


## Article

# Size–Abundance Relationships of Freshwater Macroinvertebrates in Two Contrasting Floodplain Channels of Rhone River

Vojsava Gjoni <sup>1,2,\*</sup> , Pierre Marle <sup>1,3</sup>, Bastiaan W. Ibelings <sup>1</sup> and Emmanuel Castella <sup>1</sup>

<sup>1</sup> Department F.-A. Forel for Environmental and Aquatic Sciences, Institute for Environmental Sciences, University of Geneva, 66 Boulevard Carl-Vogt, CH-1205 Geneva, Switzerland; pierre.marle@unige.ch (P.M.); bastiaan.ibelings@unige.ch (B.W.I.); emmanuel.castella@unige.ch (E.C.)

<sup>2</sup> Department of Biological and Environmental Sciences and Technologies, University of Salento, Via Monteroni, Ecotekne, 73100 Lecce, Italy

<sup>3</sup> Ecology and Fluvial Hydrosystems Laboratory, University Claude Bernard Lyon 1, 69100 Villeurbanne, France

\* Correspondence: vojsava.gjoni@unige.ch

**Abstract:** Body size is perhaps the most fundamental property of an organism and its relationship with abundance is one of the most studied relationships in ecology. Although numerous studies have examined these relationships in local communities, few have investigated how they vary at different temporal and spatial scales. We investigated the relationship between body size and abundance of local macroinvertebrate communities in two floodplain channels of the French upper Rhone River. The two channels differ in their vegetation coverage (high vs. low vegetation) and hydrological regimes. The shapes of the size–abundance relationship were similar between channels on a yearly basis but differed when compared between months. The variation in local size–abundance relationships between months was related to variation in the functional diversity across time. Our findings suggest that local size–abundance relationships are able to quantitatively describe temporal changes in community structure, showing the importance of relating diversity with ecosystem function in a more realistic context.

**Keywords:** body size–abundance relationship; energetic equivalence hypothesis; river ecosystems; functional feeding groups



**Citation:** Gjoni, V.; Marle, P.; Ibelings, B.W.; Castella, E. Size–Abundance Relationships of Freshwater Macroinvertebrates in Two Contrasting Floodplain Channels of Rhone River. *Water* **2022**, *14*, 794. <https://doi.org/10.3390/w14050794>

Academic Editors: Jun Yang and Christophe Piscart

Received: 31 January 2022

Accepted: 26 February 2022

Published: 3 March 2022

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

Body size is a key component of the diversity and structure of animal assemblages [1,2] as it encapsulates many ecological traits of species [3,4]. One of the most important relationships of body size is with abundance, as recognized in both terrestrial and aquatic ecology [5–7]. The relationship between body size and abundance, according to Damuth's Rule, scales with a scaling exponent of  $-0.75$  [8–10]. Body size (or mass) is also related to metabolic rate with a scaling exponent of  $0.75$  (i.e., metabolic theory in ecology (MTE) [11]). Furthermore, body size of the species is negatively related to abundance at the scale of local to global communities. Such size–abundance relationships [7] have remained at the core of our understanding of ecology for more than 20 years [12–16].

The power function of  $-0.75$  implies that the total energy or resource used (as a function of abundance and metabolism) by all the different-sized species is independent of their body size, known as the “energetic equivalence hypothesis (EER)” [17]. This pattern of size–abundance relationships has been confirmed using global-scale data sets compiled from the literature, such as the global size–abundance relationship (GSDR following [7]). However, these studies are observational and are subject to the normal limitations of an observational study, making it difficult to draw strong conclusions of the mechanisms that control size–abundance relationships. Indeed, other studies suggest that using smaller scales data sets (i.e., local communities' data [18,19]), such as local size–abundance relation-

ships (LSDR following [7]) may better reveal the mechanisms underlying size–abundance relationships.

Relationships of this sort have also been widely studied in aquatic ecosystems [20–22] for diverse types of communities in various habitats, such as rocky intertidal pool [23], stream [24], pond [25] and lagoon [26] communities. The LSDRs often show deviations from the expected power–law relationships with slopes shallower than  $-0.75$  [6,27–29]. Indeed, it has been observed that the size–frequency distributions generally exhibit a right-skewed pattern [30] with more small-sized species and fewer large-sized ones than predicted [31]. This has been described as a ‘polygonal’ size–abundance relationship with abundance peaking at small body sizes and species with low abundance being equally represented across all body sizes. Applying the logic of the “energetic equivalence hypothesis”, these deviations imply that the species present in such a local community use unequal amounts of energy [8,9,17].

This deviation of LSDR from the EER observed mostly in aquatic ecosystems may be related to abiotic and biotic factors in aquatic ecosystems. This is because body size is closely related to physical, morphological and hydrological constraints, and thus habitat complexity in aquatic ecosystems [32]. Specifically, previous studies have shown that habitat complexity is the main driver of macroinvertebrate species’ body size. For example, temporal and spatial body size patterns of aquatic macroinvertebrates may be influenced by: 1. physicochemical fluctuations [33], 2. physical characteristics, such as substrate types, grain size and water flow [34], and 3. biotic characteristics, such as vegetation coverage [35]. Furthermore, habitat complexity plays an important role in determining functional diversity across time and space [36,37]. If such variability among habitat complexities is related to species’ body size, then this variation may result in deviation of an LSDR slope from  $-0.75$ .

Although many LSDR studies demonstrate data which vary temporally (i.e., daily, weekly, monthly and yearly), few of them have considered the spatial variation that occurs at different scales [19,22]. Indeed, how the relationships between body size and abundance of local communities vary temporally, spatially and across functional diversity is poorly understood [33]. Documenting LSDR across a wide range of diversity functions and spatial and temporal scales is a step forward in understanding the relationship between biodiversity and ecosystem functioning at spatiotemporal scales. Here, we tested relationships between body size and abundance for local macroinvertebrate communities (i.e., LSDR) in two different floodplain channels of the Rhone River.

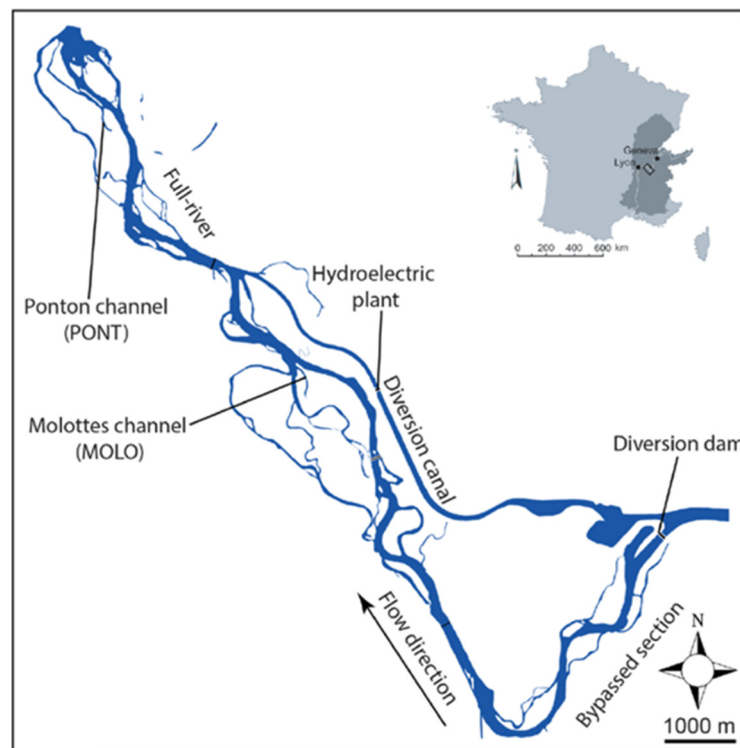
The two selected channels show differences in aquatic vegetation cover and hydrological regimes that, we suppose, modify the transfer of energy in these habitats. Furthermore, in floodplain habitats, benthic macroinvertebrates occur frequently and are functionally diverse, especially regarding feeding groups and are associated with hydrology. Because of their dynamic nature and temporal fluctuations, floodplain habitats allow us to understand how their LSDR vary temporally through the four months of high production and under different flow conditions. Hence, the main goal of our study is to identify the shape of LSDR communities between two distinct floodplains and to discover temporal or spatial differences across a spectrum of functional diversity of macroinvertebrates. Macroinvertebrate species present a high functional diversity that allows them to be categorized into functional feeding groups based on their diverse morphological and behavioral functions that characterize the ways they acquire food [38,39]. This functional diversity is strongly related to the habitat or ecosystem type where they live, making the invertebrates sensitive to environmental conditions depending on their taxonomy and traits.

## 2. Materials and Methods

### 2.1. Studied Sites

The two Rhone floodplain channels, which are former braided side-arms, are presently both connected downstream with the main river, but disconnected upstream, at average discharge. In this sector of the French Upper Rhone, between Geneva and Lyon, the mean summer discharge is about  $\sim 700 \text{ m}^3 \text{ s}^{-1}$  (see Figure 1). The hydrological context of the two

selected channels is very different. Molottes channel (MOLO) is located in the bypassed section of the Brégner–Cordon hydroelectric scheme where the regulated flow delivered by the diversion dam is  $150 \text{ m}^3 \text{ s}^{-1}$  from 1 June to 31 August,  $100 \text{ m}^3 \text{ s}^{-1}$  from 1 September to 31 October, and  $80 \text{ m}^3 \text{ s}^{-1}$  during winter [40]. This floodplain channel is influenced by backflow entries generated by water level elevation (i.e., return flow from the bypassed river section) in relation to the functioning of the hydroelectric power station. Ponton channel (PONT) is located downstream of the hydroelectric scheme and hydropeaking usually causes daily discharge fluctuations from Monday to Friday (between  $\sim 200$  and  $\sim 500 \text{ m}^3 \text{ s}^{-1}$ ). Upstream flow connections occur during high floods for less than one day per year for both floodplain channels on average [41].



**Figure 1.** The Rhône River in the valley between Geneva and Lyon and locations of the two studied floodplain channels: Molottes (MOLO) and Ponton (PONT).

The two floodplain channels vary in length (1220 m for MOLO and 910 m for PONT) and geographic position (4 km between the two channels). A slightly deeper gully (depth minimum  $\sim 0.30$  m), through which water passes continuously, allows the maintenance of a downstream connection for both channels with the main channel during low flow periods. In contrast, the upstream part of both channels was not modified by restoration works. Because of the loss of competence of the river flow when it enters into the floodplain channel from downstream, downstream alluvial plugs, composed of a mix of sand and silt were deposited in the two channels, allowing the establishment of aquatic plants, e.g., *Elodea nuttallii* and *Ceratophyllum demersum*, which, for the MOLO channel exclusively, became denser in the downstream part of the channel. Regarding PONT, the shallow upstream part of the channel is completely emerged over 15 m during reduced discharge periods. During high discharge periods, low-to-moderate water depth ( $< 50$  cm) covers the previously emerged part. Aquatic vegetation development is generally low in the PONT channel and mainly restricted to the upstream and mid-channel parts. Furthermore, aquatic vegetation cover provides egg-laying sites for, e.g., gastropods, and a substrate for periphyton, which, in turn, is highly influential for other organisms. Energy flow of these habitats is also influenced by periodic desiccation of the shallowest parts (e.g., [42]) or by stable and low flow conditions [43,44]. Despite these highly diverse habitats, there have

been no modeling efforts to study how the different flow conditions affect the transfer of energy of these channels.

