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Abstract: Intensive forestry, particularly the establishment of monospecific plantations with exotic species, can deeply impact the ecological functioning of forest streams, where riparian leaf litter is the primary source of energy. In this study we investigated the effects of *Eucalyptus globulus* afforestation on macroinvertebrate communities in 20 streams in Galicia (NW Spain) with varying levels of accumulated eucalypt leaf litter. Sampling was done in autumn 2020 and spring 2021. In autumn, six streams had leaf litter composed of >50% of eucalypt leaves, a proportion that increased to 12 streams in spring. A total of 24,705 individuals were found in autumn and 12,529 in spring, belonging to 125 taxa. Although some taxa decreased their abundance with the increase of the proportion of eucalypt litter, variability in overall macroinvertebrate abundance was mainly explained by season, stream flow and water temperature. However, species richness and diversity were significantly lower in streams mainly subsided by *Eucalyptus* litter compared to those dominated by native riparian vegetation. Macroinvertebrate abundance, richness and diversity peaked in autumn, coinciding with the influx of deciduous litterfall and lower proportion of eucalypt litter. The lower quality, low-nutrient content, and the presence of feeding deterrents in *Eucalyptus* leaf litter compared to native deciduous tree species, likely drive these observed patterns, underscoring the importance of preserving native riparian forests to sustain stream biodiversity, even in managed landscapes dominated by *Eucalyptus* plantations.

Keywords: aquatic biodiversity; conservation; plantation forestry; exotic species; detritivores

1. Introduction

Human activities frequently facilitate the relocation of species beyond their native ranges, whether intentionally or unintentionally [1]. Some of these introduced species become invasive, leading to biodiversity loss in the receptor systems [2] and contributing to global biological homogenization [3,4]. The introduction of exotic invasive species can also incur economic costs, both directly, as pests or pathogens, and indirectly, through the disruption of ecosystem services like pollination or negative impacts on human health [5,6].

The genus *Eucalyptus*, native to Australia, includes species widely used in forestry such as *E. globulus, E. nitens, E. grandis, E. camaldulensis,* as well as their hybrids [7]. These trees are extensively cultivated to provide raw material for the paper industry [8], and large *Eucalyptus* plantations have been established in regions such as South Africa, Australia, South America, India, and China [9]. In Europe, the Iberian Peninsula supports large areas managed for commercial plantations of the exotic

Eucalyptus globulus Labill [10], which cover approximately 1.5 million hectares [11], and has a clear invasive behaviour in the region, mostly after fires [12].

This widespread cultivation raises critical concerns about the ecological impacts of *Eucalyptus* plantations, particularly in riparian zones where native forests are often replaced. Stream ecosystems heavily depend on organic matter inputs from riparian vegetation with leaf litter serving as the primary energy source [13,14]. This organic matter is processed by microorganisms (mainly aquatic hyphomycetes) and shredder invertebrates, which integrate it into the food web. The chemical and physical properties of leaf litter strongly influence consumers feeding activities e.g. [15], and shifts in the composition of riparian plant species can significantly alter energy flow and biological structure of stream ecosystems e.g. [16,17].

Removing riparian forests severely affects the ecology of aquatic trophic webs [18]. Additionally, the replacement of diverse riparian forests with monospecific *Eucalyptus* plantations has been shown to homogenize litter quality and synchronize litterfall timing, potentially disrupting the ecological roles of shredders, decomposers, and overall organic matter breakdown [16,19]. Research in Central Portugal has demonstrated that streams running through *Eucalyptus* plantations host lower macroinvertebrate diversity compared to streams bordered by deciduous or mixed forests, with the shredders particularly affected [20]. This reduction in diversity is attributed to the low nutritional quality of *Eucalyptus* litter, which contains feeding deterrents [21–23] and has a low nutrient content [24–26]. Similar findings have been reported in Galicia, Northwestern Spain e.g. [19]. However, some studies in the Basque Country, Northern Spain, suggest that streams running through *Eucalyptus* plantations and native forests exhibit comparable macroinvertebrate diversity, although shredder densities remain lower in rivers dominated by eucalypt inputs [27].

Climatic conditions may explain these geographic disparities in the effects of eucalypt plantations on macroinvertebrate communities [28]. Northern Spain's humid climate ensures relatively stable flows throughout the year, while Central Portugal experiences dry summers, adding stress upon macroinvertebrates feeding on *Eucalyptus* leaf litter [28]. The intensity of plantation management is also a crucial factor that determines the ability of eucalypt plantations to offer substitutive habitats for wildlife [9], particularly when understory species are eliminated. In this study, we further document the ecological impacts of *Eucalyptus* plantations on the structure and function of aquatic macroinvertebrate assemblages in Galicia, Northwest Spain. We hypothesize that the low quality of *Eucalyptus* litter negatively affects macroinvertebrate communities, reducing abundance, richness and diversity in streams dominated by *Eucalyptus* inputs in comparison to those surrounded by mixed deciduous forests. We compared autumn and spring communities, as the native vegetation loses its leaves in autumn, in contrast to eucalypts, which lose their leaves mainly in summer [29], and therefore expected more complex communities in autumn. Additionally, we also hypothesized that shredders will be more affected, with the more generalist taxa -those capable of feeding on alternative food sources like filterers of particulate organic matter- being dominant in plantation streams. To test these hypotheses, we compared macroinvertebrate communities in 20 streams with varying levels of *Eucalyptus* litter input in Galicia, which shares a humid climate with Northern Spain but also experiences dry summers like Central Portugal.

2. Materials and Methods

2.1. Study Area

The study was carried out in streams of Galicia (NW Spain), a region characterised by a sub-Mediterranean climate [30]. Annual rainfall exceeds 1,000 mm in 80% of the region's climatic stations, with some areas receiving annual maxima exceeding 3,000 mm. The months with the highest precipitation are typically from November to January, while July and August are the driest months [30]. Floristically, the area represents a transition between the Atlantic and the Mediterranean ecosystems, thus coexisting the deciduous oak forests dominated by *Quercus robur* and the evergreen oak forest, with *Quercus suber* and other Mediterranean species [31].

Approximately 28% of tree cover in Galicia is made up of eucalypt plantations, with around 409,000 ha dominated by *Eucalyptus* species, particularly concentrated along the coastal areas [32]. We sampled 20 streams in 10 localities (see Table A1). In each locality we selected one stream predominantly running through *Eucalyptus globulus* plantations and another bordered by native deciduous forests. This design avoided spatial clustering of each type of stream. In native forests, the most abundant tree species were oak (*Quercus robur*), chestnut (*Castanea sativa*) and alder (*Alnus glutinosa*). Sampling was carried out in the fall of 2020 and spring of 2021. The average straight-line distance between each pair of streams was 3.5 ± 0.6 km (mean ± SE), estimated using Google Earth software (further details in the Supplementary Information).

2.2. Sampling Methods

Macroinvertebrates were sampled at each site along a 12 m longitudinal transect during both seasons. Each transect was divided into three 4 m sections, where we sampled all microhabitats. In each section, we took samples with a D-net with 500 μm mesh size (four kicks per section, each covering 30 x 30 cm; totalling 12 kicks per transect). Samples were cleaned of large organic debris over a white tray, sieved through a 1 mm mesh sieve, placed in a labelled bag and preserved with 70º ethanol. Additionally, a stone was collected randomly from each section, transported to the laboratory in a plastic container within an ice box to extract chlorophyll a. Stones were soaked individually in alcohol for 24 hours, and chlorophyll absorption was measured at 750 nm and 664 nm using a spectrophotometer. Chlorophyl-a concentration was calculated following Lowe and LaLiberté [33]. After biological sampling, we measured stream flow across the entire channel width, using depth and current velocity recorded every 5-10 cm. Along the transect we also recorded the substrate type (rock, stone, gravel, sand or silt) to estimate the availability of the different microhabitats. We measured water temperature, pH and conductivity, at approximately 4 m upstream of the biological sampling zone, using a Hanna HI98130 sensor. The percentage of shadow in the stream bed was established visually by the same observer to ensure consistency. To determine the solids in suspension of the stream water, we collected three water samples with a 20 ml syringe with a pre-weighed filter (Whatman GF/F filter discs 0.7 μm). These sample filters were air dried (24 h), oven dried (48 h, 60ºC) and reweighted. We then estimated the amount of solids suspended as the difference in mass of the filters. We also took three samples of leaf litter (Coarse Particulate Organic Matter, CPOM), using the area of a Surber net (33x33 cm), and three samples of Fine Benthic Particulate Organic Matter (FBPOM, <1 mm). To estimate FBPOM, we resuspended the organic matter accumulated in the stream bed in a 10x18x10 cm area delimited by a plastic cube frame. The suspension was also sampled with a 20 ml syringe, and, in the laboratory, we passed the sample through a pre-weighed filter, which was oven dried and reweighed again. In the laboratory, we separated the leaf litter into the categories *Eucalyptus* and deciduous native species. Leaf litter samples were dried in the air (48 h) and in the oven (48 h, 60ºC) and weighed (Denver Instrument Company, model XE-50).

