Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen

ISSN: 0368-0770 (Print) (Online) Journal homepage: http://www.tandfonline.com/loi/tinw19

Aquatic macroinvertebrate biodiversity in the Segura River Basin (SE Spain)

A. Mellado, M. L. Suárez, J. L. Moreno & M. R. Vidal-Abarca

To cite this article: A. Mellado, M. L. Suárez, J. L. Moreno & M. R. Vidal-Abarca (2002) Aquatic macroinvertebrate biodiversity in the Segura River Basin (SE Spain), Internationale Vereinigung für theoretische und angewandte Limnologie: Verhandlungen, 28:2, 1157-1162, DOI: 10.1080/03680770.2001.11901899

To link to this article: https://doi.org/10.1080/03680770.2001.11901899

Published online: 01 Dec 2017.

Verh. Internat. Verein. Limnol.	28	1157–1162	Stuttgart, July 2002

Aquatic macroinvertebrate biodiversity in the Segura River Basin (SE Spain)

A. Mellado, M. L. Suárez, J. L. Moreno & M. R. Vidal-Abarca

Introduction

The aquatic invertebrate fauna of the Segura River catchment is poorly known. Although there are a few studies, most are taxonomic in nature, based on groups such as the Mollusca (GOMEZ CEREZO 1988), Heteroptera (MILLÁN et al. 1988), Coleoptera (GIL et al. 1990, MILLÁN et al.1993), and Ephemeroptera or Plecoptera (UBERO-PASCAL et al. 1998). This paper presents the results of a broad-scale survey undertaken in summer 1998 as part of a regional project to assess the ecological status (sensu the EU Water Framework Directive) of the rivers in this study area, one of the most anthropogenically impacted river basins in Spain. The main aim of the survey was to characterise the macroinvertebrate fauna of the study area and to identify the main spatial patterns of distribution across environmental gradients using classification and ordination techniques.

Study area

The Segura basin is located in the south-east of the Iberian Peninsula (Fig. 1). It flows from the north-west to the south-east and drains a basin of 14,432 km^2. The climate ranges from humid in the mountains of the north-west to semi-arid elsewhere. There is a NW–SE gradient in relation to flow. The lithology of the plains is characterised by the predominance of marls and some volcanic areas, whereas calcites, dolomites and shales are the predominant rocks in the mountain head waters. Approximately 79% of the mapped water courses are ephemeral streams that are dry throughout any given year and only flow during fast flood events. Only 21% are seasonal or permanent streams.

Methods

Macroinvertebrate sampling was carried out in summer 1998 at 60 sampling sites (Fig. 1). Thirty-three streams were sampled. The sampling sites were chosen taking into account the climatic, geographic and physico–chemical variability (both natural and anthropogenic) of the study area, and in an effort to consider sites belonging to all of the ecoregions identified (VIDAL-ABARCA et al. 1990).

Invertebrates were collected with a 500-µm mesh handnet. All of the identified habitats (pools, riffles, banks, main channel, submerged macrophytes, etc.) in each site (an approx. 100-m reach) were sampled. Invertebrates were separated in the field using a portable aspirator and preserved in 70% ethanol for subsequent identification. Most taxa were identified to family level, with the exception of several groups that were placed in higher taxonomic categories.

At each site, 16 environmental variables were measured (Table 1). The pH, water temperature, conductivity at 25 °C and mean depth categories were measured in the field with portable meters. Duplicate water samples were taken at each site for laboratory measurements of dissolved oxygen, BOD$_5$, alkalinity, total suspended solids and nutrient levels of soluble reactive phosphorus, nitrite, nitrate and ammonia. Altitude and distance from source were both calculated using 1:100,000 and 1:50,000 topographic maps. Two indices were used as river health indicators: the BMWP' index, the British BMWP modified for the Iberian Peninsula (ALBA-TERCEDOR & SANCHEZ-ORTEGA 1988) and the QBR index (MUNNÉ et al. 1998) to evaluate the quality of riparian ecosystems.

Presence/absence data were used. Singleton taxa were masked out of the analysis, the resulting data set consisting of 60 sites and 81 taxa. Environmental variables were log-transformed.