Finally, basic information on physicochemical data (e.g., water temperature, conductivity, and dissolved oxygen) of the water column in MOLO and PONT channel for each month (e.g., April, May, June, July) were also collected (see Table 1). These abiotic data are not analyzed in this paper but they have a profound impact on the size–abundance relationships.

**Table 1.** The physical and chemical characteristics of the water column in MOLO and PONT channels.

Physicochemical Factors	Month	MOLO Channel		PONT Channel	
		Mean	SE	Mean	SE
Dissolved oxygen (mg/L)	April	5.35	5.26	6.88	9.49
	May	5.97	4.5	5.95	8.22
	June	5.52	3.76	3.47	4.92
	July	4.85	0.73	7.38	1.12
Temperature (°C)	April	13.68	0.38	13.7	0.66
	May	16.58	0.76	14.86	0.55
	June	19.36	0.95	18.23	0.31
	July	21.86	0.28	21.55	0.46
Conductivity (µS/cm)	April	259.49	29.62	242.08	3.31
	May	293.32	31.73	295.08	17.28
	June	242.58	5.51	271.00	0.44
	July	260.8	20.9	275.02	6.01

## 2.2. Sampling Method and Ecological Traits

A total of 24 samples was used, where 3 samples were collected from each of 2 given floodplain channel sites on the same date of each month (across 4 months). For each channel site, the 3 samples were collected from 3 random spots along a 30 m transect (in a straight line). Specifically, benthic invertebrate samples were taken in the middle part of the two floodplain channels over four dates in early 2017: April, May, June and July. The period chosen for sampling corresponds to a time of much higher diversity and productivity compared with winter or fall. After July, many aquatic insects with annual voltinism emerge [45] however, others undergo extreme conditions (e.g., dissolved oxygen and temperature conditions) where the abundance of the macroinvertebrates decreases, thus limiting productivity and functional diversity.

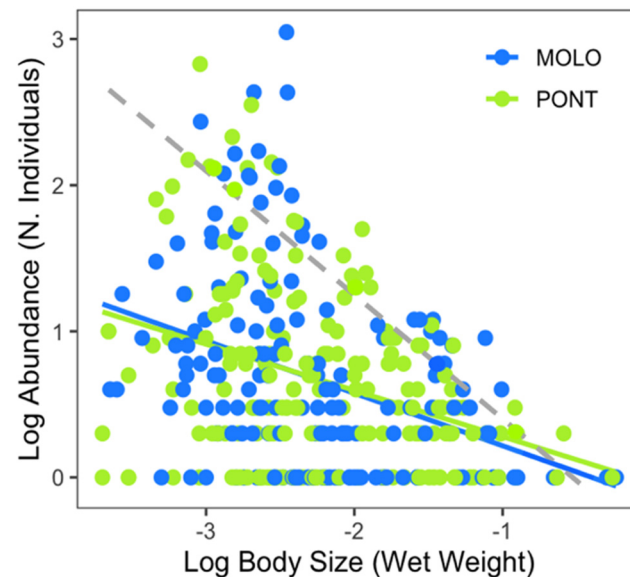
Benthic invertebrates living among aquatic macrophytes and in or on the sediment/litter upper layer were both sampled within a 0.5 × 0.5 m metal frame with a hand net (mesh size 500 µm). The collected samples of benthic invertebrates were weighed on a balance as wet weight (g) for each individual present in the sample. Benthic invertebrates were then sorted under a stereomicroscope, where they were counted (i.e., abundance) and identified to genus or species level, when possible. Diptera were identified up to the family level.

Feeding type was extracted for each taxon from the freshwater ecology database available online (<http://www.freshwaterecology.info>, accessed on 31 July 2021). It consists in assigning a positive score (from 0 to 10) that describes the affinity of a taxon for pre-defined feeding categories, i.e., filtering collectors, gathering collectors, grazers, shredders and predators (see Appendix B—Table A4).

## 2.3. Statistical Analysis

A linear model was fitted to the raw data of average body size relative to their average abundance (both variables in log<sub>10</sub>, see Figure 2) per taxon, in order to test the size–abundance relationship of freshwater macroinvertebrate among the two channels. This approach to studying the size–abundance relationships was based on calculating local size–abundance relationship (LSDR), which plots average size and average abundance of each taxon (see [7]). Least-squares regression (LSR) was fitted on average wet weight

and average abundance (number of individuals): i. among the two channels (all months included), ii. among the two channels and across months, and iii. among the two channels and across functional feeding groups.



**Figure 2.**  $\log_{10}$ – $\log_{10}$  relationship between average body size (wet weight) and abundance (number of individuals) per macroinvertebrate taxon between the two channels (all months included). Dashed line represents the energetic equivalence hypothesis value of  $-0.75$ .

We used least-squares regression (LSR) for analyzing body size and abundance relationships. LSR is more appropriate than reduced major axis regression when measurement error in the independent variable (body mass) is less than that of the dependent variable (abundance), as is the case in our study [46,47]. We used  $\log_{10}$ -transformation to normalize the data variation, and to permit proportional, linear relationships to be readily discerned [48,49]. Significant differences between scaling exponents (slopes) and intercepts (elevations) were estimated by ANCOVA (with body mass as a covariate).

### 3. Results

Both  $\text{LSDR}_{\text{MOLO}}$  and  $\text{LSDR}_{\text{PONT}}$  showed significant relationships between body weight and abundance of macroinvertebrate taxon (Figure 2, Table 2). The scaling slopes were shallower than the energetic equivalence hypothesis value of  $-0.75$  ( $-0.39$  and  $-0.33$ , for MOLO and PONT, respectively), thus the slopes and intercepts were not significantly different between the two channels (Table A1).

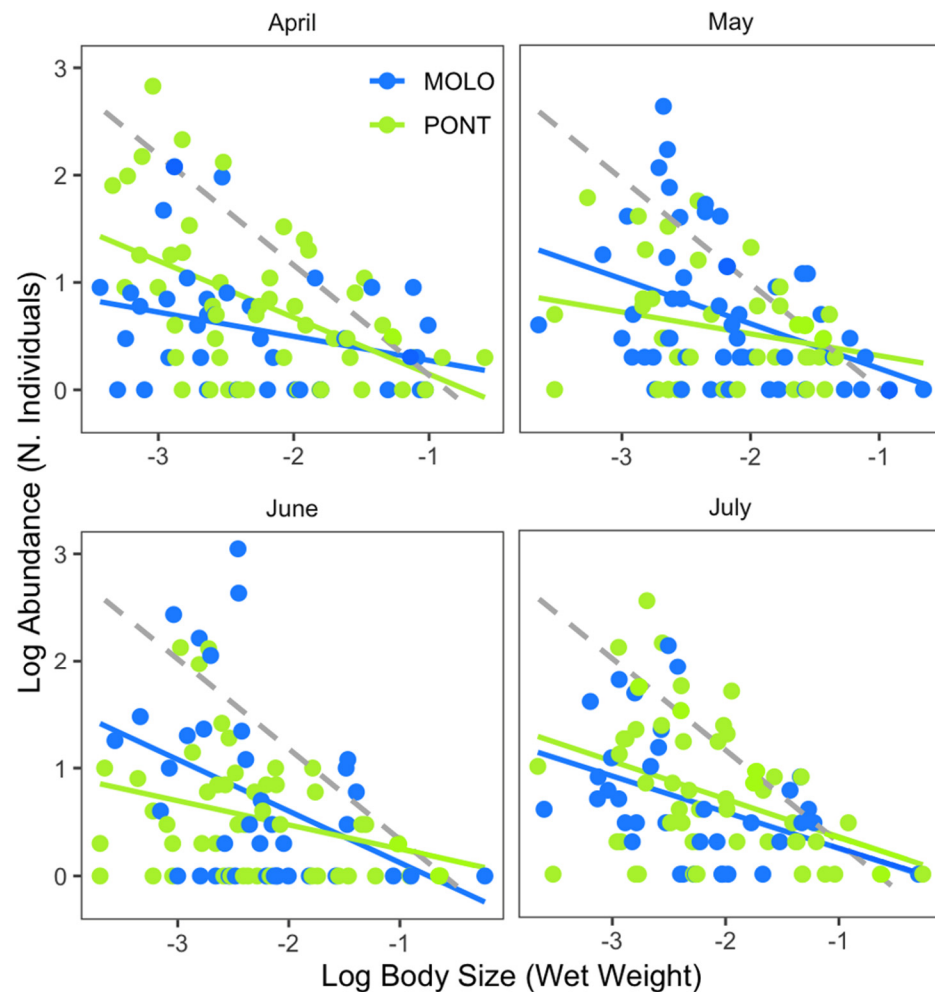
**Table 2.** Results of the LSR analyses of  $\log_{10}$  abundance in relation to  $\log_{10}$  body weight in two floodplain channels of the Rhone River.

Sampling Site	n	Slope	95% CI	Intercept	$r^2$	$p$
MOLO	162	$-0.39$	$-0.53$ to $-0.24$	$-0.19$	0.19	***
PONT	193	$-0.33$	$-0.45$ to $-0.21$	$-0.07$	0.13	***

\*\*\*  $p < 0.001$ .

Furthermore, the two channels showed significant relationships over time (April, May, June and July), although the pattern was different (Figure 3, Table 3). Specifically,  $\text{LSDR}_{\text{PONT}}$  showed a significantly steeper scaling slope ( $-0.53$ ) than  $\text{LSDR}_{\text{MOLO}}$  ( $-0.31$ ) in April. By contrast,  $\text{LSDR}_{\text{MOLO}}$  showed steeper scaling slopes ( $-0.42$  and  $-0.48$ ) than  $\text{LSDR}_{\text{PONT}}$  ( $-0.28$  and  $-0.26$ ) for May and June. However, both channels showed similar scaling slopes ( $-0.34$  and  $-0.29$ , respectively) in July. The scaling slopes of the two channels

were significantly different for April, May and June and the intercept was significantly different for April and June (Appendix A—Table A2).



**Figure 3.**  $\log_{10} - \log_{10}$  relationship between macroinvertebrate body size (wet weight) and abundance (number of individuals) per macroinvertebrate taxon between the two channel sites and across month. Dashed line represents the energetic equivalence hypothesis value of  $-0.75$ .