Once in the laboratory, macroinvertebrates were sorted and identified to the genus level, except for Diptera, Oligochaeta and some larval Coleoptera, which were identified to the family level or higher (see Supplementary Information).

2.3. Data Analysis

We followed an Information Theory approach [34] to model the effect of environmental variables on the response variables (abundance, richness and diversity). Complementarily, we also used a frequentist approach based on statistical hypothesis testing for some *a priori* expectations. However, it should be taken into account that our experiment is not manipulative, a fact that may affect the validity of frequentist tests [35]. Macroinvertebrate abundance was calculated as the total number of individuals, community richness as the number of different taxa found at each site (when possible at the genus level), and diversity using the Shannon-Wiener index [36].

Our *a priori* proxy to estimate the impact of eucalypt plantations on stream macroinvertebrate communities was the proportion of eucalypt litter in the stream bed (negative effect), as well as the weight of eucalypt litter (negative effect) and that of native litter (positive effect). We also expected relevant seasonal changes related to litter seasonality [29]. Therefore, we first explored the effects of the proportion of eucalypt litter and season (and their interaction) on the abundance of the commonest taxa, by using linear mixed-effects models fitted by restricted maximum likelihood (REML), with stream identity included as a random term.

For community abundance, richness and diversity, we built REML models including the following predictor variables: proportion of eucalypt litter, the weight of eucalypt and native litter, season, chlorophyll-a, conductivity, CPOM, FBPOM, stream flow, pH, shadow, temperature and stream width. First, we built REML models with all 13 predictor variables one by one (and the constant term) and ranked these models by their Akaike's Information Criterion corrected for small samples (AICc) [37]. In a second step, we retained the variable that produced the best model (minimum AICc) and built all models with that variable and the remaining predictor variables and ranked them by their AICc. When the proportion of eucalypt litter performed among the best univariate models, this variable was also used for further model building. Finally, models with more variables were only built using the best models with 2-3 variables, and specifically included the proportion of eucalypt litter, the weight of eucalypt litter and the weight of native litter, as these were our *a priori* main predictor variables. Finally, all models were ranked again by their AICc values. Details of the models and their performance are in Tables A2-4. Means are presented with their standard errors. All analyses were conducted using GenStat 24th edition (VSN International) and JASP (Version 0.19.3).

3. Results

3.1. Stream Site Characterization

Sampled streams were 0.2–2.2 m wide, with a maximum depth of 47 cm, mean flow of 47.2±9.0 L/sec (range: 1.1-279.2), and shaded by 73.4±2.5% (range: 40-100). Water conductivity was 58.0±6.4 µS/cm (range: 20.2-191.3), with a pH of 6.5±0.1 (range: 5.8-7.4). Chlorophyl averaged 9.1±2.9 µg/m² (range: 0-82.9), FBOPM averaged 0.39±0.07 µg/L (range: 0-1.83), and CPOM 272.1±28.0 g/m² (range: 0.04-871.2). The correlation among environmental variables was in general low (Figure A1). However, some values worth highlighting are the negative correlation between the proportion of eucalypt litter and community diversity (r=-0.49, p=0.001), and the positive correlation between flow rate and diversity (r=0.50, p=0.001). CPOM was positively correlated with the weight of native litter (0.79, p<0.001), emphasising the prominent contribution of native vegetation to CPOM standing stock. The width of the stream was negatively correlated with the weight of eucalypt litter (r=-0.43, p=0.006) and positively with diversity (r=0.44, p=0.005). Finally, the weight of native litter was positively correlated with richness (r=0.33, p=0.037) and diversity (r=0.45, p=0.005). Correlation values are in the Supplementary Information.

All environmental variables were similar between seasons (Table A1), with three exceptions: FBOPM was higher in autumn than in spring (0.58±0.09 versus 0.19±0.09, t_{37}=3.13, p=0.003), CPOM was higher and more variable in autumn (357.4±45.4 versus 186.8±87.7, $t_{25.84}$=3.45, p=0.002), and the amount of native litter was also higher and more variable in autumn (25.1±20.5 versus 6.9±4.6, $t_{20.92}$=3.87, p<0.001; Figure 1). In autumn, only six streams had more than 50% of their litter composed of eucalypt leaves, whereas in spring, 12 streams showed a predominance of eucalypt litter (Table 1). Although the overall amount of eucalypt litter was slightly higher in autumn (16.7±3.2 g versus 13.3±2.3 g; Table 1; Figure 1), the nearly four-fold increase in native litter during this season (25.1±4.6 g versus 6.9±1.0 g; Table 1; Figure 1) made eucalypt inputs more relevant in spring.

Table 1. Characteristics of 20 streams sampled in the autumn of 2020 and the spring of 2021. Values are the means of measurements taken at three sections of each transect. "Eucalypt" and deciduous "Native" refers to

the dry mass of benthic litter (g in the area of the Surber, 0.1089 m²; see Methods), expressed as a percentage in % eucalypt. Abundance, richness, and Shannon (diversity) refer to macroinvertebrate taxa, generally identified to the genus level.

| Autunm						
Locality and stream	**Eucalypt (g)**	**Native (g)**	**% eucalypt**	**Abundance**	**Richness**	**Shannon**
Aldán,Bouzas	38.67	4.32	90	1993	41	3.20
Aldán, Orxas	4.16	14.56	22	714	40	4.24
Marín, Agrela	38.51	11.67	77	178	18	3.40
Marín, Gorgadas	1.06	40.13	3	669	39	4.13
Vilaboa, Portiño	45.87	13.56	77	1776	61	3.93
Vilaboa, Maior	5.56	33.15	14	1378	41	4.30
Coruxo, Gontade	41.78	1.43	97	1285	41	4.00
Coruxo, Saiáns	15.98	47.20	25	4586	57	4.02
Gondomar, Peitieiros	12.69	40.49	24	845	38	4.15
Gondomar, Mordagáns	7.64	24.07	24	751	68	4.93
Mondariz, da Vida	26.63	0.68	98	1369	35	3.49
Mondariz, Cillarga	9.37	51.84	15	976	29	3.76
Porriño, da Fraga	16.68	13.44	55	376	28	4.16
Porriño, Louro	7.38	44.89	14	489	31	3.42
Campo Lameiro, Grande	8.35	18.62	31	534	43	4.00
Campo Lameiro, Teixoeiras	12.86	81.41	14	990	34	4.15
Pontevedra, Seixiña	11.29	19.13	37	2414	54	3.18
Pontevedra, As Laceiras	0.04	18.90	0	867	32	3.77
Ponteareas, Xabriña	22.71	11.48	66	1486	36	3.54
Ponteareas, Fragón	6.50	10.11	39	1029	35	3.46
Mean	16.69	25.05	41	1235.25	40.05	3.86
Spring						
Aldán,Bouzas	25.95	4.60	85	1241	18	2.54
Aldán, Orxas	10.50	3.29	76	565	24	3.73
Marín, Agrela	31.21	5.88	84	249	17	3.36
Marín, Gorgadas	6.47	17.83	27	948	36	4.39
Vilaboa, Portiño	11.38	0.58	95	554	30	3.48
Vilaboa, Maior	1.13	5.11	18	503	28	3.70
Coruxo, Gontade	25.02	10.50	70	1319	27	2.37
Coruxo, Saiáns	4.98	3.84	57	1379	31	3.30
Gondomar, Peitieiros	8.99	7.54	54	695	30	3.64
Gondomar, Mordagáns	6.52	7.96	45	276	26	3.61
Mondariz, da Vida	27.04	2.37	92	785	24	2.91
Mondariz, Cillarga	9.21	12.10	43	516	25	2.80
Porriño, da Fraga	15.27	9.60	61	227	23	3.27
Porriño, Louro	6.07	8.91	41	1006	28	2.98
Campo Lameiro, Grande	21.08	1.11	95	191	20	2.78
Campo Lameiro, Teixoeiras	7.95	14.25	36	553	28	3.31
Pontevedra, Seixiña	28.89	0.32	99	191	19	3.11
Pontevedra, As Laceiras	0.00	5.51	0	306	28	4.10
Ponteareas, Xabriña	18.70	7.16	72	570	34	3.49
Ponteareas, Fragón	0.00	9.49	00	455	29	3.21
Mean	13.32	6.90	58	626.45	26.25	3.30
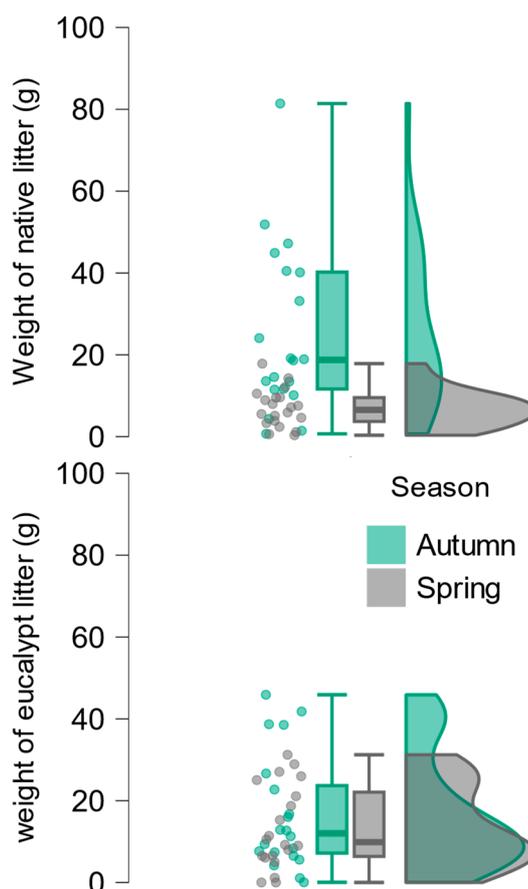
Figure 1. Raincloud plot showing the distribution of native (left) and eucalypt litter (right) weight by season. Note that eucalypt litter was very similar between seasons, but native litter was more abundant in autumn.