A site classification was made in order to differentiate distinct groups of sites according to their macroinvertebrate communities. These groups were then superimposed on a Canonical Correspondence Analysis (CCA) ordination diagram in order to identify the main environmental trends. Sites were clustered with the flexible unweighted pair-group method using arithmetic averages (UPGMA) with the Sørensen coefficient to calculate similarities using the MVSP 3.11h package. Variations in macroinvertebrate data were directly compared with the mea-

0368-0770/02/0028-1157 $ 1.50

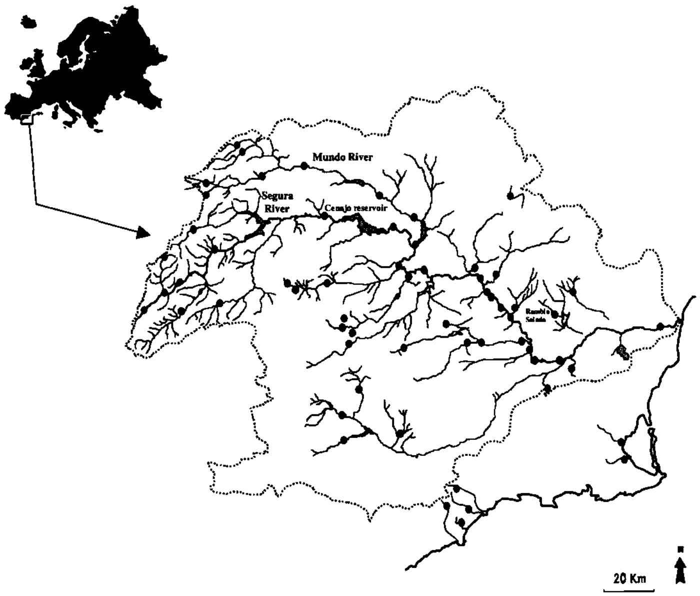

Fig. 1. Study area showing locations of the 60 sampling sites (black circles). Only the main rivers in the basin and the reservoirs mentioned in the text are named.

sured environmental variables by CCA (TER BRAAK 1986).

Results and discussion

Ninety-three taxa were collected (Table 2). Most organisms were identified at the family level (87) and others at higher levels: Phylum Nematoda, Class Oligochaeta, Class Hirudinea, Subclass Ostracoda, Order Tricladida and Hydracarina Group (with no taxonomic value). Diptera (16 families) and Coleoptera (15 families) were the richest orders, followed by Heteroptera (11 families), Ephemeroptera, Trichoptera and Odonata (all 3 with 9 families).

The classification of the 60 sampling sites enabled the distinction of eight groups of sites (Fig. 2): six major groups, a group of four members and another of two members. The following method was used to discriminate between groups: Group 1 was separated from all other groups by the first dendrogram division, Group 2 by the second division and so on.

Groups 1 and 2 consisted of heavily impacted sites, organically polluted lowland reaches of the Segura River and other streams near important towns receiving urban, industrial and/or agricultural waste waters. The biological quality of their waters was very low. Oligochaeta, Chironomidae and the snail Physidae were among pollution-tolerant taxa generally found in this group (Fig. 3B).

Groups 3 and 4 were the most difficult to interpret. Group 3 consisted of four temporal water bodies, which were almost dry at the time of sampling, consisting of isolated pools without flow. Only two sites formed Group 4, one with a high diversity (20 taxa) located in the upper catchment and another with only nine taxa located at the exit of the Cenajo Reservoir.

Sites in Group 5 were semi-arid streams (locally known as 'ramblas'), which are wide, usually dry, channels flowing only in fast-flood events, although in some reaches small permanent or temporary streams, springs or pools can be formed by either groundwater seepage in the stream bed or by waste water from human activities. Some of these water bodies flow across salt-rich rocks such as sedimentary Miocene marls and gypsum and therefore their salinity is naturally high (MORENO et al. 1997).

Table 1. Mean and SD of environmental variables in each of the eight UPGMA classification groups of 60 sites and 81 taxa. Variable codes used in Fig. 3(A) and a brief group description are shown.