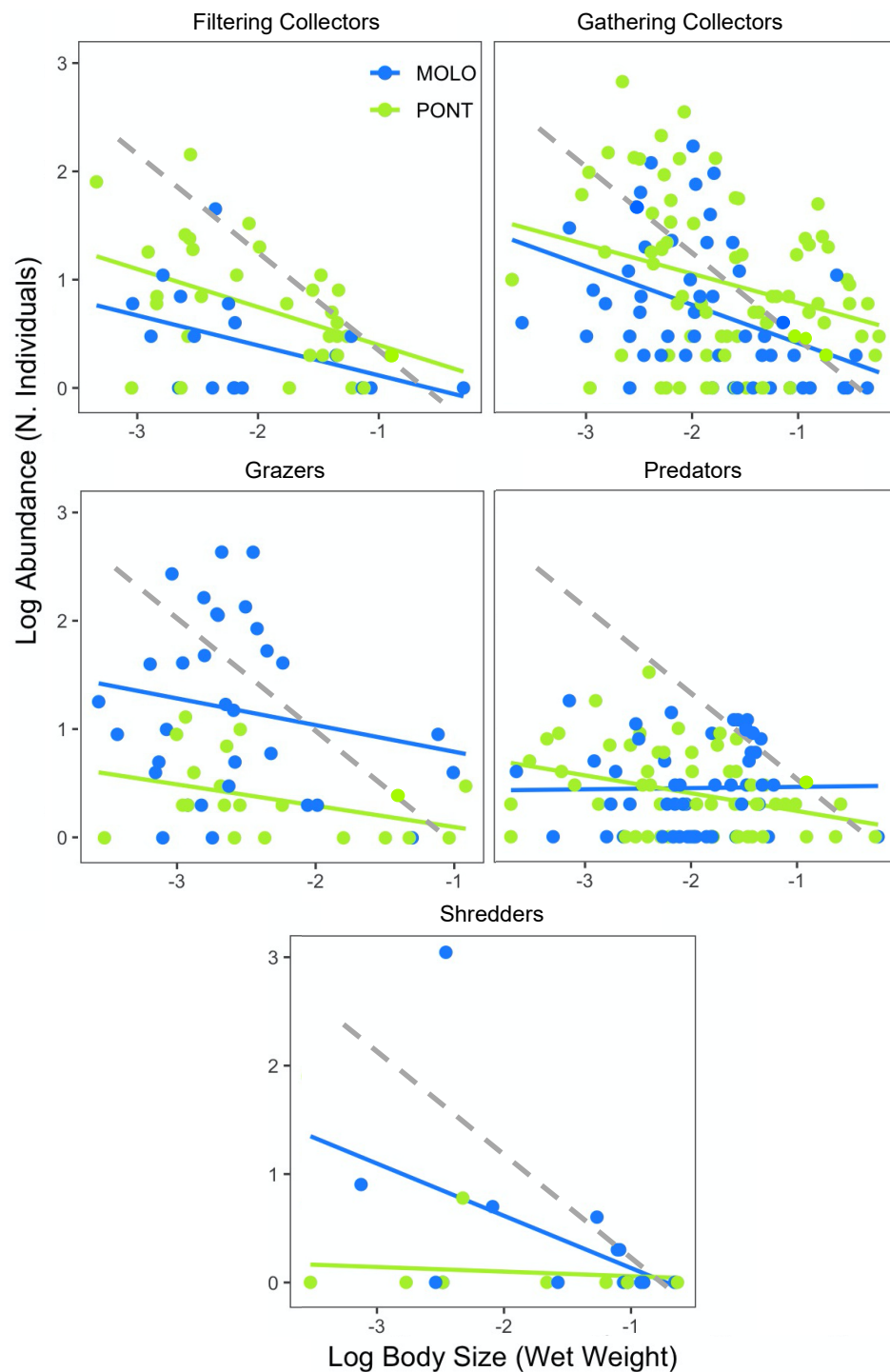
**Table 3.** Results of the LSR analyses of  $\log_{10}$  abundance in relation to  $\log_{10}$  body weight in two floodplain channels of the Rhone River across time.

Sampling Site	Month	n	Slope	95% CI	Intercept	r <sup>2</sup>	p
MOLO	April	35	-0.31	-0.56 to -0.06	-0.10	0.16	*
	May	53	-0.42	-0.69 to -0.14	-0.22	0.15	**
	June	38	-0.48	-0.85 to -0.10	-0.35	0.16	*
	July	36	-0.34	-0.60 to -0.07	-0.10	0.16	*
PONT	April	50	-0.53	-0.79 to -0.27	-0.38	0.26	***
	May	41	-0.28	-0.55 to -0.01	-0.04	0.10	*
	June	55	-0.26	-0.49 to -0.02	-0.04	0.10	*
	July	47	-0.29	-0.52 to -0.07	0.09	0.12	*

\*  $p < 0.05$ ; \*\*  $p < 0.005$ ; \*\*\*  $p < 0.001$ .

Finally, the scaling slopes of  $LSDR_{MOLO}$  and  $LSDR_{PONT}$  across functional feeding groups showed similar patterns for both channels, with the exception of the predators and shredders (Figure 4, Table 4). Specifically, gathering collectors showed steeper scaling slopes for  $LSDR_{MOLO}$  and  $LSDR_{PONT}$  ( $-0.60$  and  $-0.45$ , respectively), whereas filtering collectors ( $-0.27$  and  $-0.35$ , respectively) and grazers ( $-0.31$  and  $-0.28$ , respectively)

resulted in less steep slopes for both  $LSDR_{MOLO}$  and  $LSDR_{PONT}$ . The scaling slopes across functional feeding groups were not significantly different for the two channels, while the intercepts were different for grazers, filterers and gatherers (Appendix A—Table A3). Finally, predators and shredders showed different LSDR slopes, where only predators of PONT ( $-0.16$ ) and shredders of MOLO ( $-0.49$ ) were significant.



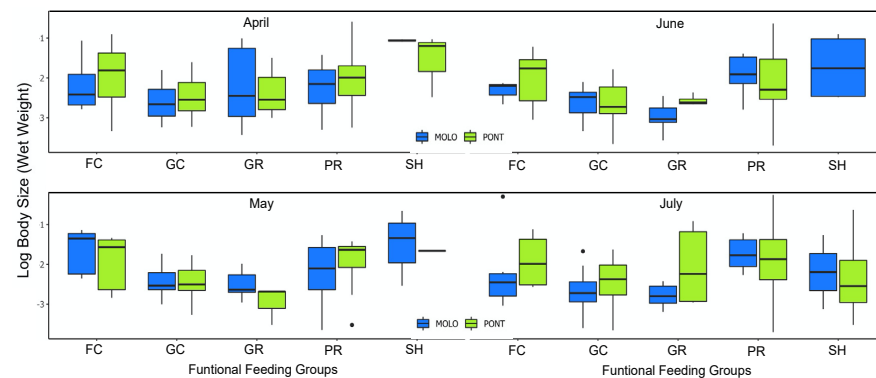
**Figure 4.**  $\log_{10}$ – $\log_{10}$  relationship between macroinvertebrate body weight (wet weight) and abundance (number of individuals) per macroinvertebrate taxon between the two channel sites and across functional feeding groups. Dashed line represents the energetic equivalence hypothesis value of  $-0.75$ .

**Table 4.** Results of the LSR analyses of  $\log_{10}$  abundance in relation to  $\log_{10}$  body weight in two floodplain channels of the Rhone River across functional diversity.

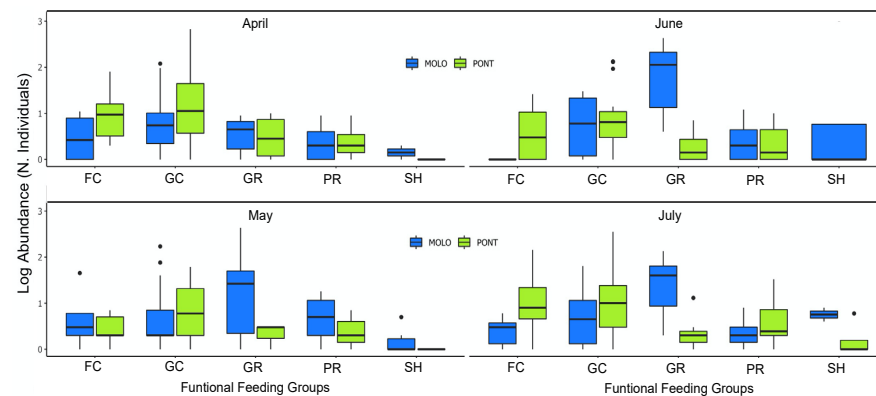
Sampling Site	Functional Feeding Group	n	Slope	95% CI	Intercept	r <sup>2</sup>	p
MOLO	Filterers	18	−0.27	−0.58 to 0.03	−0.16	0.19	*
	Gatherers	51	−0.60	−0.98 to −0.22	−0.82	0.15	***
	Grazers	31	−0.31	−0.80 to 0.17	−0.42	0.06	ns
	Predators	48	−0.02	−0.22 to 0.18	−0.41	0.00	ns
	Shredders	14	−0.49	−1.11 to 0.13	−0.37	0.22	*
PONT	Filterers	33	−0.35	−0.63 to −0.07	0.04	0.18	**
	Gatherers	75	−0.45	−0.79 to −0.12	−0.15	0.10	***
	Grazers	19	−0.28	−0.51 to −0.04	−0.27	0.27	*
	Predators	58	−0.16	−0.29 to −0.04	−0.07	0.11	*
	Shredders	8	−0.04	−0.32 to 0.23	−0.01	0.02	ns

\*  $p < 0.05$ ; \*\*  $p < 0.005$ ; \*\*\*  $p < 0.001$ , ns—not significant

However, at a monthly scale, the average body size and average abundance across functional feeding groups of MOLO and PONT were consistent with the monthly patterns of  $LSDR_{MOLO}$  and  $LSDR_{PONT}$ . Specifically, in April, small filtering and gathering collectors in PONT showed higher abundance than MOLO (Figures 5 and 6), forming a steeper slope (−0.53 vs. −0.31) than the one for MOLO. Whereas, in May and June, small-sized grazers in MOLO showed higher abundances than in PONT (Figures 5 and 6) resulting in steeper slopes for MOLO than PONT (−0.42 vs. −0.28 and −0.48 vs. −0.26, respectively). Furthermore, the large-sized shredders that were present only in PONT contributed to form less steep slopes for PONT than the ones of MOLO.



**Figure 5.** Boxplot of  $\log_{10}$  body size distribution across functional feeding groups (filtering collectors—FC, gathering collectors—GC, grazers—GR, predators—PR, shredders—SH) at monthly scale.



**Figure 6.** Boxplot of  $\log_{10}$  abundance distribution across functional feeding groups (filtering collectors—FC, gathering collectors—GC, grazers—GR, predators—PR, shredders—SH) at monthly scale.



## 4. Discussion

### 4.1. Patterns of $LSDR_{MOLO}$ and $LSDR_{PONT}$ (All Months Included)

The patterns of the LSDR across the two floodplain channels, considering the whole dataset including all the months, were both statistically significant, with similar slopes (i.e.,  $-0.39$  and  $-0.33$  for MOLO and PONT, respectively) that were significantly shallower than predicted by Damuth [8–10]. Our patterns were consistent with several studies that suggested that the relationship between body size and abundance is much shallower than the value of  $-0.75$  for aquatic macroinvertebrate communities (e.g., [26,50–52]) and other animal communities (e.g., [19,53–56]). However, the shallower slopes found were not consistent with the EER. This deviation of LSDR provides evidence against the universality of EER, showing that the amount of energy used is not the same for all species [7]. Because the EER predicts that size–abundance relationships arise from the metabolic scaling, environmental factors that alter size-dependent metabolic demands may alter size–abundance relationships [17]. Therefore, the shallower slope of LSDR in both freshwater channels implies a shallower slope of the metabolic scaling with body size.

Indeed, the metabolic scaling slope of macroinvertebrate species in aquatic ecosystems was previously found to be shallower than the expected MTE value of 0.75 (reviewed by [57]). For reasons that are still not completely understood, the metabolic scaling slope of benthic macroinvertebrates often shows less steep slopes (i.e.,  $\sim 0.30$  to  $\sim 0.55$ ) than the  $-0.75$  value. Whether this variation in macroinvertebrate metabolic scaling slope is related to environmental factors, such as water temperature [58,59] and biological factors, such as predation pressure [60,61], is less known. Moreover, this variation of metabolic responses in relation to predation threats may be temperature-dependent [62,63]. These studies showed that smaller macroinvertebrates in both freshwater springs and saltwater lagoons more strongly increased their metabolism under high temperature and predation threat, when compared with the larger taxa. However, large macroinvertebrates, that do not change their metabolism in the presence of a predation threat, were present at a higher abundance. This again implies that the slope of the size–abundance relationships of benthic macroinvertebrates should scale with a less steep slope (i.e.,  $\sim -0.30$  to  $\sim -0.55$ ), and indeed this was found for both channels considered in our study (Figure 3). The size-dependent effects of abiotic and biotic factors on metabolic rate may change the metabolic scaling slope and, as a consequence, it may influence the size–abundance relationship slope. This may explain the competitive advantage of large macroinvertebrate species over smaller ones also observed by other studies [64,65].