3.2. Macroinvertebrate Abundance, Richness and Diversity

A total of 24,705 individuals were sampled in autumn and 12,529 in spring, belonging to 125 taxa. Of these, 30 taxa had a total abundance ≥5% (Table 2). Four taxa, mainly grazers or shredders, namely *Protonemura* (Plecoptera), *Gammarus* (Amphipoda; Figure 2c), Tanytarsini (Chironomidae) and *Hydrophsyche* (Trichoptera) accounted for 50% of all individuals.

The effects of the proportion of eucalypt litter and season on macroinvertebrate abundance was analysed with a REML with site as a random term. The abundance of *Limnephilus* (Trichoptera; Figure 2a), *Crunoecia* (Trichoptera) and *Ecdyonurus* (Ephemeroptera; Figure 2b) was negatively associated with the proportion of eucalypt litter, particularly in autumn (Table 2, Figure 3). The abundance of nine taxa, including *Gammarus*, *Simulium* (Diptera; Figure 2d), Orthocladiinae (Diptera), *Leuctra* (Plecoptera), *Lepidostoma* (Trichoptera), *Diplectrona* (Trichoptera), *Rhyacophila* (Trichoptera), Oligochaeta, and *Hexatoma* (Diptera) was higher in autumn than in spring (Table 2, Figure 3), *Gammarus* being especially relevant as it accounted for 17.4% of total individuals.

The best model to explain variability in macroinvertebrate abundance included the effects of season, flow and temperature, with an AICc of 552.19, and an Akaike weight of 0.35 (Table A2). The estimates of parameters from this model indicate that abundance in autumn was higher than in spring (coefficient: 765.6±204.2), stream flow had a negative effect (-4.539±2.001) and temperature had a positive effect (267.8±98.9). However, five models with one additional variable performed in a similar way (delta AICc 1.45-2.61). The variables included were conductivity, weight of native litter, proportion of eucalypt litter, stream width and weight of eucalypt litter. The Akaike weight of models including weight of native litter (0.12), proportion of eucalypt litter (0.11) and weight of eucalypt litter (0.10) is relatively high, supporting the hypothesis that these variables are relevant explaining

variability in macroinvertebrate abundance. In agreement with our hypothesis, the effect of native litter was positive on abundance (4.728±7.286), the impact of eucalypt litter was negative, measured as eucalypt litter mass (-1.444±9.545) or proportion of eucalypt litter (-182.30±375.10). However, the standard errors were large, indicating high variability.

Community richness was best explained by a model including season and FBPOM, with an AICc of 219.19 and an Akaike weight of 0.32 (Table A3). Richness was higher in autumn compared to spring (11.35±3.07), and FBPOM had a positive effect (4.13±6.17). Two further models had a delta AICc of 1.50-2.00, and an Akaike weight of 0.15-0.12. The first model added the negative effect of proportion of eucalypt litter (-4.88±5.27). The second model only included season and a negative effect of stream flow (-0.0072±0.0292). Again, standard errors were very large.

The best model explaining invertebrate diversity included the proportion of eucalypt litter, season, stream width and pH (AICc=-28.54; Table A4). This model is highly supported by the data, given its Akaike weight of 0.43. The effect of eucalypt litter was negative (-0.488±0.202), autumn diversity was higher (0.476±0.123), stream width had a positive effect (0.291±0.107) and pH also (0.334±0.177). The second model excluded pH and has a delta AICc of 1.32, and is therefore of similar explanatory power, with an Akaike weight of 0.22.

Finally, we used a frequentist approach to test our *a priori* hypothesis that predicted a negative effect of the proportion of eucalypt litter and a positive effect of autumn season on our three community variables. Given the contrasting effect of eucalypt litter on the different taxa (Figure 3), we found that total invertebrate abundance showed no significant relation with the proportion of eucalypt litter (Figure 4; REML, $F_{1,30.8}=0.78$, $p=0.385$), but abundance was higher in autumn ($F_{1,20.4}=9.00$, $p=0.007$). However, richness decreased with the increase in the proportion of eucalypt litter (Figure 4; $F_{1,28.6}=7.47$, $p=0.011$), and was also higher in autumn ($F_{1,20.1}=22.44$, $p<0.001$), and the same was observed with diversity, which was clearly reduced with an increase of eucalypt litter (Figure 4; $F_{1,29.0}=14.38$, $p<0.001$) and was also significantly higher in autumn ($F_{1,20.1}=13.56$, $p<0.001$).

Table 2. Abundance (number of individuals) of macroinvertebrates by season. Only taxa that appeared with a frequency of ≥5% are indicated. Statistical tests (F) and p-values derive from a REML analysis, testing the effect of the proportion of eucalypt litter and season on taxon abundance, including site as a random term. The interaction term between % eucalypt and season was never significant.