	UPGMA group:	1		2		3		4		5		6		7		8	
	Group description:	Heavily impacted sites		Heavily impacted sites		Isolated pools		Not definable		Semi-arid 'ramblas'		Middle Segura and Mundo Rivers		Middle catchment tributaries		Upper headwaters	
	Number of sites:	8		10		4		2		13		6		10		7	
Variable	Variable code	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
pH	pH	8.1	0.44	8.27	0.21	7.94	0.82	8.49	0.02	8.14	0.28	8.35	0.06	7.95	0.71	8.42	0.38
Water temperature (°C)	Tw	21.81	6.32	22.2	1.86	17.0	5.1	19.5	2.12	21.77	5.29	21.25	2.32	22.9	4.05	17.07	4.07
Conductivity at 25 °C (μS cm^{-1})	Con25°	5228.45	5899.88	1820.6	1708.48	1226.2	1167.56	420.9	30.97	16,278.97	24,287.55	649.6	229.6	3061.64	2990.83	532.14	267.32
Dissolved oxygen (mg L^{-1})	O2	5.45	2.45	4.37	2.38	8.49	2.78	7.7	0.04	8.07	3.79	10.01	3.02	8.01	1.56	7.91	1.0
Oxygen demand (mg L^{-1})	BOD5	1.78	2.09	2.16	1.89	2.35	1.38	2.71	2.1	2.95	4.32	4.34	3.04	1.28	0.87	1.97	0.7
Suspended solids (mg L^{-1})	SS	0.03	0.01	0.02	0.01	0.01	0.0	0.03	0.02	0.06	0.11	0.02	0.02	0.01	0.01	0.01	0.01
Alkalinity (meq L^{-1})	Alka	4.92	2.58	3.9	1.69	4.3	1.78	3.72	1.63	4.41	2.51	2.75	0.92	4.39	0.58	3.34	0.8
Altitude (m a.s.l.)	Alt	352.88	273.75	231.7	164.3	665.0	338.08	785.0	530.33	440.0	402.72	463.33	146.38	518.5	411.92	1028.57	201.2
N-Nitrite (mg L^{-1})	NO2	81.72	127.08	56.98	95.35	0.8	0.29	0.44	0.47	50.7	87.85	1.17	0.69	36.78	55.1	1.05	1.25
N-Nitrate (mg L^{-1})	NO3	1790.33	1183.35	907.51	544.09	2645.04	3200.24	20.1	28.43	5269.63	7775.0	620.01	503.19	4411.14	3775.0	438.6	220.57
N-Ammonia (mg L^{-1})	NH4	760.21	1241.56	876.96	2019.00	21.68	41.83	0.0	0.0	299.12	991.53	12.66	11.31	47.74	88.49	1.84	4.86
Soluble reactive phosphorus (mg L^{-1})	SRP	356.64	490.36	257.12	471.87	14.11	16.68	6.38	0.82	179.16	623.53	11.31	4.8	29.82	82.07	20.65	18.7
QBR (Riparian forest quality index)	QBR	28.13	28.65	19.0	17.61	62.5	40.93	52.5	60.1	40.0	25.82	74.17	18.82	54.5	26.71	72.86	23.95
BMWP′ (Macroinvertebrate index)	BMWP′	21.88	12.7	30.3	15.66	57.0	30.82	73.0	56.57	80.15	31.62	104.17	27.74	102.6	23.85	150.43	37.48
Mean depth (category 1–5)*	Depth	3.29	1.6	4.22	1.3	2.0	1.41	3.5	2.12	2.5	1.73	3.5	1.22	1.9	0.88	2.29	0.49
Distance from source (km)	DFS	109.14	105.17	142.4	74.69	6.0	12.0	55.0	69.3	2.42	2.78	74.17	34.61	6.1	7.2	13.14	7.56

*Depth categories: 1, 1–10 cm, 2, 11–30 cm, 3, 30–50 cm, 4, 50–100 cm, 5, >100 cm