### 4.2. Patterns of $LSDR_{MOLO}$ and $LSDR_{PONT}$ across Months

The size–abundance relationship varied at the monthly scale for both channels (i.e.,  $LSDR_{MOLO}$  and  $LSDR_{PONT}$ ). The size–abundance relationship across the two sites showed different, site-specific patterns for April and May, while LSDRs for June and July followed comparable patterns. Our findings were consistent with other studies that showed a temporal [24,33] and spatial (reviewed by [6]) variation in size–abundance relationship of local communities. This pattern implies that time and space are both able to shape the local communities, resulting in different shapes of size–abundance relationships, for which differently sized species acquire energy differently.

PONT showed a slightly steeper size–abundance relationship for the months of May and June, while MOLO showed a slightly steeper size–abundance relationship only for April, compared with the other months. These patterns show an increase in the abundance of small taxa during May and June for PONT, and April for MOLO. Small aquatic macroinvertebrates may have reached their highest abundance during May and June for MOLO and during April for PONT. This is because reproduction and the appearance of juveniles (gastropods in particular) tend to peak during this period of time (i.e., from April to July) for most macroinvertebrate species [66]. However, this peak for each species or functional group varies because of differences in life cycles and resource availability. Thus, the LSDRs changed in a different way for MOLO and PONT across time, following

the proposed hypothesis based on the specifics of reproduction and juvenile appearance, implying that juveniles of the species present in PONT peaked at a different moment across the four months than those in MOLO. Therefore, our findings suggest that although the size–abundance relationships of the two sites were broadly the same when looking at all months combined, this result does not hold when considered at the monthly scale.

#### 4.3. Patterns of $LSDR_{MOLO}$ and $LSDR_{PONT}$ across Functional Diversity

The size–abundance relationship of local communities at both sites taking functional diversity into account, showed the same shape with different intercepts, with the exception of the predators and shredders.  $LSDR_{PONT}$  showed significantly higher abundance of filtering and gathering collectors, independent of body size, than  $LSDR_{MOLO}$ . However,  $LSDR_{MOLO}$  showed significantly higher abundance of grazers regardless of their body size than  $LSDR_{PONT}$ . Our findings therefore showed different energy flow patterns for the two channels. Filtering and gathering collectors in PONT and grazers in MOLO are shown here to have higher energy flow compared with the other functional groups. This suggests a difference in the energy flow across the functional groups, depending on differences in the habitat structure of the two channels [67]. To repeat, MOLO was characterized by slow and less active backflows from the by-passed section of the river, whereas PONT was subjected to more frequent oscillations associated with hydropeaking in the full river and characterized by lower vegetation density.

The various macroinvertebrate functional feeding groups translate their diversity in terms of food acquisition strategies. Specifically, in our study the filtering feeders were mostly bivalves, gathering collectors were mostly insects and some gastropods, grazers were mostly gastropods, and shredders were mostly crustaceans. The difference of the intercept of the functional groups independent of their body size implies higher energy flow for the functional feeding groups with higher intercepts [62]. Our findings showed that the energy flow of filtering and gathering collectors was higher in PONT, while the energy flow of grazers was higher in MOLO.

Our study indicates that energy transfers through floodplain feeding groups are linked to and may change as a function of the vegetation cover and the water flow conditions in the two channels. Specifically, the functional groups of filtering collectors, gathering collectors and grazers showed different patterns in energy transfers between the two channels [68]. These variations suggest that water movement (enhanced by hydropeaking) may increase the suspended matter load as food for filtering and gathering feeders in MOLO [66]. Low and more stable flow conditions may increase temperature and promote biofilm/algal growth upon macrophytes for grazing in PONT [69]. Because the energy flow in floodplain channels probably relies on hydrology in addition to their connection (or reconnection in the case of restoration) with the main channel, it would be possible to adapt water releases from dams in the Rhone River to control energy transfers in floodplain channels [70]. Restricting hydropeaking (see [71]) might suffice to allow the proliferation of grazers that would tend to increase the energy transfers and thus support more top predators for PONT than MOLO channel.

Additionally, functional feeding groups were able to also explain the different monthly  $LSDR$  slopes of the two channels. Specifically, small-sized filtering and gathering collectors showed higher abundance for MOLO in May and June, whereas small-sized grazers showed higher abundance for PONT in April. Therefore, our findings suggest that the  $LSDR$  shape of most functional feeding groups was apparently the same, but they showed a different energy flow (i.e., higher abundance regardless of their body size). Furthermore, the body size and abundance of functional feeding groups when considered at a monthly scale were able to explain the monthly pattern of  $LSDRs$  in the two channels. Our finding confirms that the changes in habitat conditions across time and space, such as vegetation coverage and water flow, are closely related to the functional diversity and  $LSDR$  shape.

## 5. Conclusions

Size–abundance relationships link individual- and population-level energetics with the structure of ecological communities based on principles that are generally applicable. Broadly evaluating the variation of size–abundance relationship in local communities (i.e., LSDR) and understanding how it arises from biological and ecological processes at population- and community-levels would represent a major advance in our present understanding of ecosystems. This study offers a potential method of using size–abundance relationships for describing community structure, and the underlying processes across time, space, habitat type and functional diversity. This methodological approach links biodiversity and ecosystem functioning processes, improving our ability to make predictions of how environmental change will shape aquatic ecosystems, and is relevant for research and management policies for the conservation of biodiversity.

**Author Contributions:** Conceptualization, V.G. and P.M.; methodology, P.M.; formal analysis, V.G.; investigation, V.G.; resources, P.M. and E.C.; data curation, P.M. and V.G.; writing—original draft preparation, V.G. and P.M.; writing—review and editing, V.G., P.M., B.W.I. and E.C.; visualization, V.G.; supervision V.G., B.W.I. and E.C., project administration, V.G. and B.W.I.; funding acquisition, V.G. and B.W.I. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by a Swiss National Foundation grant called “Scientific Exchange” awarded to Vojsava Gjoni in support of her research visit at the University of Geneva in Switzerland. The data of this study have been provided in the context of the OHM Vallée du Rhône, the LabEx DRIIHM and in the EUR H2O/Lyon (ANR-17-EURE-0018) of Université de Lyon.

**Acknowledgments:** We thank all the research teams involved in the monitoring of the Rhône River ecological restoration (RhônEco program) for making data available and for discussions. We thank the Syndicat du Haut-Rhône for their technical support. Furthermore, we would like to thank Pablo Timoner for his help on classifying the species into functional feeding groups. We are grateful for the helpful suggestions and comments by three anonymous reviewers.

**Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

## Appendix A

In order to quantify the difference between the two channel sites we have used ANCOVA ( $p$  value) for slope and intercept comparison between  $LSDR_{MOLO}$  and  $LSDR_{PONT}$ : across all months, and across each month. Specifically, the differences between slopes were assessed by comparing 95% CI. When the slopes were not significantly different, the differences between elevations were estimated by ANCOVA (with body mass as a covariate). Least-squares regression (LSR) was fitted on average body size and average abundance (number of individuals): i. among the two channels (all months included—Table A1), ii. among the two channels and across months (Table A2), and iii. among the two channels and across functional feeding group (Table A3).

**Table A1.**  $p$  value for slope and intercept comparison of the LSDR analyses in Table 1. The differences among slopes were assessed by comparing 95% CI. When the slopes were not significantly different, the differences between elevations were estimated by ANCOVA (with body mass as a covariate).

Sampling Site	$p$ Value for Slope <sup>a</sup>		$p$ Value for Intercept <sup>b</sup>	
	MOLO	PONT	MOLO	PONT
MOLO	-	ns	-	ns
PONT	ns	-	ns	-

<sup>a</sup> Significance of slope differences; <sup>b</sup> Significance of intercept differences; ns—not significant; - not measurable.

**Table A2.** *p* value for slope and intercept comparison of the two streams LSDR analyses in Table 2. The differences among slopes were assessed by comparing 95% CI. When the slopes were not significantly different, the differences between elevations were estimated by ANCOVA (with body mass as a covariate).

Month	<i>p</i> Value for Slope <sup>a</sup>				<i>p</i> Value for Intercept <sup>b</sup>			
	April	May	June	July	April	May	June	July
April	**	-	-	-	*	-	-	-
May	-	*	-	-	-	-	-	-
June	-	-	*	-	-	-	*	-
July	-	-	-	ns	-	-	-	ns

<sup>a</sup> Significance of slope differences; <sup>b</sup> Significance of intercept differences; \* *p* < 0.05; \*\* *p* < 0.005; ns—not significant; - not measurable.

**Table A3.** *p* value for slope and intercept comparison of the LSDR analyses in Table 3. The differences among slopes were assessed by comparing 95% CI. When the slopes were not significantly different, the differences between elevations were estimated by ANCOVA (with body mass as a covariate).

Feeding Types	<i>p</i> Value for Slope <sup>a</sup>					<i>p</i> Value for Intercept <sup>b</sup>				
	FC	GC	GR	PR	SH	FC	GC	GR	PR	SH
Filtering Collectors	ns	-	-	-	-	*	-	-	-	-
Gathering Collectors	-	ns	-	-	-	-	*	-	-	-
Grazers	-	-	ns	-	-	-	-	*	-	-
Predators	-	-	-	ns	-	-	-	-	ns	-
Shredders	-	-	-	-	ns	-	-	-	-	ns

<sup>a</sup> Significance of slope differences; <sup>b</sup> Significance of intercept differences; \* *p* < 0.05; ns—not significant; - not measurable.

### Appendix B

This table contains the estimated average wet weight, abundance and feeding traits for 54 taxa collected across 2 floodplain channels in the French upper Rhone River. Below are the column names and a brief description of them: Channel = channel name (MOLO—Molottes and PONT—Ponton; Month = month of sampling; Site = sampling site in each channel (1, 2, or 3); Taxon = species name; FFG = functional feeding groups; Abundance = total abundance per taxon.

**Table A4.** A unified dataset of taxon names, functional feeding groups and total abundance of macroinvertebrate species collected from the two channels on the Rhone River floodplain.

Channel	Month	Site	Order	Family	Genus	Species	FFG	Abundance
MOLO	April	2	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	1
MOLO	April	2	Diptera	Ceratopogonidae			Gathering collectors	5
MOLO	April	2	Diptera	Chironomidae			Gathering collectors	47
MOLO	April	2	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	9
MOLO	April	2	Gastropoda	Planorbidae	Haitia	acuta	Grazers	4
MOLO	April	2	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	6
MOLO	April	2	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	11
MOLO	April	2	Odonata	Platycnemididae	Platycnemis	pennipes	Predators	1
MOLO	April	2	Bivalvia	Sphaeriidae	Sphaerium	sp.	Filtering collectors	1
MOLO	April	2	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	3
MOLO	April	3	Diptera	Ceratopogonidae			Gathering collectors	7
MOLO	April	3	Diptera	Chironomidae			Gathering collectors	120
MOLO	April	3	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	5
MOLO	April	3	Gastropoda	Planorbidae	Haitia	acuta	Grazers	1
MOLO	April	3	Coleoptera	Halplidae	Halplius	sp.	Predators	1

Table A4. Cont.

