**Serial incubations invertebrates – biomass and abundance graphs, preliminary analysis**

Cummins – 24 October 2023

**Methodological things to note:**

* These invertebrate data come from YR1 *Rhododendron* leaf bags from the serial incubations leaf litter breakdown study. This dataset is limited compared to what we have for leaf litter breakdown.
* “September” is actually August 31st. In the leaf litter breakdown study, I call this 31 August 2018 date a “September” deployment/collection date, so I kept that consistent here. I only flag this to assure everyone that the “September” date is still very much summer at Coweeta.

**High-level take-home points:**

* I graphed and modeled both shredder abundance and biomass and total invertebrate abundance and biomass per leaf pack (Figure 1) and per gram of AFDM of leaf litter remaining in the leaf pack on the date of collection (also the date we collected these bug samples).
* Differences in abundance between winter and summer seem to be more striking than differences in biomass between winter and summer. This is true both for abundance/biomass per leaf pack and for abundance/biomass per g AFDM remaining. This may be because we have more but smaller shredders in the summer, vs. less but larger shredders in the winter
* I have listed pairwise comparisons between all months in the tables below (extracted from lmer models using the package “*emmeans*”). Here are, I think, the most important results to focus on:
  + For the analyses involving per leaf pack data, both winter months (Dec and Jan) had significantly lower shredder abundance and shredder biomass than both summer months (July and September). These patterns were not as clear-cut for the total invertebrate community
  + However, when we correct shredder abundance/biomass per g AFDM of leaf litter that remained in the litterbags at the time we collected these samples, the only significant differences are between December and September and January and September (i.e., July shredder abundance/biomass were not significantly different than abundance/biomass in either of the winter months).
  + For total invertebrate abundance/biomass corrected per g AFDM of leaf litter remaining, we see the same pair-wise differences as we do for the shredders (see bullet point above), except we also see that July is significantly different than September.

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**Figure 1.** (a) Mean shredder abundance, (b) mean shredder biomass (mg), (c) mean total invertebrate abundance, and (d) mean total invertebrate biomass per leaf pack on the collection date for December (11 Dec 2017), January (5 January 2018), July (5 July 2018), and “September” (31 August 2018) *Rhododendron* leaf litter bags in YR1 of the serial incubations leaf litter breakdown study.

**Table 1.** Results of lmer models to test for significant differences among months for shredder/invertebrate abundance/biomass per leaf pack. All models included a random effect for stream.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model** | ***n*** | **Pairwise comparisons (from *emmeans*)** | | | | |
| lmer(shredder abundance ~ month + (1|stream))  \*\*Corresponds to Figure 1a | 120 | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| Jan-Jul | -25.08 | 2.36 | 107 | <0.0001 |
| Jan-Sep | -19.79 | 2.27 | 107 | <0.0001 |
| Jan-Dec | -1.48 | 2.29 | 107 | 0.9171 |
| Jul-Sep | 5.29 | 2.38 | 107 | 0.1238 |
| Jul-Dec | 23.6 | 2.41 | 108 | <0.0001 |
| Sep-Dec | 18.32 | 2.3 | 107 | <0.0001 |
|  |  | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| lmer(shredder biomass ~ month + (1|stream))  \*\*Corresponds to Figure 1b | 120 | Jan-Jul | -31.28 | 8.65 | 107 | 0.0025\* |
| Jan-Sep | -31.38 | 8.31 | 107 | 0.0015\* |
| Jan-Dec | -7.84 | 8.38 | 106 | 0.7859 |
| Jul-Sep | -0.10 | 8.72 | 107 | 1.0000 |
| Jul-Dec | 23.44 | 8.83 | 107 | 0.0444\* |
| Sep-Dec | 23.54 | 8.44 | 106 | 0.0314\* |
|  |  |  |  |  |  |  |
|  |  | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
|  |  | Jan-Jul | -45.3 | 11.9 | 108 | 0.0014\* |
| lmer(total invert abundance ~ month + (1|stream))  \*\*Corresponds to Figure 1c | 120 | Jan-Sep | -68.5 | 11.5 | 107 | <0.0001\* |
| Jan-Dec | -25.8 | 11.6 | 107 | 0.1235 |
| Jul-Sep | -23.2 | 12.0 | 108 | 0.2245 |
| Jul-Dec | 19.6 | 12.2 | 109 | 0.3794 |
| Sep-Dec | 42.7 | 11.7 | 107 | 0.0022\* |
| lmer(total invert biomass ~ month + (1|stream))  \*\*Corresponds to Figure 1d | 120 | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| Jan-Jul | -27.1 | 11.7 | 107 | 0.1009 |
| Jan-Sep | -47.3 | 11.3 | 107 | 0.0003\* |
| Jan-Dec | -11.7 | 11.4 | 107 | 0.7315 |
| Jul-Sep | -20.1 | 11.8 | 107 | 0.3258 |
| Jul-Dec | 15.4 | 12.0 | 107 | 0.5719 |
| Sep-Dec | 35.5 | 11.4 | 106 | 0.0127\* |

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**Figure 2.** (a) Mean shredder abundance, (b) mean shredder biomass (mg), (c) mean total invertebrate abundance, and (d) mean total invertebrate biomass per grams of AFDM of leaf litter remaining in the corresponding leaf pack on the collection date for December (11 Dec 2017), January (5 January 2018), July (5 July 2018), and “September” (31 August 2018) *Rhododendron* leaf litter bags in YR1 of the serial incubations leaf litter breakdown study.