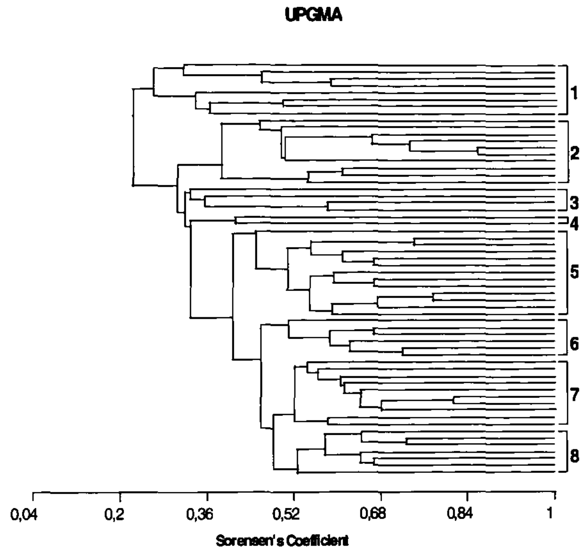

Fig. 2. Dendrogram of a UPGMA classification of 60 sampling sites in the Segura River basin based on the presence–absence matrix of 81 taxa collected. See Results and discussion for a description of groups.

The mean BMWP' index for this group was indicative of good water quality. The general taxa associated with ramblas were a range of lentic families of Heteroptera and Odonata, or organisms with a high osmotic regulation capacity capable of tolerating salinity, such as Stratiomyidae or Ephydridae, among others.

Group 6 was composed of six sites in the middle reaches of the Segura River and the Mundo River, its main affluent, with a strong influence of high summer flows from reservoirs for irrigation purposes (SUÁREZ & VIDAL-ABARCA 2000). BMWP' values were high and the riparian forest index QBR reached its highest levels. Heptageniidae, Potamanthidae, Hydrometridae, Gerridae or Tipulidae were the families generally found at these sites.

Group 7 comprised 10 sites of good water quality distributed through some of the main tributaries in the middle catchment – mostly headwater freshwater sites supporting complex macroinvertebrate communities, with families such as Simulidae, Dixidae, Gyrinidae, Dryopidae, Caenidae, Lymnaeidae and Hydrobiidae.

Finally, Group 8, with 7 mountain headwater sites in the upper north-western part of the basin, represented the most diverse sites of the study. Typical pollution-sensitive taxa scoring highly in the BMWP' index, such as Cordulegasteridae, Gomphidae, Leptophlebiidae, Polycentropodidae, Rhyacophilidae, Limnephilidae, or Leuctridae, were found at sites in this group.

The first two CCA axes explained 34.3% of the macroinvertebrate/environment variation and 12.3% of macroinvertebrate variance. The arrangement of sites in relation to the 16 environmental variables showed a broad separation along axis 1 (7.8% of macroinvertebrate variance) based on water quality parameters (BMWP', QBR, dissolved oxygen, nitrite, ammonia and conductivity) and altitude. A second environmental gradient could be identified along axis 2 (4.5% variance) linking macroinvertebrate distribution with distance from source.

UPGMA group polygons were superimposed on the CCA diagram (Fig. 3). Groups 1 and 2 (heavily impacted) clearly overlapped but were isolated from the other sites in the diagram; however, two sites belonging to Groups 4 and 5

Table 2. List of taxa of the study area with the abbreviations used in Fig. 3B. Note that only the families that were used for the analysis have abbreviations