Taxon	Autumn	Spring	Total	% of total	%Eucalypt F, p	Season F, p
Protonemura	3330	3383	6713	0.180	1.39, 0.246	0.16, 0.697
Gammarus	3885	2599	6484	0.174	0.08, 0.774	**4.51, 0.046**
Tanytarsini	3318	154	3472	0.093	0.35, 0.557	3.57, 0.074
Hydropsyche	1101	956	2057	0.055	0.97, 0.332	1.19, 0.289
Simulium	1269	581	1850	0.050	1.03, 0.316	**10.88, 0.003**
Orthocladiinae	1424	129	1553	0.042	0.66, 0.423	**5.77, 0.026**
Chironomini	810	281	1091	0.029	0.63, 0.433	1.92, 0.181
Leuctra	737	328	1065	0.029	0.86, 0.361	**4.55, 0.045**
Baetis	674	381	1055	0.028	1.71, 0.201	1.41, 0.249
Cordulegaster	485	544	1029	0.028	0.05, 0.818	0.39, 0.540
Limnephilus	667	278	945	0.025	**4.73, 0.039**	1.53, 0.231
Atherix	450	447	897	0.024	0.91, 0.345	0.22, 0.641
Elodes	402	183	585	0.016	1.11, 0.299	1.79, 0.195
Hydrocyphon	455	119	574	0.015	1.85, 0.184	2.74, 0.113
Ceratopogoninae	409	112	521	0.014	1.27, 0.269	1.41, 0.249

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Helicopsyche	319	177	496	0.013	0.04, 0.846	2.73, 0.113
Crunoecia	301	153	454	0.012	**4.71, 0.038**	3.55, 0.074
Elmis	300	142	442	0.012	3.22, 0.085	0.60, 0.447
Lepidostoma	355	56	411	0.011	0.83, 0.371	**14.21, 0.001**
Diplectrona	398	0	398	0.011	0.67, 0.419	**6.10, 0.023**
Hemerodromiidae	182	171	353	0.009	1.84, 0.182	0.00, 0.985
Rhyacophila	216	103	319	0.009	3.30, 0.078	**7.47, 0.013**
Oligochaeta	281	26	307	0.008	0.38, 0.542	**18.88, <0.001**
Limnius	159	127	286	0.008	0.03, 0.872	1.26, 0.276
Philopotamus	166	119	285	0.008	2.36, 0.133	1.15, 0.295
Nemoura	122	120	242	0.006	0.29, 0.596	0.02, 0.877
Calopteryx	112	126	238	0.006	0.30, 0.587	0.25, 0.623
Ecdyonurus	143	82	225	0.006	**5.21, 0.030**	1.60, 0.220
Hexatoma	151	50	201	0.005	2.24, 0.145	**7.53, 0.012**
Oulimnius	136	47	183	0.005	1.88, 0.180	2.35, 0.975
Other taxa	1948	555	2503	0.067		
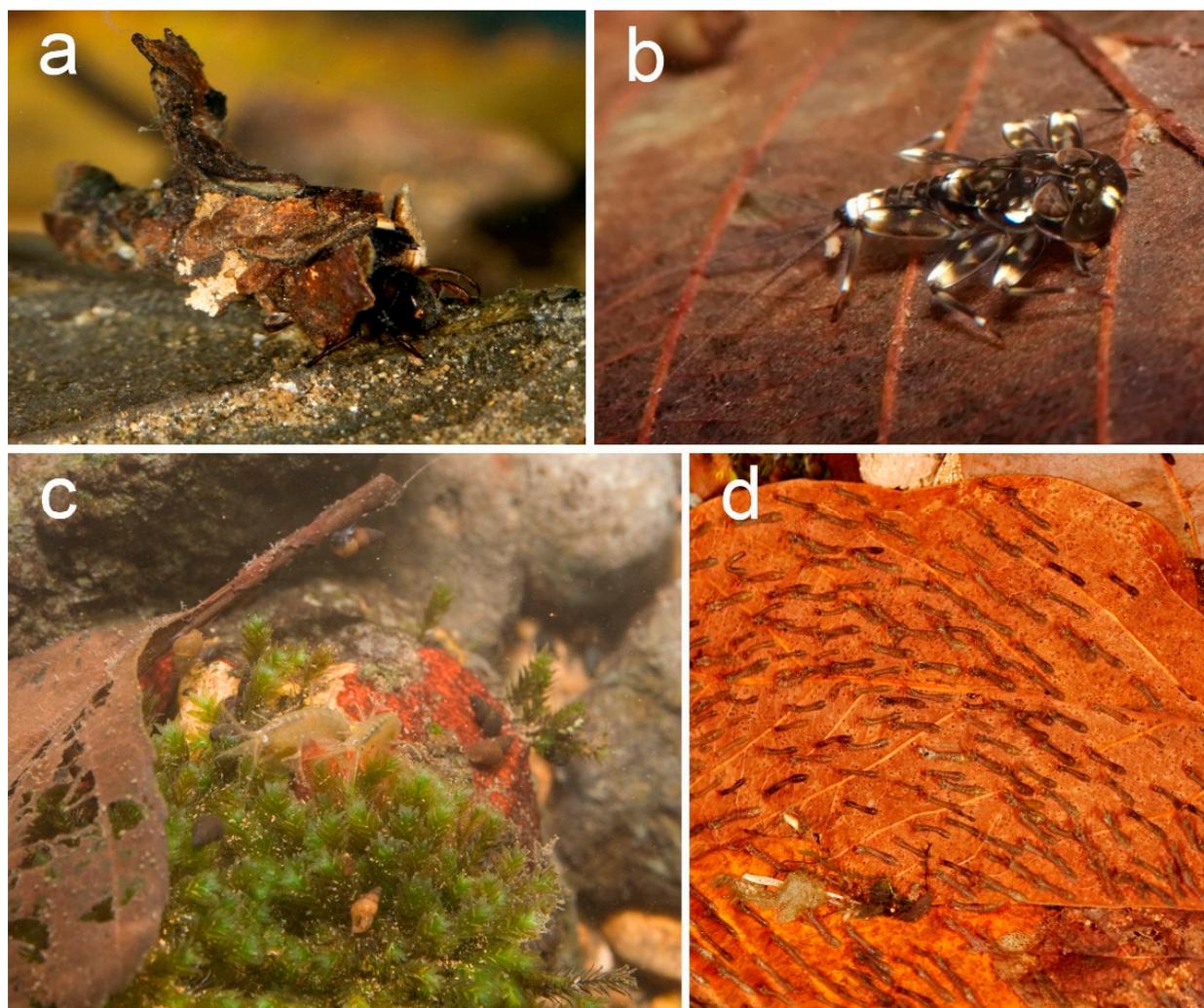
Figure 2. Habitus and behaviour of key macroinvertebrate taxa. Some caddisfly larvae, like members of the family Limnephilidae (a) and mayfly larvae (b, *Ecdyonurus*), which feed as shredders or scrapers on leaves, were among the taxa whose abundance was negatively affected by the increase in eucalypt litter, whereas grinders

like *Gammarus* (c) and several dipterans like black flies (Simuliidae, d), which are filterers, were little or not affected. Pictures by ACR.
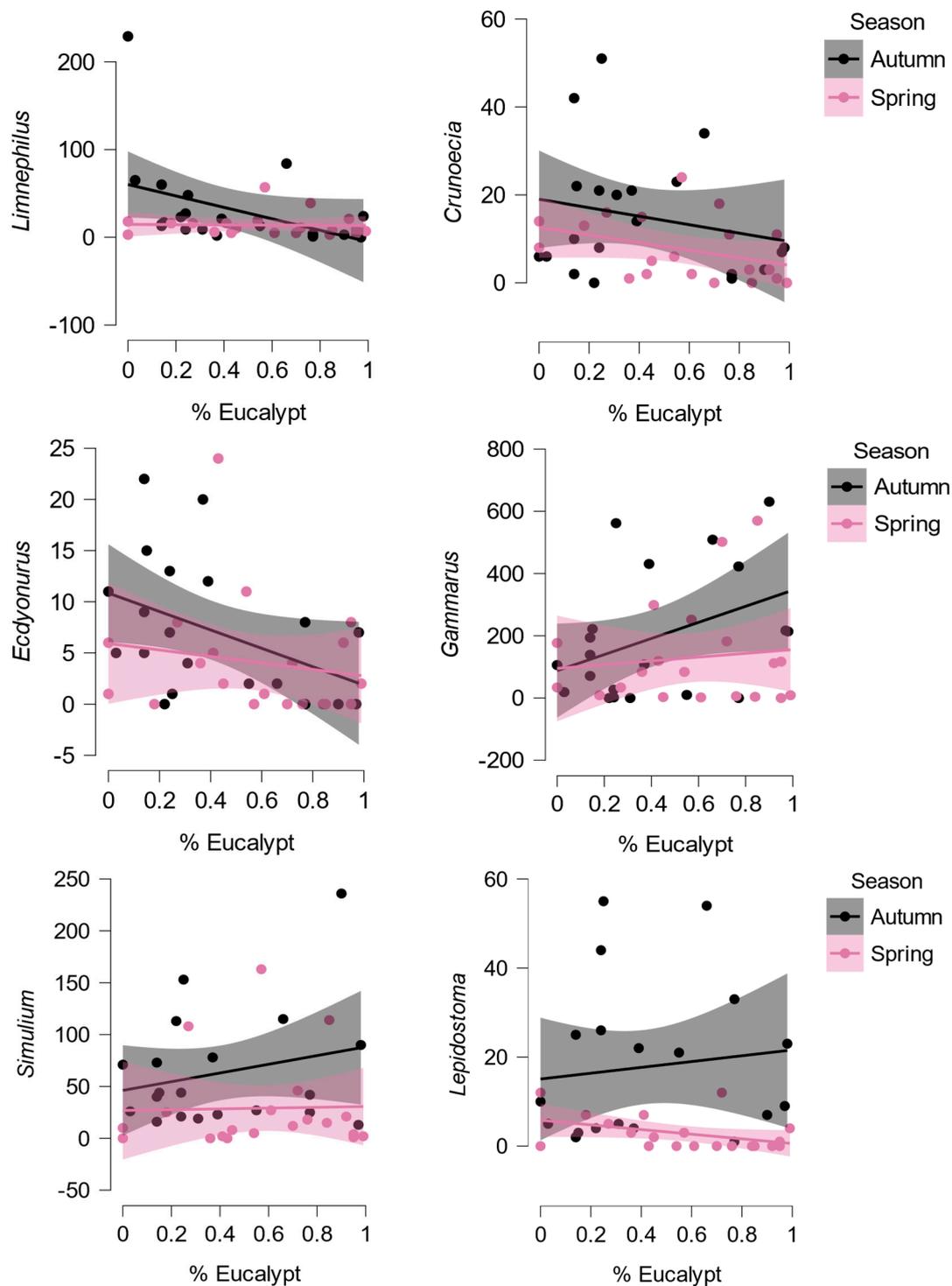

