Supplemental Material for: Use of fatty acids from aquatic prey varies with foraging strategy

Cornelia W. Twining1,2,3\*, Tarn Preet Parmar1, Margaux Mathieu-Resuge4, Martin J. Kainz4,5, Jeremy Ryan Shipley3, Dominik Martin-Creuzburg1

**1**Limnological Institute, University of Konstanz, Mainaustrasse 252, 78464 Konstanz, Germany

**2**Max Planck Institute of Animal Behavior, Am Obstberg 1, 78315 Radolfzell, Germany

3Eawag, Seestrasse 79, 6047 Kastanienbaum, Switzerland

**4**WasserCluster Lunz — Inter-University Centre for Aquatic Ecosystem Research, Dr. Carl Kupelwieser Promenade 5, A-3293 Lunz am See, Austria

5Department of Biomedical Research, Danube University Krems, 3500 Krems an der Donau, Austria

\*Corresponding author: Cornelia W. Twining, [cornelia.twining@gmail.com](mailto:cornelia.twining@gmail.com)

Supplement Figure 1: Maps of (a) nest boxes at all distances relative to Lake Mindelsee, (b) riparian nest boxes and boxes ~500m from Lake Mindelsee, and (c) occupied nest boxes ~1000 m from Lake Mindelsee.

(a)

Map

Description automatically generated

(b)

A screenshot of a computer

Description automatically generated with medium confidence

(c)

A picture containing text, green

Description automatically generated

Supplemental Figure 2: The sum of caterpillar biomass from 10 beating sheet samplings per distance over the Blue Tit breeding season



Supplemental Figure 3: Content of selected DHA (22:6n-3) in aquatic (blue) and terrestrial (green) insect taxa as well as spiders. Data represent composite means (± 1 SD).



Supplemental Table 1: Sample sizes for bulk stable isotope, fatty acid content, and compound-specific stable isotope analyses. Note that samples for terrestrial fatty acid content analyses were pooled from across all distances.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Emergence traps | Malaise traps | | |
|  | Lake surface | 0-50 m inland | 100-500 m inland | 1000 m inland |
| Bulk Stable Isotope Analysis Samples | | | | |
| Chironomidae | 5 |  |  |  |
| *Chaoborus flavicans* | 5 |  |  |  |
| Ephemeroptera | 5 |  |  |  |
| Small Tricoptera | 5 |  |  |  |
| Large Tricoptera (Limnophilidae) | 3 |  |  |  |
| Terrestrial Coleoptera |  | 4 | 3 | 2 |
| Terrestrial Diptera |  | 3 | 3 | 2 |
| Lepidoptera |  | 6 | 6 | 6 |
| Spiders |  | 6 | 4 | 7 |
| Blue Tit nestlings |  | 36 | 19 | 8 |
| Fatty Acid Analysis Samples | | | | |
| Chironomidae | 47 |  |  |  |
| Simulidae | 4 |  |  |  |
| *Chaoborus flavicans* | 22 |  |  |  |
| Other Aquatic Diptera | 3 |  |  |  |
| Ephemeroptera | 13 |  |  |  |
| Tricoptera | 25 |  |  |  |
| Cicadoidea |  | 2 | | |
| Coleoptera |  | 1 | | |
| Dermaptera |  | 1 | | |
| Other Diptera (non-aquatic) |  | 13 | | |
| Hemiptera |  | 7 | | |
| Hymenoptera |  | 10 | | |
| Lepidoptera |  | 5 | | |
| Mecoptera |  | 1 | | |
| Neuroptera |  | 1 | | |
| Psychodidae |  | 4 | | |
| Spiders |  | 11 | | |
| Thysanoptera |  | 3 | | |
| Compound-Specific Stable Isotope Samples | | | | |
| Chironomidae | 9 |  |  |  |
| *Chaoborus flavicans* | 5 |  |  |  |
| Ephemeroptera | 6 |  |  |  |
| Tricoptera | 11 |  |  |  |
| Terrestrial Coleoptera |  | 4 | 3 | 3 |
| Terrestrial Diptera |  | 1 | 4 | 2 |
| Lepidoptera |  | 5 | 5 | 4 |
| Spiders |  | 3 | 3 | 3 |
| Blue Tit nestlings |  | 6 | 5 | 4 |