Diptera		**Ephemeroptera**		**Odonata**	
Chironomidae	Chiro	Baetidae	Bae	Aeshnidae	Aesh
Simuliidae	Simu	Caenidae	Cae	Libellulidae	Libe
Tipulidae	Tipu	Heptageniidae	Hept	Gomphidae	Gomp
Dixidae	Dyx	Leptophlebiidae	Lepto	Coenagrionidae	Coen
Ceratopogonidae	Cera	Potamanthidae	Pota	Cordulegasteridae	Cogas
Stratiomyidae	Strat	Ephemerellidae	Ephll	Calopterygidae	Calop
Culicidae	Culic	Ephemeridae	Ephe	Corduliidae	Cord
Ephydridae	Ephy	Oligoneuridae		Platycnemididae	Platy
Psychodiidae	Psyc	Polymirtacyidae		Lestidae	
Athericidae	Athe				
Tabanidae	Taba	**Heteroptera**		**Mollusca**	
Thaumaleidae	Thau	Notonectidae	Noto	Hydrobiidae	Hydrobi
Anthomyidae	Anth	Corixidae	Corix	Physidae	Phy
Dolichopodidae	Doli	Gerridae	Gerr	Lymnaeidae	Lym
Limoniidae		Veliidae	Velii	Planorbidae	Plano
Syrphidae		Nepidae	Nepi	Thiaridae	Thia
Coleoptera		Hydrometridae	Hydrom	Sphaeriidae	Spha
Dytiscidae	Dyt	Naucoridae	Nau	Ancylidae	Ancy
Hydrophilidae	Hydrophi	Pleidae	Plei	Neritidae	Neri
Hydraenidae	Hdrae	Mesoveliidae	Mesov		
Dryopidae	Dryo	Hebridae	Hebri	**Crustacea**	
Elmidae	Elmi	Ochteridae	Ochte	Gammaridae	Gamm
Haliplidae	Hali			Ostracoda	Ostr
Gyrinidae	Gyr	**Trichoptera**		Astacidae	Astac
Helophoridae	Helo	Hydropsychidae	Hydropsy	Atyidae	Atyi
Scirtidae	Scir	Hydroptylidae	Hydropty	Asellidae	Asell
Curculionidae	Cur	Rhyacophilidae	Rhy		
Limnichidae	Limni	Polycentropodidae	Polyc	**Plecoptera**	
Noteridae	Note	Philopotamidae	Philop	Leuctridae	Leuc
Georissidae	Geo	Lymnephilidae	Lymnep	Nemouridae	Nemo
Hydrochidae		Psychomyiidae		Perlidae	Perli
Heteroceridae		Glossosomatidae		Perlodidae	Perlo
Tricladida	Tricla	Sericostomatidae		**Megaloptera**	
Oligochaeta	Oligo			Sialidae	
Hirudinea	Hirud			**Hydracarina**	Hydrac
				Nematoda	Nema

were very close or within these first two groups: the Group 4 site being a flow-impacted site at the exit of the largest reservoir in the basin, the Cenajo Dam, and the other (Group 5) site, the Rambla Salada, a saline stream with conductivity values of more than 90,000 µS cm^{-1} possessing a very poor macroinvertebrate community adapted to this extreme environment. Group 3 was composed of three sites located within Group 5, 6, and 8 polygons and a site near the Group 7 polygon. Group 4 had one site near Group 8 (upper headwaters) and one near Group 1 (heavily impacted) and was the most difficult group to interpret. Groups 5 and 7 overlapped slightly, reflecting the aridity–salinity gradient responsible for the different communities present in these groups. Groups 6 and 8 were well separated by the CCA despite the aforementioned interference from Group 3.

Acknowledgements

Funding for this project was provided by the Seneca Foundation and the European Fund of Regional Development (PLP10/FS/97). During this work one of the authors (A. M.) had a grant from the Spanish Education and Science Ministry.

References

Alba-Tercedor, J. & Sanchez-Ortega, A., 1988: Un método rápido y simple para evaluar la calidad biológica de las aguas corrientes basado en el de Hellawell (1978). – *Limnética* 4: 51–56.

Gil, E., Montes, C., Millán, A. & Soler, A. G., 1990: Los coleópteros acuáticos (Dryopidae & Elmidae) de la cuenca del río Segura. SE de la Península Ibérica. – *An. Biol.* 16: 23–31.