Figure 3. Losers and winners: the relationship between abundance of selected taxa and the proportion of eucalypt leaves, by season, with 95% confidence intervals. The abundance of *Limnephilus*, *Crunoecia* and *Ecdyonurus,* which feed on algae (more available in spring) or leaves, diminished with the increase of eucalypt litter, particularly in autumn. The remaining species (including all with significant seasonal effects in Table 2) had higher abundance in autumn, when more native litter was available.
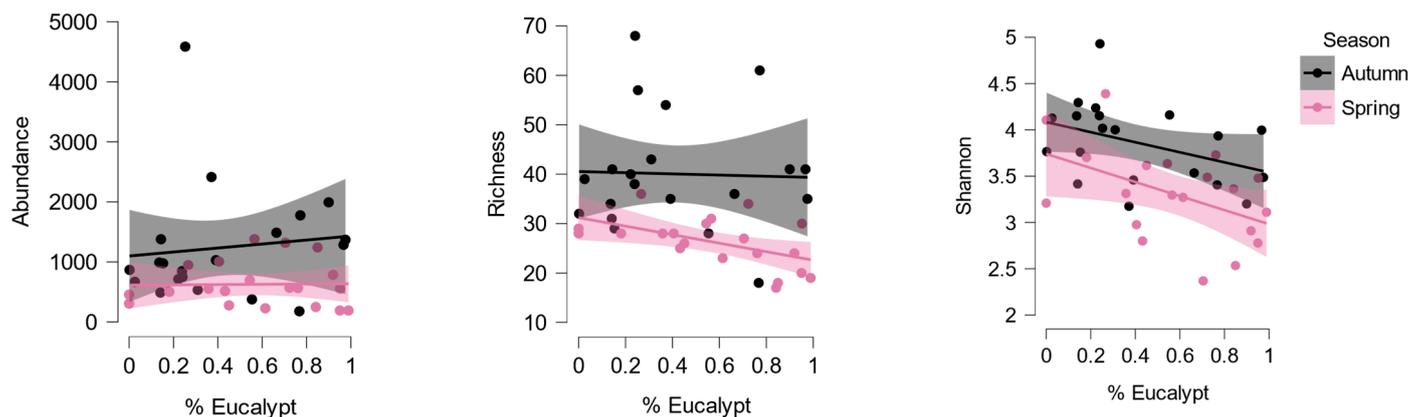
Figure 4. The relationship between the proportion of eucalypt leaves on the stream bed and the abundance (number of individuals), richness (number of taxa) and diversity (Shannon index) of the macroinvertebrate community, by season. Richness and Diversity diminished significantly with the increase of eucalypt leaves (REML), and all three variables were lower in spring than in autumn.

4. Discussion

Our findings show that eucalypt plantations influence the seasonality of litter accumulation in streams, with a higher proportion of eucalypt leaves in spring compared to autumn. We used two complementary approaches (AIC model selection and hypothesis testing) to study the effect of eucalypt litter and season on stream macroinvertebrates, and both suggest that the impact of eucalypts is negative. While overall invertebrate abundance was not affected, some taxa were less abundant when eucalypt litter increased. In agreement with our predictions, richness and diversity decreased with increasing eucalypt litter, suggesting again a negative impact on the composition of macroinvertebrate communities.

Previous studies in the Iberian Peninsula e.g. [20,38] reported similar findings regarding seasonal patterns of litterfall (higher in autumn for native vegetation) and stream discharge. In agreement with this, the accumulation of litter in spring was generally higher in eucalypt-dominated streams than in deciduous-dominated streams (Figure 1), and wider streams accumulated less eucalypt litter (r=-0.43, p=0.006; Figure A1). These results can be explained by the peak of eucalypt litterfall occurring in spring-summer [29], the longer time required for eucalypt litter to decompose, and/or lower abundance of decomposers that could breakdown eucalypt leaf litter. Therefore, as established by Ferreira et al. [28], the effects of eucalypt plantations on streams may be greater in regions where summer droughts are more pronounced and where autochthonous deciduous riparian species are absent, as the latter provide high-quality litter for macroinvertebrates that play a crucial role in riparian ecosystem processes [18]. Overall, litter decomposition in eucalypt dominated streams is reduced by 23% [11]. The effects of eucalypt plantations may vary in different geographical regions [39], according to the local macroinvertebrate community composition, the tree species used in plantations, the intensity of management, and the degree of similarity between the eucalypt litter and that of native species.

Our results also suggest that litter quality plays a crucial role in terms of physical properties and nutrient content. *Eucalyptus globulus* litter generally has lower phosphorus and nitrogen contents than Iberian riparian native litter [38]. Additionally, the higher N:P ratios increase the abundance of shredders [27], which preferentially consume high-quality leaves in deciduous forests. The preponderance of generalists in streams dominated by *Eucalyptus* [28] reinforce the importance of native litter for maintaining a healthy macroinvertebrate community [19]. In fact, the total abundance of macroinvertebrates was not affected by the increase in eucalypt litter, because some generalist species (e.g. *Protonemura*, *Gammarus*, which mainly feed as grinders, and *Hydropsyche*, a filterer-collector), were as abundant in autumn as in spring (Table 2). The abundance of *Gammarus* (Figure 2c) is very high in streams dominated by eucalypts in NW Spain, for instance, see Figure 9 in [12].

We used an information-theory approach to model abundance, richness and diversity, in function of environmental variables and found that season and the proportion of eucalypt litter were included in the most supported models in all cases, particularly in relation to diversity (Tables A2-A4). These results are in agreement with previous theoretical [12,40] and experimental work [19] which suggest that the transfer of energy from eucalypts to higher trophic levels in Europe is limited by the absence of native herbivores able to feed on eucalypts, and the inhibitory effect of leaf chemistry on leaf decomposers [11].

Although the abundance of *Eucalyptus* litter in streams did not correlate with total invertebrate abundance, we observed a significant decrease in richness and diversity with increasing proportions of eucalypt leaves. This pattern, coupled with the observation of higher richness and diversity in autumn (when the proportion of eucalypt leaves was lower), once again indicates that native litter plays a crucial role in supporting diverse and healthy macroinvertebrate communities [41]. In fact, the weight of native litter was positively correlated with richness and diversity, reinforcing the relevance of this kind of subsidy for the structuration of macroinvertebrate communities. The increase in eucalypt leaves changes the energy inputs for the macroinvertebrate community, altering its composition. Part of the differences we found between seasons could be attributed to the association of some taxa with the food types and litter available, with many trichopterans and mayflies emerging in spring and being more abundant in autumn.