Supplementary Table 2: General Linear Models of Fatty Acid Content by Arthropod Taxa. Bold values represent variables that were statistically significant at the alpha = 0.05 level.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| LIN by Taxa | | | | |
|  | Estimate | SE | t-value | p-value |
| Intercept | 7.4799 | 0.8934 | 8.373 | < 0.0001 |
| **Chironomidae** | **4.8704** | **1.0824** | **4.500** | **< 0.0001** |
| Cicadoidea | 3.9071 | 3.0947 | 1.263 | 0.208657 |
| Coleoptera | -7.4799 | 4.2844 | -1.746 | 0.082818 |
| **Dermaptera** | **30.5020** | **4.2844** | **7.119** | **< 0.0001** |
| Ephemeroptera | -2.0648 | 1.4658 | -1.409 | 0.160948 |
| Hemiptera | 2.4513 | 1.8183 | 1.348 | 0.179602 |
| **Hymenoptera** | **3.9087** | **1.5981** | **2.446** | **0.015569** |
| Lepidoptera | -4.0630 | 2.0760 | -1.957 | 0.052126 |
| Mecoptera | 1.8104 | 4.2844 | 0.423 | 0.673199 |
| **Neuroptera** | **15.2888** | **4.2844** | **3.568** | **0.000478** |
| **Other Aq. Diptera** | **8.1863** | **2.5789** | **3.174** | **0.001812** |
| Pyschodidae | -2.2708 | 2.2776 | -0.997 | 0.320312 |
| Simulidae | -1.6825 | 2.2776 | -0.739 | 0.461210 |
| Spider | 0.4724 | 1.5473 | 0.305 | 0.760569 |
| Terr. Diptera | -0.8854 | 1.4658 | -0.604 | 0.546735 |
| Thysanoptera | -2.5800 | 2.5789 | -1.000 | 0.318656 |
| Tricoptera | -2.3567 | 1.2249 | -1.924 | 0.056186 |
| Null deviance: 5543.4 on 172 df | | Residual deviance: 2721.5 on 155 df | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ALA by Taxa | | | | |
|  | Estimate | SE | t-value | p-value |
| Intercept | 6.1915 | 0.9329 | 6.637 | < 0.0001 |
| Chironomidae | 1.1359 | 1.1303 | 1.005 | 0.316504 |
| Cicadoidea | -2.5195 | 3.2316 | -0.780 | 0.436780 |
| Coleoptera | -5.7850 | 4.4739 | -1.293 | 0.197920 |
| Dermaptera | 1.6187 | 4.4739 | 0.362 | 0.717993 |
| **Ephemeroptera** | **8.1199** | **1.5307** | **5.305** | **< 0.0001** |
| **Hemiptera** | **-3.8184** | **1.8988** | **-2.011** | **0.04606** |
| Hymenoptera | -1.9477 | 1.6688 | -1.167 | 0.244956 |
| **Lepidoptera** | **8.6578** | **2.1678** | **3.994** | **0.00010** |
| Mecoptera | -3.2677 | 4.4739 | -0.730 | 0.466256 |
| Neuroptera | -5.9517 | 4.4739 | -1.330 | 0.185368 |
| Other Aq. Diptera | -2.3206 | 2.6930 | -0.862 | 0.390181 |
| Pyschodidae | -2.6244 | 2.3784 | -1.103 | 0.271551 |
| Simulidae | -2.9334 | 2.3784 | -1.233 | 0.219311 |
| **Spider** | **-4.4938** | **1.6158** | **-2.781** | **0.006088** |
| **Terr. Diptera** | **-3.3869** | **1.5307** | **-2.213** | **0.028384** |
| **Thysanoptera** | **10.4364** | **2.6930** | **3.875** | **0.000157** |
| **Tricoptera** | **6.4693** | **1.2791** | **5.058** | **< 0.0001** |
| Null deviance: 6067.4 on 172 df | | Residual deviance: 2967.6 on 155 df | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ARA by Taxa | | | | |
|  | Estimate | SE | t-value | p-value |
| Intercept | 7.3995 | 0.2616 | 28.288 | < 0.0001 |
| **Chironomidae** | **-5.2738** | **0.3169** | **-16.640** | **< 0.0001** |
| **Cicadoidea** | **-7.3995** | **0.9061** | **-8.166** | **< 0.0001** |
| **Coleoptera** | **-5.6629** | **1.2545** | **-4.514** | **< 0.0001** |
| **Dermaptera** | **-7.3995** | **1.2545** | **-5.898** | **< 0.0001** |
| **Ephemeroptera** | **-6.4000** | **0.4292** | **-14.911** | **< 0.0001** |
| **Hemiptera** | **-7.2761** | **0.5324** | **-13.666** | **< 0.0001** |
| **Hymenoptera** | **-6.5667** | **0.4679** | **-14.034** | **< 0.0001** |
| **Lepidoptera** | **-7.3375** | **0.6079** | **-12.071** | **< 0.0001** |
| **Mecoptera** | **-5.8547** | **1.2545** | **-4.667** | **< 0.0001** |
| **Neuroptera** | **-7.3995** | **1.2545** | **-5.898** | **< 0.0001** |
| **Other Aq. Diptera** | **-4.2158** | **0.7551** | **-5.583** | **< 0.0001** |
| **Pyschodidae** | **-6.2533** | **0.6669** | **-9.377** | **< 0.0001** |
| **Simulidae** | **-5.2135** | **0.6669** | **-7.818** | **< 0.0001** |
| **Spider** | **-5.8395** | **0.4531** | **-12.889** | **< 0.0001** |
