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Supplementary material

Negative effects of stagnation and drought on benthic invertebrate communities in lowland streams

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Table S1. Table S1. Summary of the AQEM/STAR substrate categories measured within stretches: control (C), stagnation (S) and drought (D) before and during the experimental flow reduction in both streams

The data are mean (±1 s.d.) values for all the substrate types measured in the study (*n* = 9 in BP, *n* = 15 in DP). AQEM/STAR, the development and testing of an integrated assessment system for the ecological quality of streams and rivers throughout Europe using benthic macroinvertebrates/standardisation of river classifications (AQEM Consortium 2006); CPOM, coarse particulate organic matter; FPOM, fine particulate organic matter; BP, before stagnation–drought period; DP, during stagnation–drought

AQEM/STAR substrate categories	Substrate type (%)	BP			DP		
		C	S	D	C	S	D
Caselas stream							
Mineral substrates							
Megalithal	Boulders	–	–	5.0 ± 0.0	–	–	–
Macrolithal	Blocks	5.0 ± 0.0	5.0 ± 0.0	15.0 ± 0.0	–	7.5 ± 2.5	10.0 ± 0.0
Mesolithal	Cobbles	3.3 ± 1.7	5.0 ± 0.0	2.5 ± 2.5	–	–	12.5 ± 7.5
Microlithal	Coarse gravel, pebbles	11.7 ± 7.3	13.3 ± 4.4	13.3 ± 8.8	18.3 ± 7.3	10.0 ± 0.0	15.0 ± 5.0
Akal	Gravel	16.3 ± 2.4	23.8 ± 3.1	32.0 ± 5.1	26.0 ± 5.0	26.0 ± 6.8	14.0 ± 4.3
Psammal/psammopelal	Sand, mud	38.0 ± 4.6	23.0 ± 4.9	25.0 ± 5.7	24 ± 7.0	27.5 ± 10.3	18.0 ± 7.2
Argyllal	Silt, loam, clay	11.0 ± 2.0	17.0 ± 6.8	17.5 ± 3.2	17 ± 4.0	21.3 ± 6.6	16.7 ± 6.7
Biotic microhabitats							
Algae	Algae	–	–	–	–	30.0 ± 0.0	3.3 ± 3.3
Sub-merged macrophytes	Submerged macrophytes	16.0 ± 7.1	24.0 ± 9.0	7.5 ± 4.8	14.0 ± 6.8	2.5 ± 2.5	20.0 ± 9.1
Emergent macrophytes	Emergent macrophytes	–	–	–	–	–	–
Living parts of terrestrial plants	Bank macrophytes	12.5 ± 4.3	5.0 ± 0.0	13.3 ± 1.7	6.3 ± 1.3	5.0 ± 0.0	10.0 ± 0.0
Xylal (wood)	Woody debris	–	1.7 ± 1.7	–	–	5.0 ± 0.0	2.5 ± 2.5
CPOM	CPOM	1.0 ± 1.0	5.0 ± 2.9	1.3 ± 1.3	–	5.0 ± 0.0	–
FPOM	FPOM	–	–	–	–	–	–
Organic mud	Organic mud	2.5 ± 2.5	6.7 ± 3.3	2.5 ± 2.5	–	–	5.0 ± 2.9
Leaves	Organic	–	3.3 ± 3.3	–	3.0 ± 1.2	16.0 ± 6.6	16.0 ± 3.0
Pego stream							
Mineral substrates							
Megalithal	Boulders	–	17.5 ± 17.5	15.0 ± 5.0	7.5 ± 2.5	–	5.0 ± 0.0
Macrolithal	Blocks	1.3 ± 1.3	7.5 ± 2.5	5.0 ± 0.0	15.0 ± 8.4	6.7 ± 6.7	11.7 ± 4.4
Mesolithal	Cobbles	19.5 ± 5.7	17.5 ± 6.0	24.0 ± 8.6	32.0 ± 4.9	28.0 ± 6.6	13.8 ± 2.4
Microlithal	Coarse gravel, pebbles	13.0 ± 4.6	11.3 ± 3.1	25.0 ± 5.9	7.5 ± 1.4	10.0 ± 0.0	10.0 ± 10.0