The dominance of specific macroinvertebrate taxa in autumn (when native litter is more abundant) strengthens the link between litter quality and community composition. Among these taxa many are ephemeropterans, trichopterans and plecopterans (Table 2), which are recognized as indicators of good ecological status in streams ETP index, [42,43]. This association is true in temperate areas but also in *Eucalyptus*-dominated regions of the Neotropics [44,45]. Conversely, shredders—a group highly affected by leaf litter quality due to their dependence on consumable organic matter—are expected to be less abundant in streams with higher proportions of eucalypt leaves. This has been demonstrated by their slower growth rates when fed on low-quality eucalypt leaves. Canhoto & Graça [22] experimentally found that the larvae of Tipulidae (Diptera) reduced their consumption of native leaves by 50% when oils and polyphenols from *E. globulus* leaves were added to native leaves. Experiments adding eucalypt leaves to small streams also found that leachates from eucalypt leaves exert toxic effects on periphyton, diatom and invertebrate assemblages [42]. All these observations align with established knowledge that eucalypt litter has lower nutritional value due to its high oil and polyphenolic content [14].

All three community variables, abundance, richness and diversity were lower in spring (Figure 4). However, the standard procedures to evaluate water quality of streams in Spain highlight the fact that sampling should be done in spring [46], albeit there is evidence that combining sampling in different seasons produces better results, at least in the Mediterranean region [47]. The autumn of 2020 was dry in NW Spain, with a precipitation 20% lower than the period 1981-2020 [48], and a similar value, 21% lower than the reference period, was recorded in the spring of 2021 [49]. Further studies should analyse whether the seasonal differences that we found are consistent over the years or could be explained by meteorological conditions of particular years.

Our study offers clear evidence of the negative effects of intensive forestry on stream ecology e.g. [50]. A previous study in the same region revealed a negative association between macroinvertebrate community richness and the percentage of eucalypt plantations on the basin, with a similar trend observed for diversity [19]. In agreement with our results, *Eucalyptus* plantations in Brazilian streams have been shown to reduce the richness and diversity of benthic macroinvertebrates [45]. The negative impacts of exotic tree monocultures extend beyond *Eucalyptus*, with oil palm plantations also modifying the physical structure and communities of aquatic insects in Brazilian streams, affecting groups such as odonates [51] and heteropterans [52]. However, these predators may only be indirectly associated with litter quality. These negative effects are not limited to invertebrates but also apply to fish [53], amphibians [54], or birds [55,56]. One clear message emerges from these studies: plantation forestry should be avoided close to the streams to prevent a

significant input of exotic litter. Currently, when streams have at least 2 m in width, eucalypts cannot be legally planted at less than 15 m in Galicia [57]. However, our streams were narrower, and the fact is that these legal requirements are not respected. The reluctance of owners to "give up" land from productive areas to protect these buffer zones is a problem for the effectiveness of such a strategy [58]. Maintaining a wide and diverse riparian forest is a guarantee for the minimization of impacts on rivers [59] and a way to promote the ecosystem services that these streams provide, including biodiversity conservation, mitigation of extreme flows, and water supply, but also services provided by aquatic insects, like pollination, pest control and soil fertilization [60] and export of nutrients to terrestrial systems [61].

While monocultures of fast-growing tree species like *Eucalyptus* offer high economic benefits for the wood industry, such as increased plantation efficiency and productivity, mixed-species plantations are expanding and becoming more common due to their numerous advantages. Mixed-species plantations, which incorporate a diverse array of tree species, have demonstrated benefits for forest health, economic sustainability, and biodiversity conservation and may have increased productivity compared to monospecific plantations [62]. The diversity in species, functions, structures, and genotypes observed within mixed-species plantations makes them more sustainable and environmentally friendly, particularly when incorporating autochthonous species [63]. Furthermore, diverse forests can buffer maximum temperatures thanks to their structural diversity [64], a fact very relevant under the current global warming. Thus, conserving native riparian areas, especially in streams impacted by *Eucalyptus* plantations, is crucial to mitigate the negative effects on stream communities and ecological processes.

Abbreviations

The following abbreviations are used in this manuscript:

AIC	Akaike's Information Criterion
CPOM	Coarse Particulate Organic Matter
FBOPM	Fine Benthic Particulate Organic Matter

Appendix A
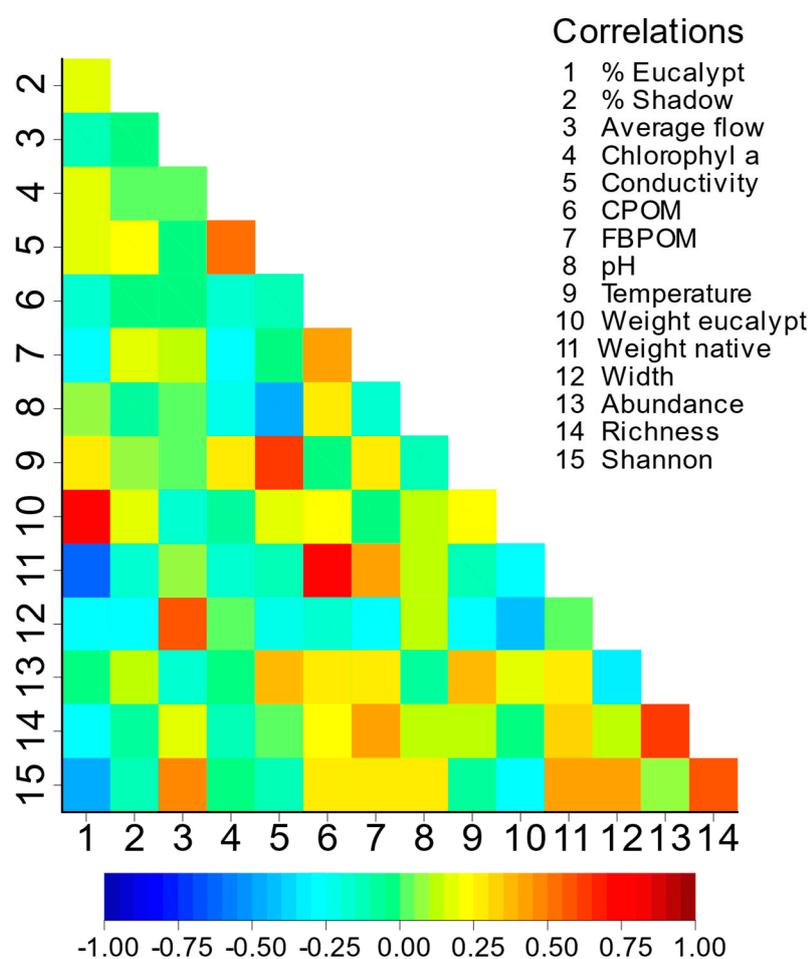
Figure A1. Correlation plot between the environmental variables and community variables.

Table A1. Geographical coordinates and environmental variables of the sampled streams. Conductivity in µS/cm, Width in m, Flow in L/s, FBPOM in g/L, CPOM in g/m², Chlorophyll in µg/m².

Autumn

Locality and stream	Latitude	Longitude	T (ºC)	Conductivity	pH	%Shadow	Width	Flow	FBPOM	CPOM	Chlorophyl a
Aldán,Bouzas	42.29872	-8.81164	14.30	171.00	5.98	70	0.65	2.93	0.3133	82.62	0.502
Aldán, Orxas	42.28328	-8.81056	14.70	153.50	6.21	70	2.17	158.45	0.3433	172.95	3.267
Marín, Agrela	42.38064	-8.66778	11.20	54.40	6.77	90	0.48	2.55	0.4383	463.80	0.241

