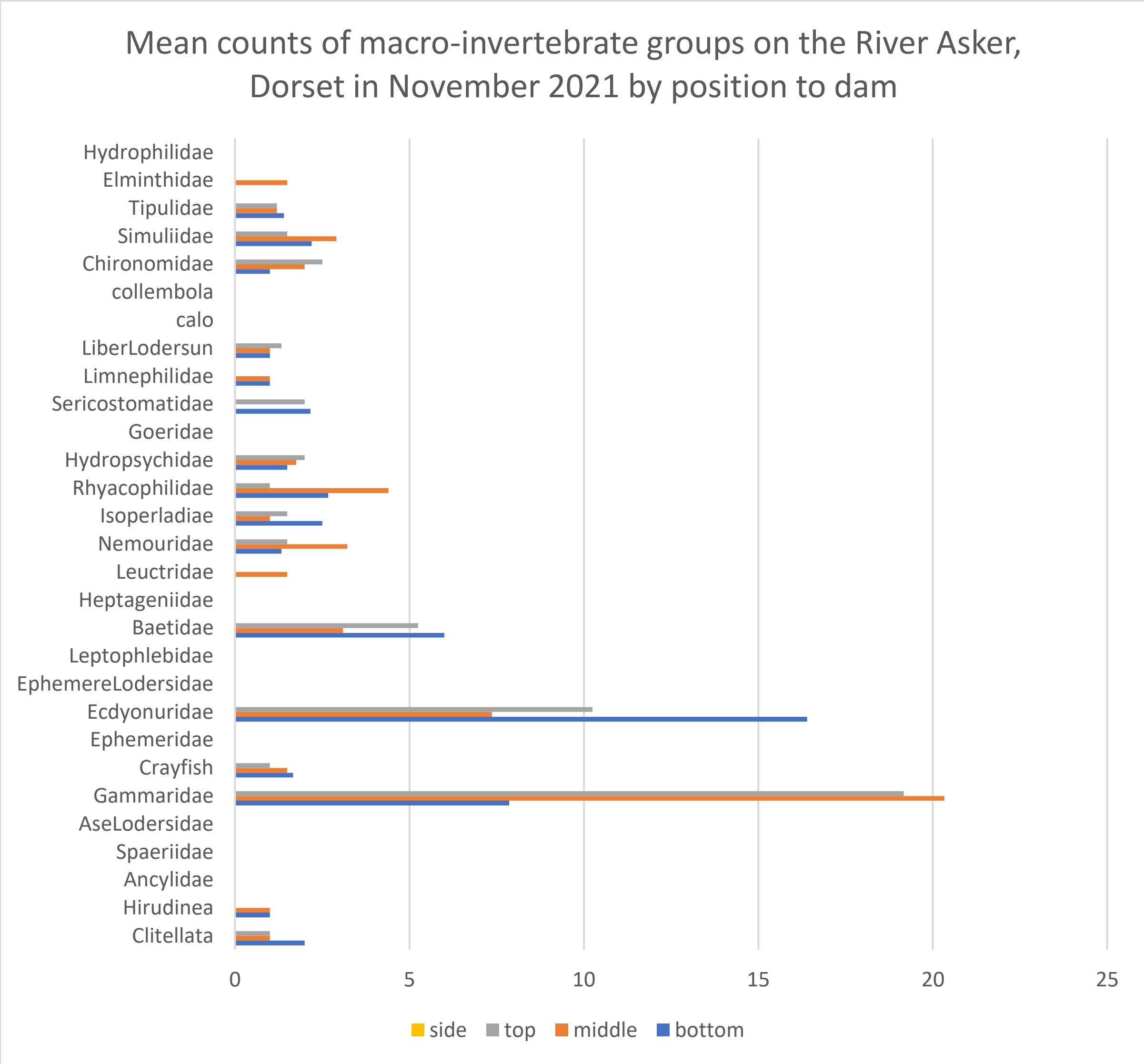


Graphs 11 to 15 show the groups, mostly by family, of macro-invertebrates in the river Asker as caught in different habitats surrounding and within the dam. This gives an idea of what was found by season as well. The thing to note is wood loving assemblages and burrowers that like softer river bed.