AQEM/STAR substrate categories	Substrate type (%)	BP			DP		
		C	S	D	C	S	D
Akal	Gravel	6.3 ± 4.7	7.5 ± 2.5	7.5 ± 1.4	–	6.7 ± 3.3	5.0 ± 0.0
Psammal/psammopelal	Sand, mud	30.0 ± 2.2	17.0 ± 3.4	23.0 ± 5.4	23.8 ± 2.4	18.0 ± 4.9	21.0 ± 4.8
Argyllal	Silt, loam, clay	15.0 ± 5.0	–	7.5 ± 2.5	3.3 ± 3.3	10.0 ± 5.8	8.3 ± 1.7
Biotic microhabitats							
Algae	Algae	–	10.0 ± 2.0	–	–	–	5.0 ± 2.9
Sub-merged macrophytes	Submerged macrophytes	6.0 ± 4.0	31.0 ± 7.8	4.0 ± 1.0	6.0 ± 1.9	–	14.0 ± 9.1
Emergent macrophytes	Emergent macrophytes	–	–	–	–	–	–
Living parts of terrestrial plants	Bank macrophytes	10.0 ± 5.0	–	10.0 ± 0.0	11.0 ± 3.3	–	10.0 ± 0.0
Xylal (wood)	Woody debris	1.3 ± 1.3	1.7 ± 1.7	2.5 ± 2.5	2.5 ± 1.4	7.0 ± 1.2	3.8 ± 2.4
CPOM	CPOM	3.1 ± 1.9	3.3 ± 3.3	2.5 ± 2.5	–	–	–
FPOM	FPOM	–	–	–	–	–	–
Organic mud	Organic mud	2.5 ± 2.5	–	2.5 ± 2.5	3.0 ± 2.0	12.5 ± 2.5	8.8 ± 4.3
Leaves	Organic	2.5 ± 2.5	5.0 ± 5.0	–	4.0 ± 1.9	19.0 ± 4.3	19.0 ± 4.6

Table S2. List of taxa inhabiting the studied streams and the average abundance of each taxa for each stream

Those specific taxa that account for most of the differences between streams assessed by SIMPER are shown in bold

Species name	Average abundance Caselas stream	Average abundance Pego stream
Leuctra geniculata	0.00	4.21
***Dupophilus* sp. Lv.**	0.00	3.55
Sericostoma vittatum	5.51	2.60
Oulimnius sp. Ad.	4.37	1.41
Elmis sp. Lv.	1.81	3.70
Habrophlebia lauta	3.66	1.79
Hexatoma sp.	4.41	1.42
Serratella ignita	4.22	1.93
Naididade Gen. sp.	0.76	3.13
Polycentropus flavomaculatus	0.00	2.86
Oulimnius sp. Lv.	4.09	2.69
***Lymnaea* sp.**	0.00	2.69
Calliarcys humilis	3.12	1.31
Tubicifidae Gen. sp.	3.56	2.41
Oxyethira frici	2.33	3.39
Leuctra gr. *fusca*	6.51	4.51
Atrichops crassipes	2.75	4.36
Prosimulium sp.	1.66	2.50
Ibisia marginata	2.30	3.37
Allogamus ligonifer	0.00	2.34
Ancylus fluviatilis	3.19	4.64
Hemerodromia sp.	0.68	2.42
Hydra sp.	1.07	2.30
Physella acuta	2.73	3.59
Dugesia sp.	1.74	3.38
Lype auripilis	2.34	2.35
Echinogammarus lusitanus	2.77	1.22
Baetis rhodani	2.23	1.02
Onychogomphus uncatus	3.71	2.03
Ceratopogonidae Gen. sp.	4.41	2.52
Lepidostoma hirtum	3.87	2.68
Brillia bifida	4.71	4.32
Mystacides azurea	2.17	0.25
Wiedemannia sp.	1.40	1.37
Caenis luctuosa	0.18	1.92
Rhyacophila adjuncta	1.88	0.45
Oecites testacea	1.54	1.53
Pisidium sp.	4.54	5.32
Hydropsychidae Gen. sp.	1.76	0.86
Calopteryx virgo	2.77	1.56
Sericostomatidae Gen. sp.	1.12	1.15
Hydraena sp. Lv.	1.69	0.75
Lumbricidae Gen. sp.	1.24	1.18
Hydrachnidia Gen. sp.	4.03	5.56
Psychomyia pusilla	0.00	1.58
Polycentropus kingi	1.74	0.65
Schizopelex festiva	0.00	1.62
Cordulegaster boltoni	2.74	2.13
Boyeria irene	2.08	1.90
Tanytarsini Gen. sp.	7.05	7.10
Limnius sp. Ad.	1.23	1.43

Species name	Average abundance Caselas stream	Average abundance Pego stream
Potamopyrgus antipodarum	8.14	6.73
Adicella reducta	0.53	1.32
Hydropsyche siltalai	1.46	0.18
Paraleptophlebia cincta	0.00	1.44
Limnius sp. Lv.	4.22	5.15
Lumbriculidae Gen. sp.	4.98	5.70
Tanypodinae Gen. sp.	5.12	6.07
Halesus radiatus	0.37	1.29
Glossosoma privatum	0.90	0.74
Gerris sp.	0.99	0.43
Chironomini Gen. sp.	5.45	6.15
Orthocladiinae Gen. sp.	5.83	5.42
Sialis lutaria	0.50	0.93
Pyrrhosoma nymphula	0.92	0.53
Simulium sp.	1.05	0.00
Nematoda Gen. sp.	1.07	0.18
Silo nigricornis	0.00	0.98
Elmis sp. Ad.	0.42	0.80
Enchytraeidae Gen. sp.	0.94	0.00
Gyrinus sp. Lv.	0.71	0.25
Ostracoda Gen. sp.	0.89	0.00
Tipula sp.	0.66	0.39
Wormaldia lusitanica	0.62	0.39
Polycelis sp.	0.83	0.00
***Psychoda* sp.**	0.00	0.74
Berdeniella sp.	0.38	0.56
Atherix ibis	0.18	0.64
***Baetis* sp.**	0.00	0.70
***Hydropsyche* sp.**	0.00	0.70
Oxygastra curtisi	0.00	0.69
Dixa sp.	0.77	0.00
Proasellus meridianus	0.61	0.18