Location	Latitude	Longitude									
Marín, Gorgadas	42.33878	-8.72917	11.70	51.90	6.31	60	1.47	75.26	0.3983	380.65	1.969
Vilaboa, Portiño	42.33289	-8.66764	13.80	43.80	6.71	75	1.55	92.78	0.7470	549.32	0.672
Vilaboa, Maior	42.33211	-8.66083	14.40	39.60	7.37	50	1.90	11.76	0.8233	357.73	0.634
Coruxo, Gontade	42.17664	-8.78444	14.80	70.40	6.81	100	0.20	1.14	1.0250	399.39	0.020
Coruxo, Saiáns	42.16736	-8.79714	14.10	113.80	6.47	100	0.54	2.49	0.9767	583.88	0.201
Gondomar, Peitieiros	42.08669	-8.73131	12.40	34.80	6.77	40	1.30	58.81	0.2900	491.47	11.829
Gondomar, Mordagáns	42.11244	-8.72339	12.20	49.80	6.76	70	1.73	121.26	0.7833	293.04	27.557
Mondariz, da Vida	42.17842	-8.58033	12.80	48.00	6.50	70	1.10	63.07	0.0633	0.0441	9.882
Mondariz, Cillarga	42.21158	-8.56094	13.20	36.00	6.50	75	0.98	75.53	0.5583	565.71	10.385
Porriño, da Fraga	42.21444	-8.58953	12.60	31.20	6.60	90	1.93	279.24	0.8400	278.37	0.052
Porriño, Louro	42.17589	-8.60692	13.70	66.50	5.80	75	0.52	31.13	1.8333	483.12	0.024
Campo Lameiro, Grande	42.53258	-8.48572	12.40	23.00	6.74	85	1.63	25.01	0.5217	249.23	0.695
Campo Lameiro, Teixoeiras	42.54658	-8.54872	12.00	28.90	6.81	60	1.56	40.96	0.4150	871.20	0.932
Pontevedra, Seixiña	42.53839	-8.46836	12.30	29.10	6.31	60	0.83	6.58	0.4883	281.18	0.878

Pontevedra, As Laceiras	42.53042	-8.41822	10.00	25.00	6.32	90	1.63	44.51	0.4467	175.05	0.667
Ponteareas, Xabriña	42.20158	-8.42372	12.80	34.70	6.32	50	2.23	108.62	0.2867	315.99	7.848
Ponteareas, Fragón	42.19333	-8.45972	13.50	61.10	6.20	65	1.64	81.58	0.0650	153.54	15.115
mean			12.95	58.33	6.51	72.25	1.30	64.18	0.58	357.41	4.67
Spring											
Aldán,Bouzas	42.29872	-8.81164	13.90	191.30	5.98	90	0.65	3.28	0.00000	282.41	75.115
Aldán, Orxas	42.28328	-8.81056	14.20	123.90	6.21	70	2.17	68.17	0.00000	127.45	82.897
Marín, Agrela	42.38064	-8.66778	12.80	43.60	6.77	65	0.48	6.13	0.00000	342.79	7.393
Marín, Gorgadas	42.33878	-8.72917	13.40	67.10	6.31	80	1.47	68.68	0.86250	224.58	25.298
Vilaboa, Portiño	42.33289	-8.66764	13.70	46.50	6.71	90	1.55	100.75	-	110.57	0.690
Vilaboa, Maior	42.33211	-8.66083	14.30	42.30	7.37	60	1.90	-	0.00000	57.64	0.188
Coruxo, Gontade	42.17664	-8.78444	14.00	66.00	6.81	95	0.20	2.88	0.49250	328.28	9.333
Coruxo, Saiáns	42.16736	-8.79714	14.10	106.40	6.47	90	0.54	10.52	0.00000	81.52	33.864
Gondomar, Peitieiros	42.08669	-8.73131	13.00	37.90	6.77	45	1.30	13.10	0.07117	152.83	29.101
Gondomar, Mordagáns	42.11244	-8.72339	13.00	53.10	6.76	70	1.73	117.64	0.00000	133.89	5.024

Mondariz, da Vida	42.17842	-8.58033	13.40	51.00	6.50	60	1.10	21.22	0.0900	271.78	0.276
Mondariz, Cillarga	42.21158	-8.56094	13.00	34.20	6.50	45	0.98	3.03	0.2650	196.92	0.374
Porriño, da Fraga	42.21444	-8.58953	13.10	31.70	6.60	90	1.93	18.63	0.1017	229.85	0.176
Porriño, Louro	42.17589	-8.60692	14.00	61.90	5.80	70	0.52	8.63	1.4317	138.39	0.182
Campo Lameiro, Grande	42.53258	-8.48572	11.50	20.20	6.74	70	1.63	22.45	0.0000	205.02	0.095
Campo Lameiro, Teixoeiras	42.54658	-8.54872	11.10	26.10	6.81	90	1.56	11.17	0.0000	205.24	0.091
Pontevedra, Seixiña	42.53839	-8.46836	12.50	26.40	6.31	80	0.83	3.07	0.0000	270.02	0.160
Pontevedra, As Laceiras	42.53042	-8.41822	11.30	24.00	6.32	60	1.63	30.26	0.0000	50.92	0.962
Ponteareas, Xabriña	42.20158	-8.42372	11.80	36.80	6.32	80	2.23	23.69	0.2867	238.97	0.161
Ponteareas, Fragón	42.19333	-8.45972	12.30	61.60	6.20	90	1.64	27.09	0.0650	87.74	0.000
Mean			13.02	57.60	6.51	74.50	1.30	29.49	0.19	186.84	13.57

Table A2. Modelling macroinvertebrate abundance in relation to environmental variables. Models were fitted by REML with stream as a random term and are ranked by increasing Akaike's Information Criterion corrected for small samples (AICc). Sample size (n) and the number of parameters (K) are indicated. Models in bold are those more supported judging by their Akaike weight. Models in **green** are similar to the first model in their statistical support.

Rank	Model	Deviance	AIC	n	K	AICc	deltaAICc	relative Likelihood	Akaike Weight
1	**Season+Flow+Temperature**	**509.00**	**551.50**	**39**	**3**	**552.19**	**0.00**	**1.00**	**0.35**
2	**Season+Flow+Temperature+Conductivity**	**505.50**	**552.46**	**39**	**4**	**553.64**	**1.45**	**0.48**	**0.17**
3	**Season+Flow+Temperature+Weigth native**	**504.61**	**553.16**	**39**	**4**	**554.34**	**2.15**	**0.34**	**0.12**
4	**Season+Flow+Temperature+% Eucalypt**	**496.92**	**553.39**	**39**	**4**	**554.57**	**2.38**	**0.30**	**0.11**
5	**Season+Flow+Temperature+Width**	**497.86**	**553.45**	**39**	**4**	**554.63**	**2.44**	**0.30**	**0.10**
6	**Season+Flow+Temperature+Weigth eucalypt**	**504.48**	**553.62**	**39**	**4**	**554.80**	**2.61**	**0.27**	**0.10**
7	Season+Flow	524.69	556.48	39	2	556.81	4.63	0.10	0.03
20	Season+FBPOM	516.69	558.66	39	2	558.99	6.81	0.03	0.01
29	FBPOM	530.91	560.22	39	1	560.33	8.14	0.02	0.01
8	Flow	546.18	565.63	39	1	565.74	13.55	0.00	0.00
9	Season+Temperature	528.63	567.99	40	2	568.31	16.13	0.00	0.00
10	Season+Conductivity	536.15	568.43	40	2	568.75	16.57	0.00	0.00
11	Season+Width	528.70	569.55	40	2	569.87	17.69	0.00	0.00
12	Season	543.21	571.49	40	1	571.60	19.41	0.00	0.00
13	Season+Weigth eucalypt	537.91	572.87	40	2	573.19	21.01	0.00	0.00
14	Season+CPOM	543.25	572.88	40	2	573.20	21.02	0.00	0.00
15	Season+Weigth native	538.62	573.06	40	2	573.38	21.20	0.00	0.00
16	Season+Shadow	538.78	573.12	40	2	573.44	21.26	0.00	0.00
17	Season+pH	530.86	573.15	40	2	573.47	21.29	0.00	0.00
18	Season+Chlorophyl	539.43	573.40	40	2	573.72	21.54	0.00	0.00
19	Season+% Eucalypt	531.17	573.54	40	2	573.86	21.68	0.00	0.00
21	Conductivity	555.16	574.95	40	1	575.06	22.87	0.00	0.00
22	Temperature	548.32	575.31	40	1	575.42	23.23	0.00	0.00
23	Weigth native	554.01	575.67	40	1	575.78	23.59	0.00	0.00
24	CPOM	558.93	575.88	40	1	575.99	23.80	0.00	0.00
25	Width	547.85	576.21	40	1	576.32	24.13	0.00	0.00
26	Weigth eucalypt	556.22	578.77	40	1	578.88	26.69	0.00	0.00
27	Shadow	557.78	579.72	40	1	579.83	27.64	0.00	0.00
28	pH	550.01	579.82	40	1	579.93	27.74	0.00	0.00

30	% Eucalypt	550.04	579.98	40	1	580.09	27.90	0.00	0.00
31	Chlorophyl	558.50	580.15	40	1	580.26	28.07	0.00	0.00

Table A3. Modelling macroinvertebrate richness in relation to environmental variables. Models were fitted by REML with stream as a random term and are ranked by increasing Akaike's Information Criterion corrected for small samples (AICc). Sample size (n) and the number of parameters (K) are indicated. Models in bold are those more supported judging by their Akaike weight. Models in green are similar to the first model in their statistical support.