Graph 11

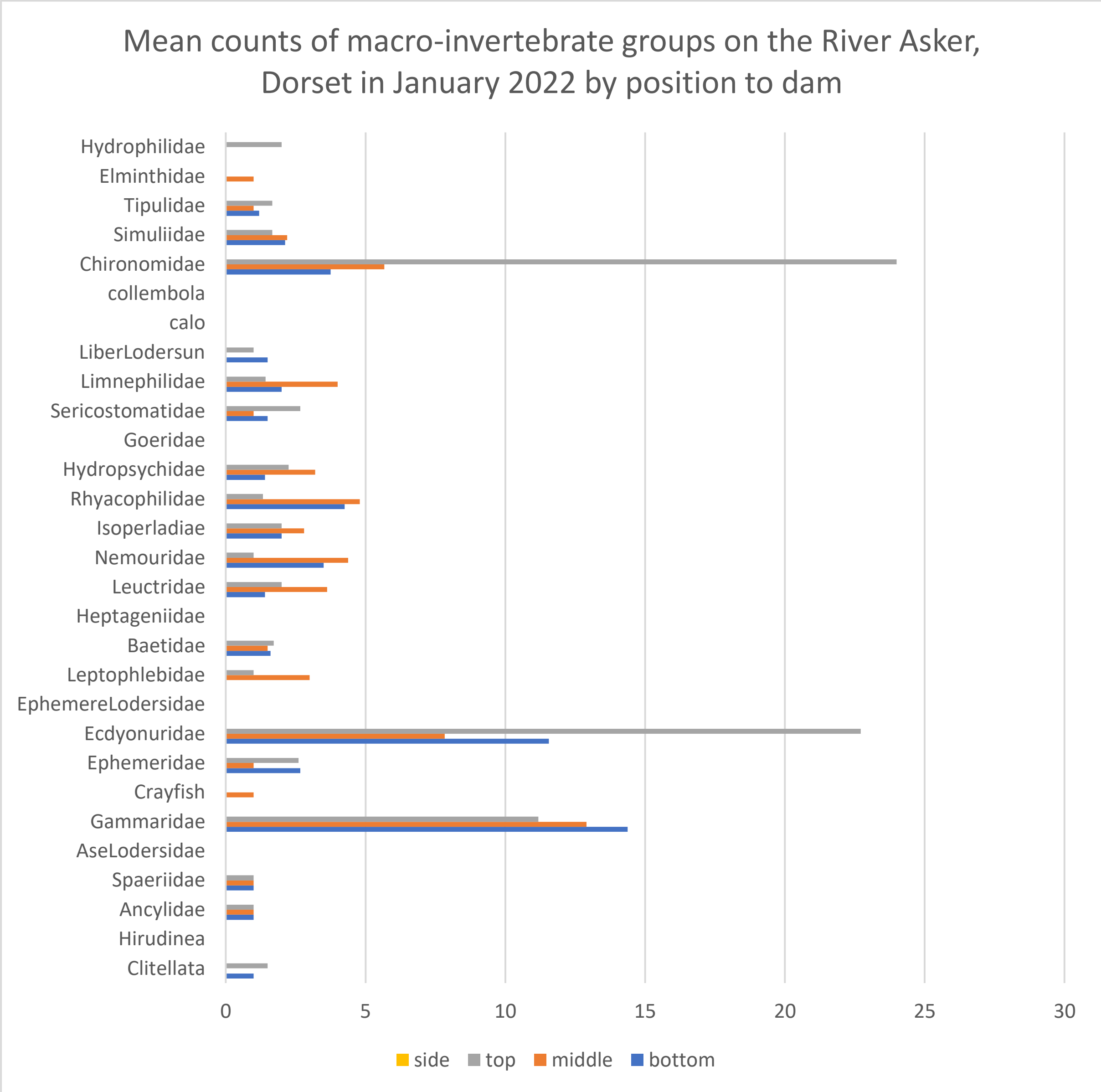


Graph 12



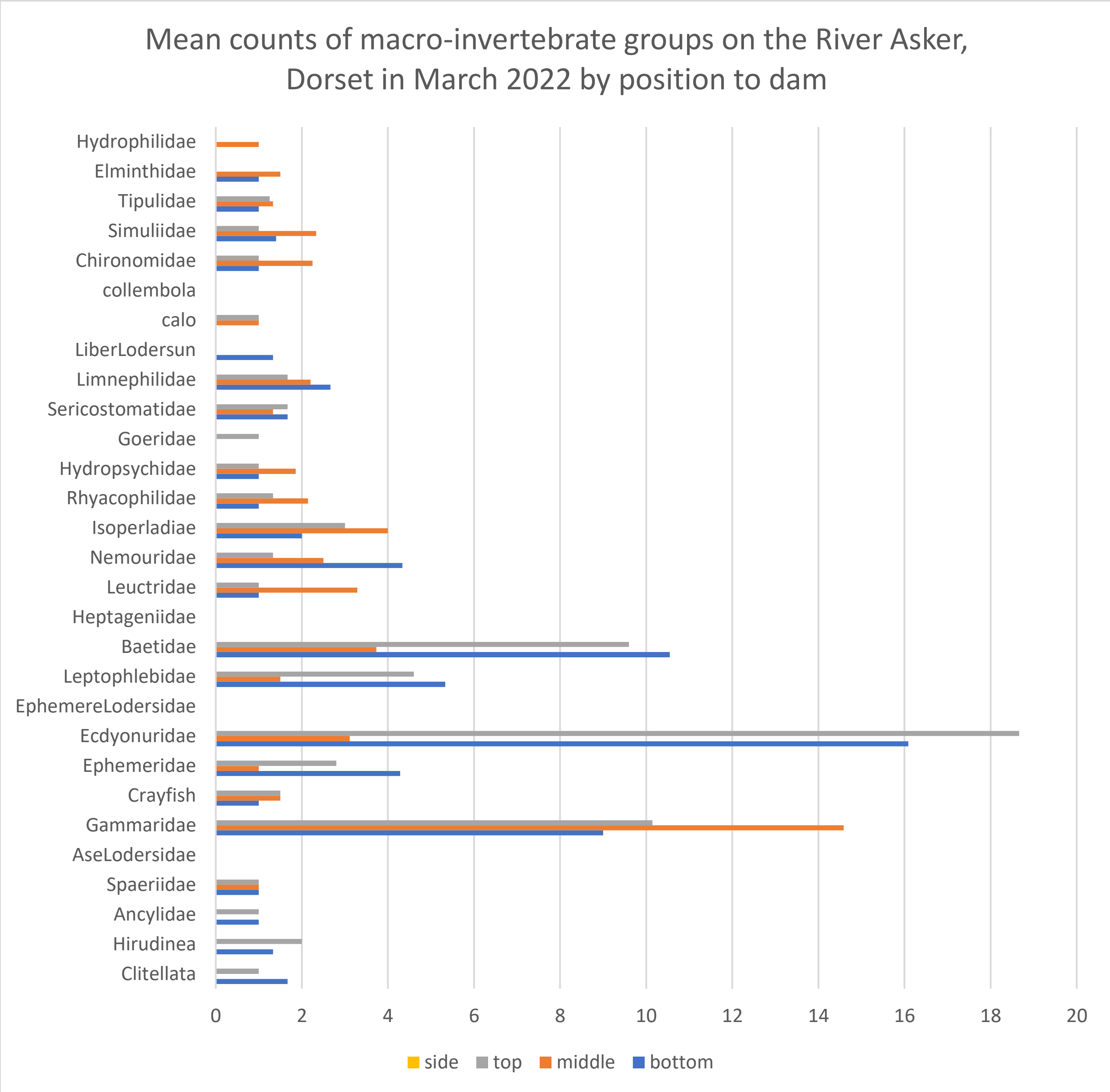
Mean counts of macro-invertebrate groups on the River Asker, Dorset in November 2021 by position to dam
Hydrophilidae
Elminthidae
Tipulidae
Simuliidae
Chironomidae
collembola
calo
LiberLodersun
Limnephilidae
Sericostomatidae
Goeridae
Hydropsychidae
Rhyacophilidae
Isoperladiae
Nemouridae
Leuctridae
Heptageniidae
Baetidae
Leptophlebidae
EphemereLodersidae
Ecdyonuridae
Ephemeridae
Crayfish
Gammaridae
AseLodersidae
Spaeriidae
Ancylidae
Hirudinea
Clitellata
0
5
10
15
20
25
side
top
middle
bottom