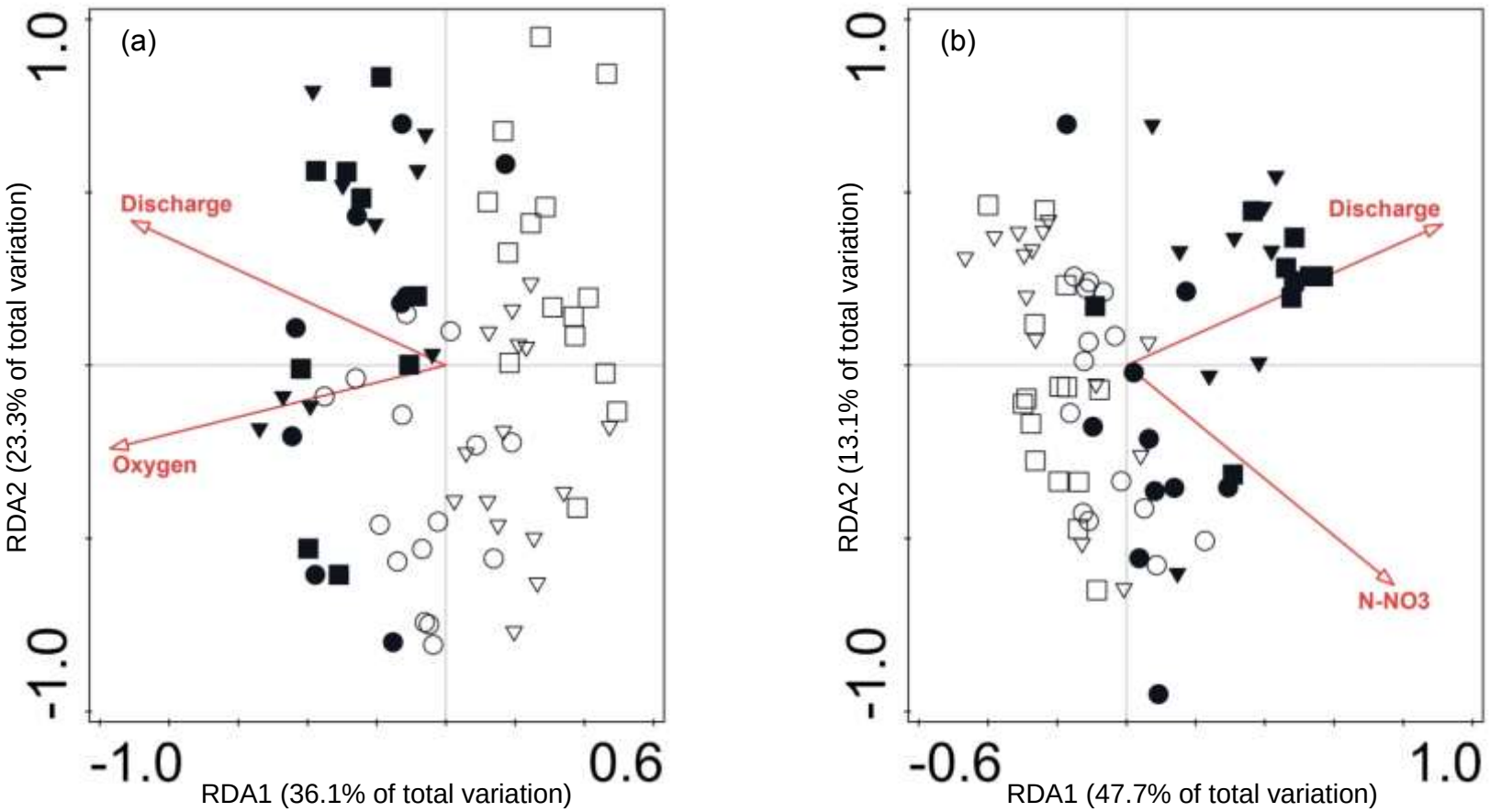

Fig. S1. Distance-based redundancy analysis (db-RDA) biplot of first and second axes relating those water chemistry parameters that better explain benthic invertebrate structure during the whole experiment: (*a*) Caselas stream and (*b*) Pego stream. Samples collected before the experiment are represented with open symbols and samples collected during the experimental water abstraction are represented with closed symbols. Different stretches are shown with different symbols (control, circles; stagnant, squares; drought, triangles)

Reference

AQEM Consortium (2006). ASTERICS: AQEM/STAR ecological river classification system. Available at http://www.fliessgewaesserbewertung.de/en/download/probenahme-sortierung [Verified 18 May 2012].