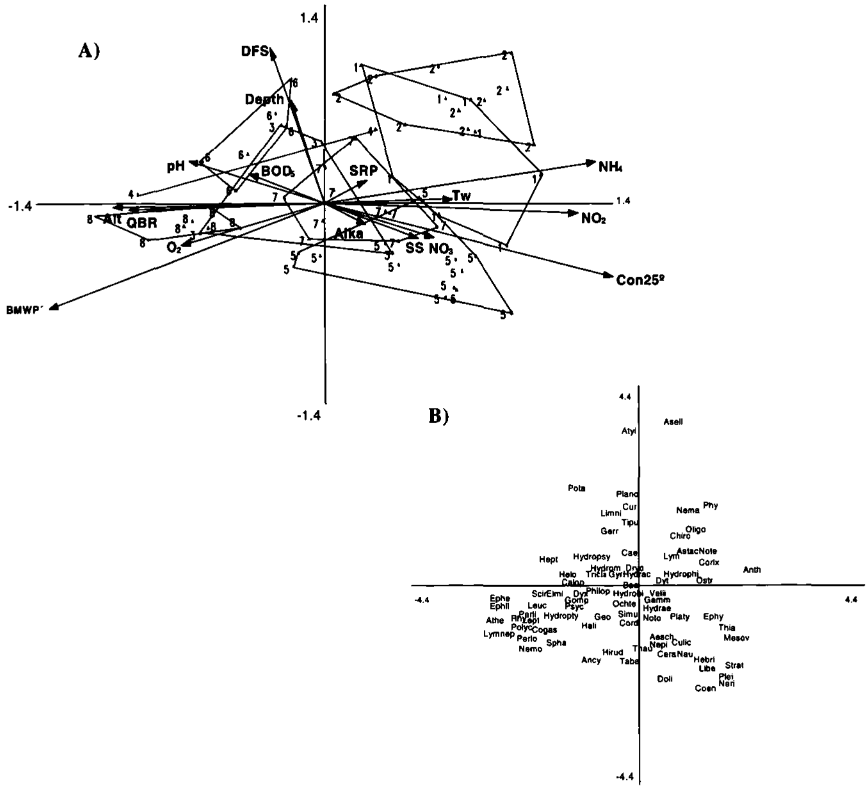

Fig. 3. (A) CCA ordination diagram of sites classified according to their UPGMA classification groups (from 1 to 8). Groups were outlined with polygons. See Table 1 for the environmental variables code descriptions. (B) CCA ordination diagram of taxa.

GOMEZ CEREZO, R. M., 1988: *Los moluscos (Gastropoda & Bivalvia) de las aguas epicontinentales de la cuenca del rio Segura (SE de España).* – Tesis de Licenciatura. Universidad de Murcia.

MILLÁN, A., VELASCO, J., NIESER, N. & MONTES, C., 1988: Heteropteros acuáticos (Gerromorpha y Nepomorpha) de la cuenca del Río Segura, SE España. – *An. Biol.* 15: 74–89.

MILLÁN, A., VELASCO, J. & SOLER, A. G., 1993: Los Coleópteros Hydradephaga de la cuenca del río Segura (SE de la Península Ibérica). Estudio corológico. – *Bol. Asoc. Esp. Entomol.* 17: 19–39.

MORENO, J. L., MILLÁN, A., SUÁREZ, M. L., VIDAL-ABARCA, M. R. & VELASCO, J., 1997: Aquatic Coleoptera and Heteroptera assemblages from ephemeral coastal streams ("ramblas") of south-eastern Spain. – *Arch. Hydrobiol.* 141(1): 93–107.

MUNNÉ, A., SOLA, C. & PRAT, N., 1998: QBR: Un índice rápido para la evaluación de la calidad de los ecosistemas de ribera. – *Tecnol. Agua* 175: 20–37.

MVSP 3.11h. Copyright (1985–2000): Kovach Computing Services. *http://www.kovcomp.com/*

SUÁREZ ALONSO, M. L. & VIDAL-ABARCA, M. R., 2000: Aplicación del índice de calidad del bosque de ribera, QBR (MUNNÉ et al. 1998) a los cauces fluviales de la cuenca del río Segura. – *Tecnol. Agua* 201: 33–45.

TER BRAAK, C. J., 1986: Canonical Correspondence Analysis: A new eigenvector technique for multivariate direct gradient analysis. – *Ecology* 67: 1167–1179.

UBERO-PASCAL, N. A., PUIG, M. A. & SOLER, A. G., 1998: Los Efemerópteros de la Cuenca del río Segura (S.E. de España): 1. Estudio faunístico. (Insecta: Ephemeróptera). – *Bol. Asoc. Esp. Entomol.* 22: 151–170.

VIDAL-ABARCA, M. R., MONTES, C., SUÁREZ, M. L. & RAMIREZ-DIAZ, L., 1990: Sectorización ecologica de cuencas fluviales: aplicación a la cuenca del río Segura (SE España). – *An. Geogr. Univ. Complutense* 10: 149–182.

Authors' address:

A. MELLADO, M. L. SUÁREZ, J. L. MORENO, M. R. VIDAL-ABARCA, Department of Ecology & Hydrology, University of Murcia, Campus de Espinardo, CP 30100 Murcia, Spain. E-mail: amellado@um.es