Graph 13



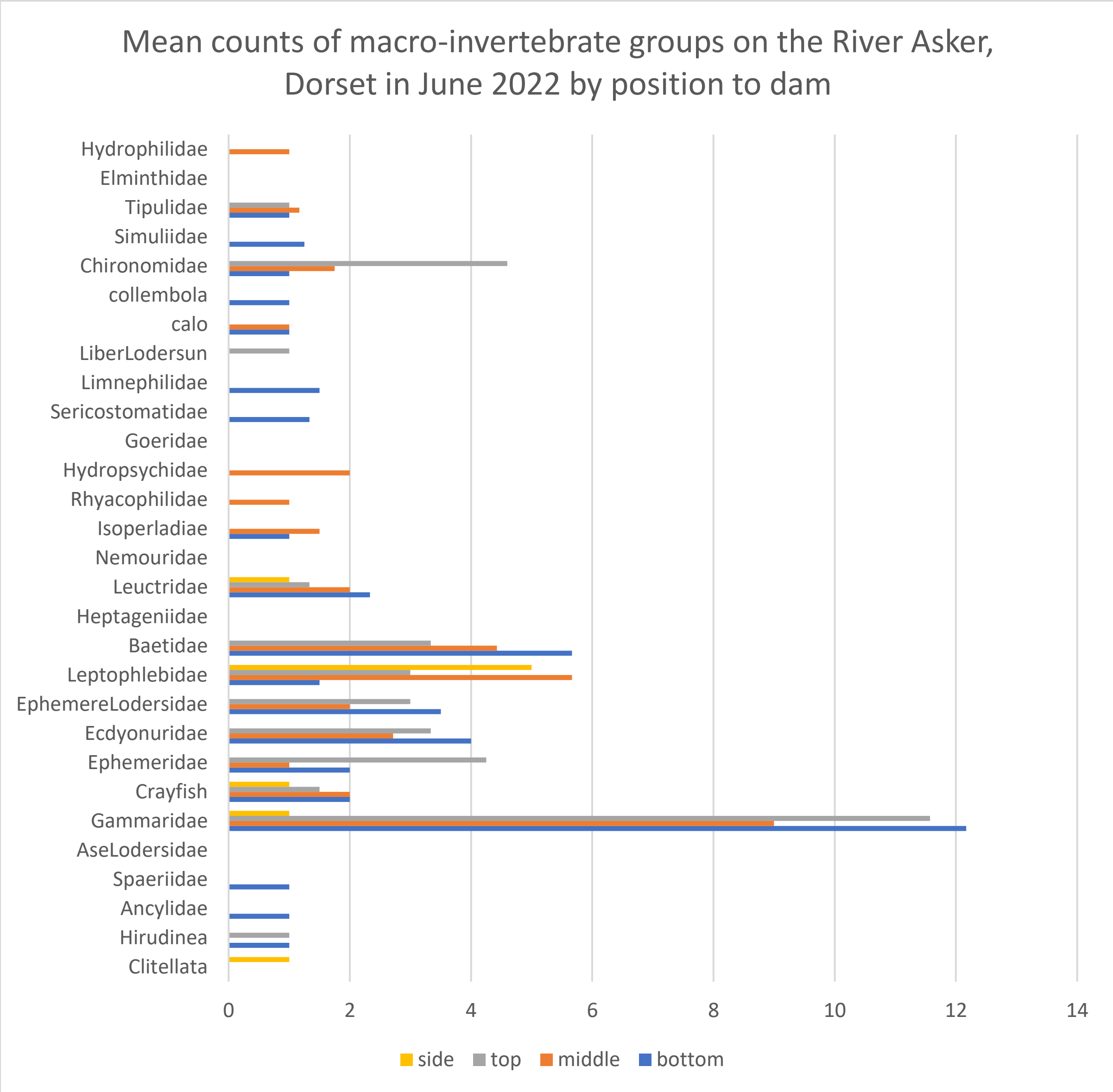
Mean counts of macro-invertebrate groups on the River Asker, Dorset in January 2022 by position to dam
Hydrophilidae
Elminthidae
Tipulidae
Simuliidae
Chironomidae
collembola
calo
LiberLodersun
Limnephilidae
Sericostomatidae
Goeridae
Hydropsychidae
Rhyacophilidae
Isoperladiae
Nemouridae
Leuctridae
Heptageniidae
Baetidae
Leptophlebidae
EphemereLodersidae
Ecdyonuridae
Ephemeridae
Crayfish
Gammaridae
AseLodersidae
Spaeriidae
Ancylidae
Hirudinea
Clitellata
0
5
10
15
20
25
30
side
top
middle
bottom