Channel	Month	Site	Order	Family	Genus	Species	FFG	Abundance
MOLO	April	3	Odonata	Coenagrionidae	Ischnura	elegans	Predators	2
MOLO	April	3	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	8
MOLO	April	3	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	7
MOLO	April	3	Megaloptera	Sialidae	Sialis	sp.	Predators	1
MOLO	April	4	Trichoptera	Limnephilidae	Anabolia	nervosa	Shredders	2
MOLO	April	4	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	3
MOLO	April	4	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	2
MOLO	April	4	Diptera	Ceratopogonidae			Gathering collectors	11
MOLO	April	4	Diptera	Chironomidae			Gathering collectors	96
MOLO	April	4	Odonata	Coenagrionidae	Coenagrion	puella	Predators	9
MOLO	April	4	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	6
MOLO	April	4	Gastropoda	Planorbidae	Haitia	acuta	Grazers	9
MOLO	April	4	Coleoptera	Halpiidae	Haliplus	sp.	Predators	4
MOLO	April	4	Trichoptera	Hydroptilidae	Hydroptila	sp.	Grazers	1
MOLO	April	4	Gastropoda	Planorbidae	Menetus	dilatatus	Grazers	2
MOLO	April	4	Odonata	Libellulidae	Orthetrum	albistylum	Predators	1
MOLO	April	4	Odonata	Platycnemididae	Platycnemis	pennipes	Predators	3
MOLO	April	4	Gastropoda	Tateidae	Potamopyrgus	antipodarum	Gathering collectors	1
MOLO	April	4	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	1
MOLO	April	4	Odonata	Zygoptera			Predators	8
MOLO	May	1	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	1
MOLO	May	1	Gastropoda	Bithynidae	Bithynia	tentaculata	Filtering collectors	3
MOLO	May	1	Diptera	Chironomidae			Gathering collectors	76
MOLO	May	1	Crustacea	Crangonyctidae	Crangonyx	pseudogracilis	Shredders	1
MOLO	May	1	Odonata	Coenagrionidae	Erythronma	najas/viridulum	Predators	12
MOLO	May	1	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	17
MOLO	May	1	Gastropoda	Planorbidae	Haitia	acuta	Grazers	53
MOLO	May	1	Odonata	Coenagrionidae	Ischnura	elegans	Predators	3
MOLO	May	1	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	2
MOLO	May	1	Gastropoda	Valvatidae	Valvata	cristata	Grazers	2
MOLO	May	1	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	1
MOLO	May	1	Odonata	Zygoptera			Predators	11
MOLO	May	2	Trichoptera	Limnephilidae	Anabolia	nervosa	Shredders	1
MOLO	May	2	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	2
MOLO	May	2	Diptera	Athericidae			Predators	1
MOLO	May	2	Gastropoda	Bithynidae	Bithynia	tentaculata	Filtering collectors	2
MOLO	May	2	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	2
MOLO	May	2	Diptera	Ceratopogonidae			Gathering collectors	3
MOLO	May	2	Diptera	Chironomidae			Gathering collectors	40
MOLO	May	2	Odonata	Coenagrionidae	Coenagrion	puella	Predators	14
MOLO	May	2	Crustacea	Crangonyctidae	Crangonyx	pseudogracilis	Shredders	5
MOLO	May	2	Odonata	Coenagrionidae	Erythronma	najas/viridulum	Predators	9
MOLO	May	2	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	41
MOLO	May	2	Gastropoda	Planorbidae	Haitia	acuta	Grazers	432
MOLO	May	2	Odonata	Coenagrionidae	Ischnura	elegans	Predators	1
MOLO	May	2	Odonata	Lestidae	Lestes	viridis	Predators	2
MOLO	May	2	Trichoptera	Limnephilidae	Limnephilus	lunatus	Shredders	2
MOLO	May	2	Gastropoda	Planorbidae	Menetus	dilatatus	Grazers	1
MOLO	May	2	Micropterna	lateralis/sequax			Shredders	1
MOLO	May	2	Odonata	Platycnemididae	Platycnemis	pennipes	Predators	5
MOLO	May	2	Gastropoda	Tateidae	Potamopyrgus	antipodarum	Gathering collectors	1
MOLO	May	2	Megaloptera	Sialidae	Sialis	sp.	Predators	2
MOLO	May	2	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	2
MOLO	May	3	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	4
MOLO	May	3	Diptera	Ceratopogonidae			Gathering collectors	7
MOLO	May	3	Diptera	Chironomidae			Gathering collectors	171
MOLO	May	3	Heteroptera	Corixidae	Corixinae	sp.	Gathering collectors	3
MOLO	May	3	Dreissena	polymorpha			Filtering collectors	1
MOLO	May	3	Odonata	Coenagrionidae	Erythronma	najas/viridulum	Predators	12
MOLO	May	3	Crustacea	Gammaridae			Shredders	1
MOLO	May	3	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	41
MOLO	May	3	Gastropoda	Planorbidae	Haitia	acuta	Grazers	116
MOLO	May	3	Coleoptera	Halpiidae	Haliplus	sp.	Predators	5
MOLO	May	3	Hydracarina				Predators	18
MOLO	May	3	Trichoptera	Hydroptilidae	Hydroptila	sp.	Grazers	2
MOLO	May	3	Gastropoda	Planorbidae	Menetus	dilatatus	Grazers	3
MOLO	May	3	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	2

Table A4. Cont.

Channel	Month	Site	Order	Family	Genus	Species	FFG	Abundance
MOLO	May	3	<i>Bivalvia</i>	<i>Sphaeridae</i>	<i>Musculium</i>	<i>lacustre</i>	Filtering collectors	6
MOLO	May	3	<i>Bivalvia</i>	<i>Sphaeridae</i>	<i>Pisidium</i>	sp.	Filtering collectors	45
MOLO	May	3	<i>Odonata</i>	<i>Platycnemididae</i>	<i>Platycnemis</i>	<i>pennipes</i>	Predators	1
MOLO	May	3	<i>Gastropoda</i>	<i>Tateidae</i>	<i>Potamopyrgus</i>	<i>antipodarum</i>	Gathering collectors	2
MOLO	May	3	<i>Megaloptera</i>	<i>Sialidae</i>	<i>Sialis</i>	sp.	Predators	4
MOLO	May	3	<i>Gastropoda</i>	<i>Valvatidae</i>	<i>Valvata</i>	<i>piscinalis</i>	Gathering collectors	7
MOLO	June	1	<i>Hirudinida</i>	<i>Glossiphoniidae</i>	<i>Glossiphonia</i>	sp.	Predators	3
MOLO	June	1	<i>Trichoptera</i>	<i>Limnephilidae</i>	<i>Anabolia</i>	<i>neroosa</i>	Shredders	1
MOLO	June	1	<i>Gastropoda</i>	<i>Bithynidae</i>	<i>Bithynia</i>	<i>tentaculata</i>	Filtering collectors	1
MOLO	June	1	<i>Diptera</i>	<i>Ceratopogonidae</i>			Gathering collectors	1
MOLO	June	1	<i>Diptera</i>	<i>Chironomidae</i>			Gathering collectors	22
MOLO	June	1	<i>Heteroptera</i>	<i>Corixidae</i>	<i>Corixinae</i>	sp.	Gathering collectors	2
MOLO	June	1	<i>Odonata</i>	<i>Coenagrionidae</i>	<i>Erythronma</i>	<i>najas/viridulum</i>	Predators	12
MOLO	June	1	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Gyraulus</i>	sp.	Grazers	272
MOLO	June	1	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Haitia</i>	<i>acuta</i>	Shredders	1114
MOLO	June	1	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Menetus</i>	<i>dilatatus</i>	Grazers	18
MOLO	June	1	<i>Gastropoda</i>	<i>Tateidae</i>	<i>Potamopyrgus</i>	<i>antipodarum</i>	Gathering collectors	1
MOLO	June	1	<i>Megaloptera</i>	<i>Sialidae</i>	<i>Sialis</i>	sp.	Predators	2
MOLO	June	1	<i>Gastropoda</i>	<i>Valvatidae</i>	<i>Valvata</i>	<i>piscinalis</i>	Gathering collectors	23
MOLO	June	2	<i>Diptera</i>	<i>Chironomidae</i>			Gathering collectors	12
MOLO	June	2	<i>Crustacea</i>	<i>Crangonyctidae</i>	<i>Crangonyx</i>	<i>pseudogracilis</i>	Shredders	1
MOLO	June	2	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Gyraulus</i>	sp.	Grazers	10
MOLO	June	2	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Haitia</i>	<i>acuta</i>	Grazers	164
MOLO	June	2	<i>Coleoptera</i>	<i>Dytiscidae</i>	<i>Laccophilus</i>	sp.	Predators	1
MOLO	June	2	<i>Odonata</i>	<i>Lestidae</i>	<i>Lestes</i>	<i>viridis</i>	Predators	6
MOLO	June	2	<i>Bivalvia</i>	<i>Sphaeridae</i>	<i>Musculium</i>	<i>lacustre</i>	Filtering collectors	1
MOLO	June	2	<i>Bivalvia</i>	<i>Sphaeridae</i>	<i>Pisidium</i>	sp.	Filtering collectors	1
MOLO	June	2	<i>Megaloptera</i>	<i>Sialidae</i>	<i>Sialis</i>	sp.	Predators	1
MOLO	June	2	<i>Gastropoda</i>	<i>Valvatidae</i>	<i>Valvata</i>	<i>piscinalis</i>	Gathering collectors	1
MOLO	June	3	<i>Diptera</i>	<i>Chironomidae</i>			Gathering collectors	20
MOLO	June	3	<i>Odonata</i>	<i>Coenagrionidae</i>	<i>Coenagrion</i>	<i>puella</i>	Predators	1
MOLO	June	3	<i>Odonata</i>	<i>Coenagrionidae</i>	<i>Erythronma</i>	<i>najas/viridulum</i>	Predators	10
MOLO	June	3	<i>Heteroptera</i>	<i>Gerridae</i>	<i>Gerris</i>	sp.	Predators	1
MOLO	June	3	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Gyraulus</i>	sp.	Grazers	113
MOLO	June	3	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Haitia</i>	<i>acuta</i>	Grazers	431
MOLO	June	3	<i>Coleoptera</i>	<i>Dytiscidae</i>	<i>Laccophilus</i>	sp.	Predators	2
MOLO	June	3	<i>Odonata</i>	<i>Lestidae</i>	<i>Lestes</i>	<i>viridis</i>	Predators	3
MOLO	June	3	<i>Trichoptera</i>	<i>Limnephilidae</i>	<i>Limnephilus</i>	<i>lunatus</i>	Shredders	1
MOLO	June	3	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Menetus</i>	<i>dilatatus</i>	Grazers	4
MOLO	June	3	<i>Odonata</i>	<i>Libellulidae</i>	<i>Orthetrum</i>	<i>albistylum</i>	Predators	1
MOLO	June	3	<i>Gastropoda</i>	<i>Tateidae</i>	<i>Potamopyrgus</i>	<i>antipodarum</i>	Gathering collectors	3
MOLO	June	3	<i>Megaloptera</i>	<i>Sialidae</i>	<i>Sialis</i>	sp.	Predators	5
MOLO	June	3	<i>Diptera</i>	<i>Tabanidae</i>			Predators	1
MOLO	June	3	<i>Gastropoda</i>	<i>Valvatidae</i>	<i>Valvata</i>	<i>piscinalis</i>	Gathering collectors	30
MOLO	July	1	<i>Diptera</i>	<i>Chironomidae</i>			Gathering collectors	12
MOLO	July	1	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Haitia</i>	<i>acuta</i>	Grazers	48
MOLO	July	1	<i>Odonata</i>	<i>Lestidae</i>	<i>Lestes</i>	<i>viridis</i>	Predators	6
MOLO	July	1	<i>Bivalvia</i>	<i>Sphaeridae</i>	<i>Pisidium</i>	sp.	Filtering collectors	3
MOLO	July	1	<i>Megaloptera</i>	<i>Sialidae</i>	<i>Sialis</i>	sp.	Predators	2
MOLO	July	1	<i>Gastropoda</i>	<i>Valvatidae</i>	<i>Valvata</i>	<i>piscinalis</i>	Gathering collectors	10
MOLO	July	2	<i>Crustacea</i>	<i>Asellidae</i>	<i>Asellus</i>	<i>aquaticus</i>	Gathering collectors	1
MOLO	July	2	<i>Gastropoda</i>	<i>Bithynidae</i>	<i>Bithynia</i>	<i>tentaculata</i>	Filtering collectors	6
MOLO	July	2	<i>Diptera</i>	<i>Chironomidae</i>			Gathering collectors	64
MOLO	July	2	<i>Bivalvia</i>	<i>Corbiculidae</i>	<i>Corbicula</i>	<i>fluminea</i>	Filtering collectors	1
MOLO	July	2	<i>Heteroptera</i>	<i>Corixidae</i>	<i>Corixinae</i>	sp.	Gathering collectors	1
MOLO	July	2	<i>Odonata</i>	<i>Coenagrionidae</i>	<i>Erythronma</i>	<i>najas/viridulum</i>	Predators	3
MOLO	July	2	<i>Crustacea</i>	<i>Gammaridae</i>			Shredders	8
MOLO	July	2	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Gyraulus</i>	sp.	Grazers	15
MOLO	July	2	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Haitia</i>	<i>acuta</i>	Grazers	85
MOLO	July	2	<i>Coleoptera</i>	<i>Halipidae</i>	<i>Halipus</i>	sp.	Predators	1
MOLO	July	2	<i>Hydracarina</i>				Predators	2
MOLO	July	2	<i>Coleoptera</i>	<i>Dytiscidae</i>	<i>Laccophilus</i>	sp.	Predators	1
MOLO	July	2	<i>Odonata</i>	<i>Lestidae</i>	<i>Lestes</i>	<i>viridis</i>	Predators	3
MOLO	July	2	<i>Gastropoda</i>	<i>Planorbidae</i>	<i>Menetus</i>	<i>dilatatus</i>	Grazers	5
MOLO	July	2	<i>Bivalvia</i>	<i>Sphaeridae</i>	<i>Pisidium</i>	sp.	Filtering collectors	1
MOLO	July	2	<i>Gastropoda</i>	<i>Tateidae</i>	<i>Potamopyrgus</i>	<i>antipodarum</i>	Gathering collectors	1
MOLO	July	2	<i>Megaloptera</i>	<i>Sialidae</i>	<i>Sialis</i>	sp.	Predators	2
MOLO	July	2	<i>Gastropoda</i>	<i>Valvatidae</i>	<i>Valvata</i>	<i>piscinalis</i>	Gathering collectors	5