| **Terr. Diptera** | **-6.1493** | **0.4292** | **-14.327** | **< 0.0001** |
| **Thysanoptera** | **-7.3995** | **0.7551** | **-9.799** | **< 0.0001** |
| **Tricoptera** | **-5.6831** | **0.3587** | **-15.845** | **< 0.0001** |
| Null deviance: 982.48 on 172 df | | Residual deviance: 233.33 on 155 df | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| EPA by Taxa | | | | |
|  | Estimate | SE | t-value | p-value |
| Intercept | 32.439 | 1.718 | 18.883 | **< 0.0001** |
| **Chironomidae** | **-14.860** | **2.082** | **-7.139** | **< 0.0001** |
| **Cicadoidea** | **-32.439** | **5.951** | **-5.451** | **< 0.0001** |
| **Coleoptera** | **-31.636** | **8.239** | **-3.840** | **0.000179** |
| **Dermaptera** | **-32.439** | **8.239** | **-3.937** | **0.000124** |
| Ephemeroptera | 5.163 | 2.819 | 1.832 | 0.068931 |
| **Hemiptera** | **-32.439** | **3.497** | **-9.277** | **< 0.0001** |
| **Hymenoptera** | **-31.101** | **3.073** | **-10.120** | **< 0.0001** |
| **Lepidoptera** | **-31.677** | **3.992** | **-7.935** | **< 0.0001** |
| **Mecoptera** | **-28.819** | **8.239** | **-3.498** | **0.000612** |
| **Neuroptera** | **-32.439** | **8.239** | **-3.937** | **0.000124** |
| **Other Aq. Diptera** | **-12.241** | **4.959** | **-2.468** | **0.014658** |
| **Pyschodidae** | **-29.570** | **4.380** | **-6.751** | **< 0.0001** |
| **Simulidae** | **-25.404** | **4.380** | **-5.800** | **< 0.0001** |
| **Spider** | **-29.011** | **2.976** | **-9.750** | **< 0.0001** |
| **Terr. Diptera** | **-30.116** | **2.819** | **-10.684** | **< 0.0001** |
| **Thysanoptera** | **-31.787** | **4.959** | **-6.410** | **< 0.0001** |
| **Tricoptera** | **-21.815** | **2.356** | **-9.261** | **< 0.0001** |
| Null deviance: 34907 on 172 df | | Residual deviance: 10064 on 155 df | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DHA by Taxa Binomial | | | | |
|  | Estimate | SE | z-value | p-value |
| Intercept | 2.157 | 6.232e+03 | 0.003 | 0.997 |
| Chironomidae | -2.425 | 6.232e+03 | -0.004 | 0.997 |
| Cicadoidea | -4.313 | 2.159e+04 | -0.002 | 0.998 |
| Coleoptera | -4.313 | 2.989e+04 | -0.001 | 0.999 |
| Dermaptera | -4.313 | 2.989e+04 | -0.001 | 0.999 |
| Ephemeroptera | -4.313 | 1.023e+04 | -0.004 | 0.997 |
| Hemiptera | -2.336 | 6.232e+03 | -0.004 | 0.997 |
| Hymenoptera | -4.313 | 1.115e+04 | -0.004 | 0.997 |
| Lepidoptera | -4.313 | 1.448e+04 | -0.003 | 0.998 |
| Mecoptera | -3.568 | 2.989e+04 | -0.000 | 1.000 |
| Neuroptera | -4.313 | 2.989e+04 | -0.001 | 0.999 |
| Other Aq. Diptera | -2.226 | 6.232e+03 | -0.004 | 0.997 |
| Pyschodidae | -4.313 | 1.589e+04 | -0.003 | 0.998 |
| Simulidae | -4.313 | 1.589e+04 | -0.003 | 0.998 |
| Spider | -4.313 | 1.079e+04 | -0.004 | 0.997 |
| Terr. Diptera | -4.313 | 1.023e+04 | -0.004 | 0.997 |
| Thysanoptera | -4.313 | 1.799e+04 | -0.002 | 0.998 |
| Tricoptera | -4.313 | 8.545e+03 | -0.005 | 0.996 |
| Null deviance: 153.183 on 172 df | | Residual deviance: 31.874 on 155 df | | |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DHA by Taxa non-zero values | | | | |
|  | Estimate | SE | t-value | p-value |
| Intercept | 1.83586 | 0.07669 | 23.938 | < 0.0001 |
| **Chironomidae** | **-2.78947** | **0.22139** | **-12.600** | **< 0.0001** |
| Hemiptera | -0.60538 | 0.36780 | -1.646 | 0.11337 |
| **Mecoptera** | **-2.67922** | **0.36780** | **-7.285** | **< 0.0001** |
| **Other Aq. Diptera** | **-1.30265** | **0.36780** | **-3.542** | **0.00174** |
| Null deviance: 17.7932 on 27 df | | Residual deviance: 2.7258 on 23 df | | |

Supplementary Table 3: Bayesian stable isotope mixing model results. SD is standard deviation.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Riparian Spiders | 500 m Spiders | 1000 m Spiders |
| Aquatic Insects (SD) | 73.9% (15.2%) | 3.3% (5.6%) | 1.4% (2.8%) |
| Caterpillars (SD) | 16.6% (14.0%) | 42.7% (15.2%) | 59.6% (15.5%) |
| Other Terrestrial Insects (SD) | 9.5% (10.1%) | 54.0% (13.7%) | 39.0% (14.9%) |