Graph 14



Mean counts of macro-invertebrate groups on the River Asker, Dorset in March 2022 by position to dam
Hydrophilidae
Elminthidae
Tipulidae
Simuliidae
Chironomidae
collembola
calo
LiberLodersun
Limnephilidae
Sericostomatidae
Goeridae
Hydropsychidae
Rhyacophilidae
Isoperladiae
Nemouridae
Leuctridae
Heptageniidae
Baetidae
Leptophlebidae
EphemereLodersidae
Ecdyonuridae
Ephemeridae
Crayfish
Gammaridae
AseLodersidae
Spaeriidae
Ancylidae
Hirudinea
Clitellata
0
2
4
6
8
10
12
14
16
18
20
side
top
middle
bottom

Graph 15



Mean counts of macro-invertebrate groups on the River Asker, Dorset in June 2022 by position to dam
Hydrophilidae
Elminthidae
Tipulidae
Simuliidae
Chironomidae
collembola
calo
LiberLodersun
Limnephilidae
Sericostomatidae
Goeridae
Hydropsychidae
Rhyacophilidae
Isoperladiae
Nemouridae
Leuctridae
Heptageniidae
Baetidae
Leptophlebidae
EphemereLodersidae
Ecdyonuridae
Ephemeridae
Crayfish
Gammaridae
AseLodersidae
Spaeriidae
Ancylidae
Hirudinea
Clitellata
0
2
4
6
8
10
12
14
side
top
middle
bottom

Discussion

The main aim is to understand through macro-invertebrates what the ecological benefits of leaky dams are. From the analysis of all measures of data in this regard we can see that the spread of seasonally collected data would provide a decent platform in the chosen West Dorset river Asker.

This river has two main tributaries in the area studied and contained man-made leaky dams as well as natural ones. The two tributaries did vary in their measure of macro-invertebrates. To this end the areas worked provided as spread of representative data to rivers and in particular chalk rivers.

Having conducted comparison of macro-invertebrate communities between there area around the dams and within, it can be seen that the populations are similar. The surrounding area samples were of substrate as that is what dominated. Although the dams would appear slightly better than downstream areas, these are mostly riffles and that's just one part of the habitats present.

It is encouraging as this shows the dam habitats have good ecology which is supported by Godfrey 2003 and Gurnell *et al.* 2005. What is more important in this, is that the habitat is instream habitat that was created and in water column of the river, where there was previously none but drifting stages of macro-invertebrates. So as a whole these sections of river now contain more macro-invertebrate life than prior to work.

These findings where interesting in relation to the type of woody material that comprised of the dams, but no differences were seen. This demonstrates that there is a wide variety of tree types useable to deliver benefits.

It was also interesting to note that there were similarities between the man-made leaky dams and natural ones. This shows that the structures created were in keeping and functioned in a way that was ecologically normal as shown by Boyer *et al.* 2003 and Opperman *et al.* 2006.

To investigate this further the leaf composition of the debris was tested for influence of the macro-invertebrate communities. However, no relationship was found which would indicate that the woody debris collected, and leaf matter are both useful.

As dams' function is influential to the flow of rivers. The communities were looked at in relation to flow surrounding the dams. This was important as different dams and locations impact the flows differently. There were no differences, which would demonstrate their functions are good in a variety of flows.

The dams also varied in size which again may have and influence on macro-invertebrates, but no relationship was seen. Presumably a bigger dam with more debris would hold a greater community overall, but it would not seem to benefit the structure for a given measure.

This is good as it shows the worth of dams man-made leaky or natural. Encouragingly, it would mean that the dams are providing additional macro-invertebrate rich habitats in the river.

Conclusion

This all means that the leaky woody dams, and that means man-made leaky ones, provide benefits for flood relief (Lockwood *et al.* 2020) also deliver benefits to the ecology of the river. This would normally have knock on beneficial effects for fish, birds and animals in the ecosystem. And as macro-invertebrates drift it can benefit downstream areas as well. These dams are good for benefiting human populations locally and downstream in all respects.

Acknowledgements

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