Table A4. Cont.

Channel	Month	Site	Order	Family	Genus	Species	FFG	Abundance
MOLO	July	4	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	4
MOLO	July	4	Diptera	Chironomidae			Gathering collectors	4
MOLO	July	4	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	40
MOLO	July	4	Gastropoda	Planorbidae	Haitia	acuta	Grazers	135
MOLO	July	4	Odonata	Lestidae	Lestes	viridis	Predators	8
MOLO	July	4	Gastropoda	Planorbidae	Menetus	dilatatus	Grazers	2
MOLO	July	4	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	3
MOLO	July	4	Heteroptera	Naucoridae	Naucoris	maculatus	Predators	1
MOLO	July	4	Lepidoptera	Crambidae	Parapoynx	stratitotata	Shredders	4
MOLO	July	4	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	3
MOLO	July	4	Megaloptera	Sialidae	Sialis	sp.	Predators	3
MOLO	July	4	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	22
PONT	April	2	Trichoptera	Limnephilidae	Anabolia	nervoosa	Shredders	1
PONT	April	2	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	3
PONT	April	2	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	8
PONT	April	2	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	19
PONT	April	2	Ephemeroptera	Caenidae	Caenis	robusta	Gathering collectors	5
PONT	April	2	Diptera	Ceratopogonidae			Gathering collectors	149
PONT	April	2	Diptera	Chironomidae			Gathering collectors	674
PONT	April	2	Odonata	Coenagrionidae	Coenagrion	puella	Predators	1
PONT	April	2	Odonata	Coenagrionidae	Erythronma	najas/viridulum	Predators	2
PONT	April	2	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	10
PONT	April	2	Gastropoda	Planorbidae	Hippeutis	complanatus	Grazers	2
PONT	April	2	Hydracarina				Predators	9
PONT	April	2	Trichoptera	Hydroptilidae	Hydroptila	sp.	Grazers	1
PONT	April	2	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	6
PONT	April	2	Bivalvia	Sphaeriidae	Musculium	lacustre	Filtering collectors	18
PONT	April	2	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	11
PONT	April	2	Bivalvia	Sphaeriidae			Filtering collectors	3
PONT	April	2	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	25
PONT	April	3	Trichoptera	Limnephilidae	Anabolia	nervoosa	Shredders	1
PONT	April	3	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	4
PONT	April	3	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	11
PONT	April	3	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	5
PONT	April	3	Diptera	Chironomidae			Gathering collectors	132
PONT	April	3	Odonata	Coenagrionidae	Coenagrion	puella	Predators	2
PONT	April	3	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	4
PONT	April	3	Gastropoda	Planorbidae	Haitia	acuta	Grazers	1
PONT	April	3	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	1
PONT	April	3	Odonata	Libellulidae	Orthetrum	albistylum	Predators	2
PONT	April	3	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	3
PONT	April	3	Bivalvia	Sphaeriidae			Filtering collectors	2
PONT	April	3	Diptera	Tabanidae			Predators	1
PONT	April	3	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	3
PONT	April	4	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	7
PONT	April	4	Trichoptera	Leptoceridae	Athripsodes	sp.	Shredders	1
PONT	April	4	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	33
PONT	April	4	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	34
PONT	April	4	Diptera	Ceratopogonidae			Gathering collectors	98
PONT	April	4	Diptera	Chironomidae			Gathering collectors	214
PONT	April	4	Odonata	Coenagrionidae	Coenagrion	puella	Predators	1
PONT	April	4	Hirudinida	Glossiphoniidae	Glossiphonia	sp.	Predators	2
PONT	April	4	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	9
PONT	April	4	Odonata	Coenagrionidae	Ischnura	elegans	Predators	2
PONT	April	4	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	18
PONT	April	4	Trichoptera	Leptoceridae	Mystacides	azurea	Gathering collectors	1
PONT	April	4	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	80
PONT	April	4	Odonata	Platycnemididae	Platycnemis	pennipes	Predators	6
PONT	April	4	Gastropoda	Tateidae	Potamopyrgus	antipodarum	Gathering collectors	1
PONT	April	4	Bivalvia	Sphaeriidae			Filtering collectors	4
PONT	April	4	Diptera	Tabanidae			Predators	6
PONT	April	4	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	20
PONT	May	1	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	1
PONT	May	1	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	5
PONT	May	1	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	5
PONT	May	1	Diptera	Ceratopogonidae			Gathering collectors	20
PONT	May	1	Diptera	Chironomidae			Gathering collectors	61
PONT	May	1	Odonata	Coenagrionidae	Erythronma	najas/viridulum	Predators	2

Table A4. Cont.

Channel	Month	Site	Order	Family	Genus	Species	FFG	Abundance
PONT	May	1	Hirudinida	Glossiphoniidae	Glossiphonia	sp.	Predators	2
PONT	May	1	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	3
PONT	May	1	Trichoptera	Limnephilidae	Limnephilus	lunatus	Shredders	1
PONT	May	1	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	1
PONT	May	1	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	7
PONT	May	1	Gastropoda	Tateidae	Potamopyrgus	antipodarum	Gathering collectors	1
PONT	May	1	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	9
PONT	May	2	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	2
PONT	May	2	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	5
PONT	May	2	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	16
PONT	May	2	Diptera	Ceratopogonidae			Gathering collectors	33
PONT	May	2	Diptera	Chironomidae			Gathering collectors	57
PONT	May	2	Odonata	Coenagrionidae	Coenagrion	puella	Predators	4
PONT	May	2	Hirudinida	Glossiphoniidae	Glossiphonia	sp.	Predators	4
PONT	May	2	Hydracarina				Predators	7
PONT	May	2	Bivalvia	Sphaeriidae	Musculium	lacustre	Filtering collectors	1
PONT	May	2	Trichoptera	Leptoceridae	Oecetis	ochracea	Predators	1
PONT	May	2	Megaloptera	Sialidae	Sialis	sp.	Predators	4
PONT	May	2	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	6
PONT	May	4	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	3
PONT	May	4	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	2
PONT	May	4	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	21
PONT	May	4	Diptera	Chironomidae			Gathering collectors	41
PONT	May	4	Odonata	Coenagrionidae	Erythromma	najas/viridulum	Predators	4
PONT	May	4	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	3
PONT	May	4	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	2
PONT	May	4	Bivalvia	Sphaeriidae	Musculium	lacustre	Filtering collectors	1
PONT	May	4	Trichoptera	Leptoceridae	Mystacides	azurea	Gathering collectors	1
PONT	May	4	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	6
PONT	May	4	Odonata	Platycnemididae	Platycnemis	pennipes	Predators	4
PONT	May	4	Megaloptera	Sialidae	Sialis	sp.	Predators	5
PONT	May	4	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	6
PONT	June	1	Coleoptera	Dytiscidae	Laccophilus	sp.	Predators	2
PONT	June	2	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	1
PONT	June	2	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	4
PONT	June	2	Diptera	Ceratopogonidae			Gathering collectors	6
PONT	June	2	Diptera	Chironomidae			Gathering collectors	93
PONT	June	2	Odonata	Coenagrionidae	Coenagrion	puella	Predators	3
PONT	June	2	Hirudinida	Erpobdellidae			Predators	1
PONT	June	2	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	2
PONT	June	2	Gastropoda	Planorbidae	Haitia	acuta	Grazers	1
PONT	June	2	Hydracarina				Predators	8
PONT	June	2	Coleoptera	Dytiscidae	Laccophilus	sp.	Predators	1
PONT	June	2	Trichoptera	Leptoceridae	Oecetis	ochracea	Predators	1
PONT	June	2	Gastropoda	Tateidae	Potamopyrgus	antipodarum	Gathering collectors	2
PONT	June	2	Megaloptera	Sialidae	Sialis	sp.	Predators	9
PONT	June	2	Diptera	Tabanidae			Predators	3
PONT	June	2	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	7
PONT	June	3	Odonata	Aeschnidae	Aeschna	sp.	Predators	1
PONT	June	3	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	3
PONT	June	3	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	3
PONT	June	3	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	7
PONT	June	3	Diptera	Ceratopogonidae			Gathering collectors	10
PONT	June	3	Diptera	Chironomidae			Gathering collectors	131
PONT	June	3	Heteroptera	Corixidae	Corixinae	sp.	Gathering collectors	3
PONT	June	3	Coleoptera	Dytiscidae	Dytiscus	sp.	Predators	3
PONT	June	3	Odonata	Coenagrionidae	Erythromma	najas/viridulum	Predators	1
PONT	June	3	Hirudinida	Glossiphoniidae	Glossiphonia	sp.	Predators	2
PONT	June	3	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	7
PONT	June	3	Gastropoda	Planorbidae	Haitia	acuta	Grazers	1
PONT	June	3	Hydracarina				Predators	7
PONT	June	3	Odonata	Libellulidae	Libellula	despressa	Predators	1
PONT	June	3	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	26
PONT	June	3	Megaloptera	Sialidae	Sialis	sp.	Predators	10
PONT	June	3	Bivalvia	Sphaeriidae			Filtering collectors	6
PONT	June	3	Diptera	Tabanidae			Predators	1
PONT	June	3	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	10
PONT	June	4	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	1



Table A4. Cont.