**Table 2.** Results of lmer models to test for significant differences among months for shredder/invertebrate abundance/biomass corrected per g AFDM leaf litter remaining in the corresponding leaf bag. All models included a random effect for stream.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model** | ***n*** | **Pairwise comparisons (from *emmeans*)** | | | | |
| lmer(shredder abundance g AFDM-1 ~ month + (1|stream))  \*\*Corresponds to Figure 2a | 117 | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| Jan-Jul | -9.545 | 4.83 | 105 | 0.2037 |
| Jan-Sep | -18.271 | 4.63 | 104 | 0.0008\* |
| Jan-Dec | -0.613 | 4.68 | 104 | 0.9992 |
| Jul-Sep | -8.726 | 4.89 | 104 | 0.287 |
| Jul-Dec | 8.932 | 4.97 | 107 | 0.2803 |
| Sep-Dec | 17.658 | 4.76 | 104 | 0.0019\* |
|  |  | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| lmer(shredder biomass g AFDM-1 ~ month + (1|stream))  \*\*Corresponds to Figure 2b | 117 | Jan-Jul | -16.01 | 10.34 | 104 | 0.4128 |
| Jan-Sep | -38.09 | 9.91 | 103 | 0.0012\* |
| Jan-Dec | -2.95 | 10.01 | 104 | 0.9910 |
| Jul-Sep | -22.07 | 10.47 | 104 | 0.1570 |
| Jul-Dec | 13.06 | 10.66 | 105 | 0.6125 |
| Sep-Dec | 35.13 | 10.18 | 104 | 0.0044\* |
|  |  | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
|  |  | Jan-Jul | -19.51 | 12.7 | 105 | 0.4188 |
| lmer(total invert abundance g AFDM-1 ~ month + (1|stream))  \*\*Corresponds to Figure 2c | 117 | Jan-Sep | -61.95 | 12.2 | 104 | <0.0001\* |
| Jan-Dec | -6.96 | 12.3 | 104 | 0.9419 |
| Jul-Sep | -42.44 | 12.8 | 104 | 0.0071\* |
| Jul-Dec | 12.55 | 13.0 | 107 | 0.7712 |
| Sep-Dec | 54.99 | 12.5 | 105 | 0.0002\* |
| lmer(total invert biomass g AFDM-1 ~ month + (1|stream))  \*\*Corresponds to Figure 2d | 117 | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| Jan-Jul | -17.74 | 14.6 | 104 | 0.6195 |
| Jan-Sep | -57.71 | 14.0 | 104 | 0.0004\* |
| Jan-Dec | -4.23 | 14.2 | 104 | 0.9907 |
| Jul-Sep | -39.96 | 14.8 | 104 | 0.0396\* |
| Jul-Dec | 13.51 | 15.1 | 105 | 0.8063 |
| Sep-Dec | 53.48 | 14.1 | 104 | 0.0018\* |

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**Figure 3.** Mean loge(total invertebrate biomass (mg) / grams AFDM of leaf litter remaining) on the collection date for the December (11 Dec 2017), January (5 January 2018), July (5 July 2018), and “September” (31 August 2018) *Rhododendron* leaf litter bags in YR1 of the serial incubations leaf litter breakdown study.

**Table 2.** Results of lmer models to test for significant differences among months for shredder/invertebrate abundance/biomass corrected per g AFDM leaf litter remaining in the corresponding leaf bag. All models included a random effect for stream.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| lmer(loge(total invert biomass / g AFDM)~ month + (1|stream))  \*\*Corresponds to Figure 3 | 117 | ***Months*** | ***estimate*** | ***SE*** | ***df*** | ***p*** |
| Jan-Jul | -1.279 | 0.269 | 104 | <0.0001\* |
| Jan-Sep | -1.931 | 0.258 | 104 | <0.0001\* |
| Jan-Dec | -0.342 | 0.260 | 104 | 0.5567 |
| Jul-Sep | -0.652 | 0.272 | 104 | 0.0841 |
| Jul-Dec | 0.938 | 0.277 | 105 | 0.0054\* |
| Sep-Dec | 1.589 | 0.264 | 104 | <0.0001\* |