Rank	Model	Deviance	AIC	n	K	AICc	deltaAICc	relative Likelihood	Akaike Weight
1	**Season+FBPOM**	**203.10**	**218.86**	**39**	**2**	**219.19**	**0.00**	**1.00**	**0.32**
2	**% eucalyp+Season+FBPOM**	**198.93**	**220.05**	**39**	**3**	**220.74**	**1.54**	**0.46**	**0.15**
3	**Season+Flow**	**214.90**	**220.86**	**39**	**2**	**221.19**	**2.00**	**0.37**	**0.12**
4	Season+Flow+Temperature	212.95	221.62	39	3	222.31	3.11	0.21	0.07
5	% Eucalypt+Season+Flow	210.39	221.67	39	3	222.36	3.16	0.21	0.06
6	Season	212.38	223.25	40	1	223.36	4.16	0.12	0.04
7	% Eucalypt+Season+Flow+Weight native	213.62	222.85	39	4	224.03	4.83	0.09	0.03
8	Season+Temperature	210.42	223.90	40	2	224.22	5.03	0.08	0.03
9	% Eucalypt+Season	207.97	224.04	40	2	224.36	5.17	0.08	0.02
10	% Eucalypt+Season+Temperature	205.18	223.84	40	3	224.51	5.31	0.07	0.02
11	% Eucalypt+Season+Flow+Weight eucalypt	212.80	223.42	39	4	224.60	5.40	0.07	0.02
12	Season+Width	209.86	224.70	40	2	225.02	5.83	0.05	0.02
13	Weigth eucalypt+Season	216.11	224.87	40	2	225.19	6.00	0.05	0.02
14	Season+pH	209.10	225.06	40	2	225.38	6.19	0.05	0.01
15	Season+CPOM	221.56	225.18	40	2	225.50	6.31	0.04	0.01
16	Season+Conductivity	218.83	225.28	40	2	225.60	6.41	0.04	0.01
17	Season+Shadow	217.07	225.30	40	2	225.62	6.43	0.04	0.01
18	Season+Chlorophyl	217.39	225.32	40	2	225.64	6.45	0.04	0.01
19	Weigth native+Season	216.95	225.32	40	2	225.64	6.45	0.04	0.01
20	% Eucalypt+Season+Weight native	211.55	225.48	40	3	226.15	6.95	0.03	0.01

Rank	Model	Deviance	AIC	n	K	AICc	deltaAICc	relative Likelihood	Akaike Weight
21	% Eucalypt+Season+Weight eucalypt	210.44	225.66	40	3	226.33	7.13	0.03	0.01
22	FBPOM	217.21	229.37	39	1	229.48	10.28	0.01	0.00
23	Flow	231.86	233.85	39	1	233.96	14.76	0.00	0.00
24	Weigth native	232.69	237.07	40	1	237.18	17.98	0.00	0.00
25	% Eucalypt	225.88	238.16	40	1	238.27	19.07	0.00	0.00
26	CPOM	238.95	238.74	40	1	238.85	19.65	0.00	0.00
27	Temperature	229.67	239.25	40	1	239.36	20.16	0.00	0.00
28	Width	228.88	239.71	40	1	239.82	20.62	0.00	0.00
29	pH	228.12	240.07	40	1	240.18	20.98	0.00	0.00
30	Chlorophyl	235.84	240.11	40	1	240.22	21.02	0.00	0.00
31	Weigth eucalypt	235.28	240.14	40	1	240.25	21.05	0.00	0.00
32	Conductivity	237.82	240.27	40	1	240.38	21.18	0.00	0.00
33	Shadow	235.84	240.31	40	1	240.42	21.22	0.00	0.00

Table A4. Modelling macroinvertebrate diversity (Shannon index) in relation to environmental variables. Models were fitted by REML with stream as a random term and are ranked by increasing Akaike's Information Criterion corrected for small samples (AICc). Sample size (n) and the number of parameters (K) are indicated. Models in bold are those more supported judging by their Akaike weight. Models in green are similar to the first model in their statistical support.

Rank	Model	Deviance	AIC	n	K	AICc	deltaAICc	relative Likelihood	Akaike Weight
1	**% Eucalypt+Season+Width+pH**	**-22.50**	**-29.68**	**40**	**4**	**-28.54**	**0.00**	**1.00**	**0.43**
2	**% Eucalypt+Season+Width**	**-22.57**	**-27.88**	**40**	**3**	**-27.21**	**1.32**	**0.52**	**0.22**
3	% Eucalypt+Season+Width+Weight eucalypt	-13.92	-26.23	40	4	-25.09	3.45	0.18	0.08
4	% Eucalypt+Season+Width+Weight native	-12.28	-25.96	40	4	-24.82	3.72	0.16	0.07
5	% Eucalypt+Season+Width+Flow	-9.53	-25.94	39	4	-24.76	3.77	0.15	0.07
6	% Eucalypt+Season+Flow	-11.01	-25.31	39	3	-24.62	3.91	0.14	0.06
7	% Eucalypt+Season+pH	-20.35	-24.22	40	3	-23.55	4.98	0.08	0.04
8	% Eucalypt+Flow	-9.78	-22.14	39	2	-21.81	6.73	0.03	0.01
9	% Eucalypt+Season	-19.36	-21.70	40	2	-21.38	7.16	0.03	0.01

10	% Eucalypt+Season+Weight eucalypt	-10.39	-19.71	40	3	-19.04	9.49	0.01	0.00
11	% Eucalypt+Season+Weight native	-9.05	-19.64	40	3	-18.97	9.56	0.01	0.00
12	% Eucalypt+Season+CPOM	-3.88	-19.61	40	3	-18.94	9.59	0.01	0.00
13	Season	-17.08	-18.28	40	1	-18.17	10.36	0.01	0.00
14	% Eucalypt+Width	-14.95	-17.96	40	2	-17.64	10.90	0.00	0.00
15	% Eucalypt+pH	-14.18	-15.84	40	2	-15.52	13.02	0.00	0.00
16	% Eucalypt	-13.09	-13.18	40	1	-13.07	15.46	0.00	0.00
17	% Eucalypt+Weight eucalypt	-5.72	-12.88	40	2	-12.56	15.98	0.00	0.00
18	% Eucalypt+CPOM	0.71	-12.79	40	2	-12.47	16.07	0.00	0.00
19	% Eucalypt+Weight native	-4.28	-12.66	40	2	-12.34	16.20	0.00	0.00
20	Flow	-1.65	-12.04	39	1	-11.93	16.61	0.00	0.00
22	Width	-9.83	-11.32	40	1	-11.21	17.32	0.00	0.00
21	% Eucalypt+FBPOM	-10.52	-11.44	39	2	-11.11	17.43	0.00	0.00
27	Weigth native	-3.24	-11.02	40	1	-10.91	17.62	0.00	0.00
23	% Eucalypt+Shadow	-2.57	-11.22	40	2	-10.90	17.64	0.00	0.00
24	% Eucalypt+Chlorophyl	-2.22	-11.22	40	2	-10.90	17.64	0.00	0.00
25	% Eucalypt+Temperature	-7.96	-11.22	40	2	-10.90	17.64	0.00	0.00
26	% Eucalypt+Conductivity	-0.69	-11.21	40	2	-10.89	17.65	0.00	0.00
33	FBPOM	-7.84	-7.55	39	1	-7.44	21.10	0.00	0.00
28	Weigth eucalypt	1.02	-6.32	40	1	-6.21	22.32	0.00	0.00
29	CPOM	6.71	-5.44	40	1	-5.33	23.20	0.00	0.00
30	pH	-5.24	-5.02	40	1	-4.91	23.62	0.00	0.00
31	Shadow	4.50	-2.79	40	1	-2.68	25.85	0.00	0.00
32	Conductivity	6.36	-2.72	40	1	-2.61	25.92	0.00	0.00
34	Chlorophyl	5.41	-2.13	40	1	-2.02	26.51	0.00	0.00
35	Temperature	-0.22	-2.10	40	1	-1.99	26.54	0.00	0.00

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