Channel	Month	Site	Order	Family	Genus	Species	FFG	Abundance
PONT	June	4	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	3
PONT	June	4	Diptera	Ceratopogonidae			Gathering collectors	2
PONT	June	4	Diptera	Chironomidae			Gathering collectors	134
PONT	June	4	Coleoptera	Dytiscidae	Dytiscus	sp.	Predators	4
PONT	June	4	Odonata	Coenagrionidae	Erythromma	najas/viridulum	Predators	1
PONT	June	4	Hirudinida	Glossiphoniidae	Glossiphonia	sp.	Predators	1
PONT	June	4	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	14
PONT	June	4	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	19
PONT	June	4	Megaloptera	Sialidae	Sialis	sp.	Predators	6
PONT	June	4	Bivalvia	Sphaeriidae			Filtering collectors	1
PONT	June	4	Diptera	Tabanidae			Predators	1
PONT	June	4	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	1
PONT	July	1	Trichoptera	Limnephilidae	Anabolia	nerooosa	Shredders	1
PONT	July	1	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	17
PONT	July	1	Trichoptera	Leptoceridae	Athripsodes	sp.	Shredders	6
PONT	July	1	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	143
PONT	July	1	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	130
PONT	July	1	Ephemeroptera	Caenidae	Caenis	luctuosa	Gathering collectors	1
PONT	July	1	Diptera	Ceratopogonidae			Gathering collectors	10
PONT	July	1	Diptera	Chironomidae			Gathering collectors	354
PONT	July	1	Heteroptera	Corixidae	Corixinae	sp.	Gathering collectors	24
PONT	July	1	Ephemeroptera	Ephemeridae	Ephemera	sp.	Filtering collectors	24
PONT	July	1	Odonata	Coenagrionidae	Erythromma	najas/viridulum	Predators	2
PONT	July	1	Odonata	Coenagrionidae	Erythromma	najas/viridulum	Predators	7
PONT	July	1	Hirudinida	Glossiphoniidae	Glossiphonia	sp.	Predators	33
PONT	July	1	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	13
PONT	July	1	Gastropoda	Planorbidae	Haitia	acuta	Grazers	3
PONT	July	1	Coleoptera	Halplidae	Haliplus	sp.	Predators	4
PONT	July	1	Gastropoda	Planorbidae	Hippeutis	complanatus	Grazers	2
PONT	July	1	Hydracarina				Predators	18
PONT	July	1	Trichoptera	Limnephilidae	Limnephilus	lunatus	Shredders	1
PONT	July	1	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	50
PONT	July	1	Trichoptera	Leptoceridae	Mystacides	azurea	Gathering collectors	1
PONT	July	1	Odonata	Libellulidae	Orthetrumalbistylum		Predators	1
PONT	July	1	Gastropoda	Tateidae	Potamopyrgus	antipodarum	Gathering collectors	5
PONT	July	1	Megaloptera	Sialidae	Sialis	sp.	Predators	8
PONT	July	1	Bivalvia	Sphaeriidae			Filtering collectors	1
PONT	July	1	Diptera	Tabanidae			Predators	1
PONT	July	1	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	3
PONT	July	3	Trichoptera	Leptoceridae	Athripsodes	sp.	Shredders	1
PONT	July	3	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	22
PONT	July	3	Diptera	Chironomidae			Gathering collectors	54
PONT	July	3	Heteroptera	Corixidae	Corixinae	sp.	Gathering collectors	6
PONT	July	3	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	2
PONT	July	3	Gastropoda	Planorbidae	Haitia	acuta	Grazers	1
PONT	July	3	Coleoptera	Halplidae	Haliplus	sp.	Predators	3
PONT	July	3	Coleoptera	Dytiscidae	Laccophilus	sp.	Predators	1
PONT	July	3	Odonata	Lestidae	Lestes	viridis	Predators	2
PONT	July	3	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	7
PONT	July	3	Bivalvia	Sphaeriidae	Pisidium	sp.	Filtering collectors	7
PONT	July	3	Megaloptera	Sialidae	Sialis	sp.	Predators	4
PONT	July	3	Bivalvia	Sphaeriidae			Filtering collectors	8
PONT	July	3	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	17
PONT	July	4	Crustacea	Asellidae	Asellus	aquaticus	Gathering collectors	4
PONT	July	4	Gastropoda	Bithyniidae	Bithynia	tentaculata	Filtering collectors	20
PONT	July	4	Ephemeroptera	Caenidae	Caenis	horaria	Gathering collectors	18
PONT	July	4	Diptera	Chironomidae			Gathering collectors	56
PONT	July	4	Heteroptera	Corixidae	Corixinae	sp.	Gathering collectors	2
PONT	July	4	Gastropoda	Planorbidae	Gyraulus	sp.	Grazers	2
PONT	July	4	Gastropoda	Planorbidae	Haitia	acuta	Grazers	1
PONT	July	4	Coleoptera	Dytiscidae	Laccophilus	sp.	Predators	2
PONT	July	4	Odonata	Lestidae	Lestes	viridis	Predators	2
PONT	July	4	Heteroptera	Corixidae	Micronecta	sp.	Gathering collectors	1
PONT	July	4	Megaloptera	Sialidae	Sialis	sp.	Predators	9
PONT	July	4	Bivalvia	Sphaeriidae			Filtering collectors	3
PONT	July	4	Gastropoda	Valvatidae	Valvata	piscinalis	Gathering collectors	2

## References

1. Blackburn, T.M.; Gaston, K.J. Animal body size distributions: Patterns, mechanisms and implications. *Trends Ecol. Evol.* **1994**, *9*, 471–474. [[CrossRef](#)]
2. Blackburn, T.M.; Gaston, K.J. The relationship between animal abundance and body size: A review of the mechanisms. *Adv. Ecol. Res.* **1999**, *28*, 181–210.
3. Woodward, G.U.Y.; Hildrew, A.G. Body size determinants of niche overlap and intraguild predation within a complex food web. *J. Anim. Ecol.* **2002**, *71*, 1063–1074. [[CrossRef](#)]
4. Woodward, G.; Ebenman, B.; Emmerson, M.; Montoya, J.M.; Olesen, J.M.; Valido, A.; Warren, P.H. Body size in ecological networks. *Trends Ecol. Evol.* **2005**, *20*, 402–409. [[CrossRef](#)]
5. Brown, J.H. *Macroecology*; University of Chicago Press: Chicago, IL, USA, 1995.
6. Gaston, K.J.; Blackburn, T.M. *Pattern and Process in Macroecology*; Blackwell Science: Oxford, UK, 2000.
7. White, E.P.; Ernest, S.M.; Kerkhoff, A.J.; Enquist, B.J. Relationships between body size and abundance in ecology. *Trends Ecol. Evol.* **2007**, *22*, 323–330. [[CrossRef](#)]
8. Damuth, J.D. Population density and body size in mammals. *Nature* **1981**, *290*, 699–700. [[CrossRef](#)]
9. Damuth, J.D. Of size and abundance. *Nature* **1991**, *351*, 268–269. [[CrossRef](#)]
10. Damuth, J.D. Population ecology: Common rules for animals and plants. *Nature* **1998**, *395*, 115–116. [[CrossRef](#)]
11. Brown, J.H.; Gillooly, J.F.; Allen, A.P.; Savage, V.M.; West, G.B. Toward a metabolic theory of ecology. *Ecology* **2004**, *85*, 1771–1789. [[CrossRef](#)]
12. Brown, J.H.; Maurer, B.A. Evolution of species assemblages: Effects of energetic constraints and species dynamics on the diversification of the North American avifauna. *Am. Nat.* **1987**, *130*, 1–17. [[CrossRef](#)]
13. Damuth, J. Cope's rule, the island rule and the scaling of mammalian population density. *Nature* **1993**, *365*, 748–750. [[CrossRef](#)] [[PubMed](#)]
14. Illius, A.W.; Gordon, I.J. Modelling the nutritional ecology of ungulate herbivores: Evolution of body size and competitive interactions. *Oecologia* **1992**, *89*, 428–434. [[CrossRef](#)] [[PubMed](#)]
15. Gaston, K.J.; Blackburn, T.M. Global scale macroecology: Interactions between population size, geographic range size and body size in the Anseriformes. *J. Anim. Ecol.* **1996**, *65*, 701–714. [[CrossRef](#)]
16. Siemann, E.; Tilman, D.; Haarstad, J. Insect species diversity, abundance and body size relationships. *Nature* **1996**, *380*, 704–706. [[CrossRef](#)]
17. Nee, S.; Read, A.F.; Greenwood, J.J.; Harvey, P.H. The relationship between abundance and body size in British birds. *Nature* **1991**, *351*, 312–313. [[CrossRef](#)]
18. Blackburn, T.M.; Harvey, P.H.; Pagel, M.D. Species number, population density and body size relationships in natural communities. *J. Anim. Ecol.* **1990**, *59*, 335–345. [[CrossRef](#)]
19. Blackburn, T.M.; Brown, V.K.; Doube, B.M.; Greenwood, J.J.; Lawton, J.H.; Stork, N.E. The relationship between abundance and body size in natural animal assemblages. *J. Anim. Ecol.* **1993**, *62*, 519–528. [[CrossRef](#)]
20. Cyr, H.; Peters, R.H.; Downing, J.A. Population density and community size structure: Comparison of aquatic and terrestrial systems. *Oikos* **1997**, *80*, 139–149. [[CrossRef](#)]
21. Jonsson, T.; Cohen, J.E.; Carpenter, S.R. Food webs, body size, and species abundance in ecological community description. *Adv. Ecol. Res.* **2005**, *36*, 1–84.
22. Cyr, H. Individual energy use and the allometry of population density. In *Scaling in Biology*; Brown, J.H., West, G.B., Eds.; University Press: Oxford, UK, 2000; pp. 267–283.
23. Marquet, P.A.; Navarrete, S.A.; Castilla, J.C. Scaling population-density to body size in rocky intertidal communities. *Science* **1990**, *250*, 1125–1127. [[CrossRef](#)]
24. Schmid-Araya, J.M.; Schmid, P.E.; Majdi, N.; Traunspurger, W. Biomass and production of freshwater meiofauna: A review and a new allometric model. *Hydrobiologia* **2020**, *847*, 2681–2703. [[CrossRef](#)]
25. Arim, M.; Berazategui, M.; Barreneche, J.M.; Ziegler, L.; Zarucki, M.; Abades, S.R. Determinants of density–body size scaling within food webs and tools for their detection. *Adv. Ecol. Res.* **2011**, *45*, 1–39.
26. Gjoni, V.; Cozzoli, F.; Rosati, I.; Basset, A. Size-density relationships: A cross-community approach to benthic macroinvertebrates in Mediterranean and Black Sea lagoons. *Estuar. Coast* **2017**, *40*, 1142–1158. [[CrossRef](#)]
27. Lawton, J.H. Species richness and population dynamics of animal assemblages. Patterns in body size: Abundance space. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **1990**, *330*, 283–291.
28. Cotgreave, P. The relationship between body size and population abundance in animals. *Trends Ecol. Evol.* **1993**, *8*, 244–248. [[CrossRef](#)]
29. Marquet, P.A.; Navarrete, S.A.; Castilla, J.C. Body size, population density, and the energetic equivalence rule. *J. Anim. Ecol.* **1995**, *64*, 325–332. [[CrossRef](#)]
30. Greve, M.; Gaston, K.J.; Van Rensburg, B.J.; Chown, S.L. Environmental factors, regional body size distributions and spatial variation in body size of local avian assemblages. *Glob. Ecol. Biogeogr.* **2008**, *17*, 514–523. [[CrossRef](#)]
31. Kozłowski, J.; Gawelczyk, A.T. Why are species' body size distributions usually skewed to the right? *Funct. Ecol.* **2002**, *16*, 419–432. [[CrossRef](#)]

32. Statzner, B.; Moss, B. Linking ecological function, biodiversity and habitat: A mini-review focusing on older ecological literature. *Basic Appl. Ecol.* **2004**, *5*, 97–106. [[CrossRef](#)]
33. Stead, T.K.; Schmid-Araya, J.M.; Schmid, P.E.; Hildrew, A.G. The distribution of body size in a stream community: One system, many patterns. *J. Anim. Ecol.* **2005**, *74*, 475–487. [[CrossRef](#)]
34. Schmid, P.E.; Tokeshi, M.; Schmid-Araya, J.M. Scaling in stream communities. *Proc. R. Soc. Lond. B* **2002**, *269*, 2587–2594. [[CrossRef](#)] [[PubMed](#)]
35. Schmid, P.E.; Tokeshi, M.; Schmid-Araya, J.M. Relation between population density and body size in stream communities. *Science* **2000**, *289*, 1557–1560. [[CrossRef](#)] [[PubMed](#)]
36. Bell, S.S.; McCoy, E.D.; Mushinsky, H.R. *Habitat Structure: The Physical Arrangement of Objects in Space*; Chapman and Hall: London, UK, 1991.
37. Stelzer, P.S.; Mazzuco, A.C.A.; Gomes, L.E.; Martins, J.; Netto, S.; Bernardino, A.F. Taxonomic and functional diversity of benthic macrofauna associated with rhodolith beds in SE Brazil. *PeerJ* **2021**, *9*, e11903. [[CrossRef](#)] [[PubMed](#)]
38. Wallace, J.B.; Webster, J.R. The role of macroinvertebrates in stream ecosystem function. *Annu. Rev. Entomol.* **1996**, *41*, 115–139. [[CrossRef](#)]
39. Cummins, K.W.; Merritt, R.W.; Andrade, P.C. The use of invertebrate functional groups to characterize ecosystem attributes in selected streams and rivers in south Brazil. *Stud. Neotrop. Fauna Environ.* **2005**, *40*, 69–89. [[CrossRef](#)]
40. Olivier, J.M.; Carrel, G.; Lamouroux, N.; Dole-Olivier, M.J.; Malard, F.; Bravard, J.P.; Amoros, C. Chapter 7—The Rhône River Basin. In *Rivers of Europe*; Academic Press: Cambridge, MA, USA, 2009; pp. 247–295.
41. Marle, P.; Riquier, J.; Timoner, P.; Mayor, H.; Slaveykova, V.I.; Castella, E. The interplay of flow processes shapes aquatic invertebrate successions in floodplain channels—A modelling applied to restoration scenarios. *Sci. Total Environ.* **2021**, *750*, 142081. [[CrossRef](#)]
42. Blinn, W.; Shannon, J.P.; Stevens, L.E.; Carder, J.P. Consequences of fluctuating discharge for communities. *J. N. Am. Benthol. Soc.* **1995**, *14*, 233–248. [[CrossRef](#)]
43. Humphries, P.; King, A.J.; Koehn, J.D. Fish, flows and flood plains: Links between freshwater fishes and their environment in the Murray-Darling River system, Australia. *Environ. Biol. Fishes* **1999**, *56*, 129–151. [[CrossRef](#)]
44. King, A.J.; Humphries, P.; Lake, P.S. Fish recruitment on floodplains: The roles of patterns of flooding and life history characteristics. *Can. J. Fish. Aquat. Sci.* **2003**, *60*, 773–786. [[CrossRef](#)]
45. Marle, P.; Rabarivelo, S.; Marechal, S.; Castella, E.; Rosset, V.; Roger, M. Light-trapped caddisfly assemblages in two floodplain reaches of the French upper Rhone River [Trichoptera]. *Ephemera* **2016**, *18*, 41–59.
46. Smith, R.J. Use and misuse of the reduced major axis for line-fitting. *Am. J. Phys. Anthropol.* **2009**, *140*, 476–486. [[CrossRef](#)] [[PubMed](#)]
47. Glazier, D.S. A unifying explanation for diverse metabolic scaling in animals and plants. *Biol. Rev.* **2010**, *85*, 111–138. [[CrossRef](#)] [[PubMed](#)]
48. Kerkhoff, A.J.; Enquist, B.J. Multiplicative by nature: Why logarithmic transformation is necessary in allometry. *J. Theor. Biol.* **2009**, *257*, 519–521. [[CrossRef](#)]
49. Glazier, D.S. Log-transformation is useful for examining proportional relationships in allometric scaling. *J. Theor. Biol.* **2013**, *334*, 200–203. [[CrossRef](#)]
50. Gjoni, V.; Ghinis, S.; Pinna, M.; Mazzotta, L.; Marini, G.; Ciotti, M.; Rosati, I.; Vignes, F.; Arima, S.; Basset, A. Patterns of functional diversity of macroinvertebrates across three aquatic ecosystem types, NE Mediterranean. *MMS* **2019**, *20*, 703–717. [[CrossRef](#)]
51. Gjoni, V.; Basset, A. A cross-community approach to energy pathways across lagoon macroinvertebrate guilds. *Estuar. Coast* **2018**, *41*, 2433–2446. [[CrossRef](#)]
52. Gjoni, V.; Glazier, D.S. A perspective on body size and abundance relationships across ecological communities. *Biology* **2020**, *9*, 42. [[CrossRef](#)]
53. Blackburn, J.H.; Gaston, J.F. A critical assessment of the form of the interspecific relationship between abundance and body size in animals. *J. Anim. Ecol.* **1997**, *66*, 233–249. [[CrossRef](#)]
54. Pagel, M.D.; Harvey, P.H.; Godfray, H.C.J. Species-abundance, biomass, and resource-use distributions. *Am. Nat.* **1991**, *138*, 836–850. [[CrossRef](#)]
55. Brawn, J.D.; Karr, J.R.; Nichols, J.D. Demography of birds in a Neotropical forest: Effects of allometry, taxonomy, and ecology. *Ecology* **1995**, *76*, 41–51. [[CrossRef](#)]
56. Russo, S.E.; Robinson, S.K.; Terborgh, J. Size-abundance relationships in an Amazonian bird community: Implications for the energetic equivalence rule. *Am. Nat.* **2003**, *161*, 267–283. [[CrossRef](#)] [[PubMed](#)]
57. Glazier, D.S. The 3/4-power law is not universal: Evolution of isometric, ontogenetic metabolic scaling in pelagic animals. *BioScience* **2006**, *56*, 325332. [[CrossRef](#)]
58. Shokri, M.; Ciotti, M.; Vignes, F.; Gjoni, V.; Basset, A. Components of standard metabolic rate variability in three species of gammarids. *Web. Ecol.* **2019**, *19*, 1–13. [[CrossRef](#)]
59. Cozzoli, F.; Shokri, M.; Ligetta, G.; Ciotti, M.; Gjoni, V.; Marocco, V.; Vignes, F.; Basset, A. Relationship between individual metabolic rate and patch departure behaviour: Evidence from aquatic gastropods. *Oikos* **2020**, *129*, 1657–1667. [[CrossRef](#)]
60. Glazier, D.S.; Butler, E.M.; Lombardi, S.A.; Deptola, T.J.; Reese, A.J.; Satterthwaite, E.V. Ecological effects on metabolic scaling: Amphipod responses to fish predators in freshwater springs. *Ecol. Monog.* **2011**, *81*, 599–618. [[CrossRef](#)]

61. Glazier, D.S.; Borrelli, J.J.; Hoffman, C.L. Effects of fish predators on the mass-related energetics of a keystone freshwater crustacean. *Biology* **2020**, *9*, 40. [[CrossRef](#)]
62. Gjoni, V.; Basset, A.; Glazier, D.S. Temperature and predator cues interactively affect ontogenetic metabolic scaling of aquatic amphipods. *Biol. Lett.* **2020**, *16*, 20200267. [[CrossRef](#)]
63. Glazier, D.S.; Gring, J.P.; Holsopple, J.R.; Gjoni, V. Temperature effects on metabolic scaling of a keystone freshwater crustacean depend on fish-predation regime. *J. Exp. Biol.* **2020**, *223*, jeb232322. [[CrossRef](#)]
64. Gaston, K.J. Patterns in the local and regional dynamics of moth populations. *Oikos* **1988**, *53*, 49–57. [[CrossRef](#)]
65. Morse, D.R.; Stork, N.E.; Lawton, J.H. Species number, species abundance and body length relationships of arboreal beetles in Bornean lowland rain forest trees. *Ecol. Entomol.* **1988**, *13*, 25–37. [[CrossRef](#)]
66. Verberk, W.C.; Siepel, H.; Esselink, H. Life-history strategies in freshwater macroinvertebrates. *Fresh. Biol.* **2008**, *53*, 17221738. [[CrossRef](#)]
67. McHugh, P.A.; Thompson, R.M.; Greig, H.S.; Warburton, H.J.; McIntosh, A.R. Habitat size influences food web structure in drying streams. *Ecography* **2015**, *38*, 700–712. [[CrossRef](#)]
68. Tockner, K.; Pennetzdorfer, D.; Reiner, N.; Schiemer, F.; Ward, J.V. Hydrological connectivity, and the exchange of organic matter and nutrients in a dynamic river-floodplain system (Danube, Austria). *Fresh. Biol.* **1999**, *41*, 521–535. [[CrossRef](#)]
69. Keckeis, S.; Baranyi, C.; Hein, T.; Holarek, C.; Riedler, P.; Schiemer, F. The significance of zooplankton grazing in a floodplain system of the River Danube. *J. Plankton Res.* **2003**, *25*, 243–253. [[CrossRef](#)]
70. Olden, J.D.; Konrad, C.P.; Melis, T.S.; Kennard, M.J.; Freeman, M.C.; Mims, M.C.; Williams, J.G. Are large-scale flow experiments informing the science and management of freshwater ecosystems? *Front. Ecol. Environ.* **2014**, *12*, 176–185. [[CrossRef](#)]
71. Poff, N.L.; Schmidt, J.C. How dams can go with the flow. *Science* **2016**, *353*, 1099–1100. [[CrossRef](#)]