



Article Assessing the Zooplankton Metacommunity (Branchiopoda and Copepoda) from Mediterranean Wetlands in Agricultural Landscapes

Juan Diego Gilbert ^{1,2,*}, Francisco J. Márquez ¹ and Francisco Guerrero ^{1,2}

- ¹ Department of Animal Biology, Plant Biology and Ecology, University of Jaén, Campus de las Lagunillas, s/n, 23071 Jaén, Spain
- ² Center for Advances Studies in Earth Sciences, Energy and Environment, University of Jaén, Campus de las Lagunillas, s/n, 23071 Jaén, Spain
- * Correspondence: dgilbert@ujaen.es; Tel.: +34-953212796

Abstract: Mediterranean wetlands are suitable ecosystems for studying metacommunity theory, since they are isolated ecosystems within a land matrix with well-established limits, often with watersheds destined for agricultural uses. The zooplankton community of wetlands in agricultural landscapes is the result of processes that operate in a different multiscale context. We selected 24 ponds in Alto Guadalquivir region (SE Spain) with different local environmental variables (biological, limnological and land uses). The zooplankton community of the wetlands under study consists of a total of 60 species: 38 branchiopods and 22 copepods. This community (total, branchiopods and copepods) was analysed through two different and complementary metacommunity approaches. The pattern approach determines the species distribution along environmental gradients, and the mechanistic approach considers the involved processes, such as environmental control and dispersal limitation. The results indicated a nested metacommunity, in which five limnological variables, three land uses and six spatial variables are the main drivers that explain zooplankton distribution in these wetlands. In conclusion, species sorting and dispersal processes play a role in the structuring of the zooplankton metacommunity. This conclusion has implications for the development of adequate management policies on Mediterranean wetland protection and diversity conservation in agricultural contexts.

Keywords: anthropogenic impacts; elements of metacommunity structure; endorheic ponds; redundancy analysis; spatial scale

1. Introduction

The identification of the community structure and species distributions in aquatic ecosystems, along with variation across the landscape, represent a major concern in aquatic ecology [1]. Traditionally, this has been studied at a local scale, driven by environmental factors (i.e., hydroperiod length, predation or competition). However, this is not the only scale in which ecological processes occur [2], since processes at the regional scale (dispersal processes and habitat heterogeneity) are also important [3,4]. The integration of both scales allows for the obtainment of more ecologically realistic results [5] and introduces the concept of metacommunity, defined as a set of local communities connected by dispersal processes [3]. From this point of view, metacommunity ecology provides a conceptual framework to study the multiscale processes that create non-random species distributions along the landscape [3,4,6,7].

Mediterranean wetlands are suitable island ecosystems for studying metacommunity theory. They represent isolated ecosystems within a terrestrial matrix, with well-defined boundaries. Their biological communities are easy to identify and the organisms that comprise them can disperse depending on the degree of connectivity among wetlands and



Citation: Gilbert, J.D.; Márquez, F.J.; Guerrero, F. Assessing the Zooplankton Metacommunity (Branchiopoda and Copepoda) from Mediterranean Wetlands in Agricultural Landscapes. *Diversity* 2023, *15*, 362. https://doi.org/ 10.3390/d15030362

Academic Editors: Joana Cruz, Alexandra Teodósio and Cátia Bartilotti

Received: 30 January 2023 Revised: 20 February 2023 Accepted: 27 February 2023 Published: 2 March 2023



Copyright: © 2023 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/). the dispersal capacity of the taxa involved [8,9]. They are also subject to strong anthropogenic pressures that result in an environmental and landscape homogenisation [10,11]. Among them, the impacts of agricultural practices at a local and regional scale produce ecosystem alterations that involve, for example, an increase in nutrient enrichment [8,12]. The variation in their biotic communities is threatened by this degradation process, leading to the disappearance of species and the simplification of the metacommunity structure [13].

The aquatic communities that inhabit Mediterranean wetlands are unique in most cases [14,15]. Zooplankton represent a key community with high diversity and richness of species that differ in their life cycles, life histories and functional and trophic traits [16]. They have a passive dispersal capacity in which individuals and egg banks are dispersed by biotic and abiotic vectors [17,18]. As a consequence of these dispersive processes, they are strongly affected by the impacts generated in the drainage basins [8]. The influence of environmental factors on zooplankton communities in Mediterranean wetlands has been thoroughly studied [13,19,20]. Nevertheless, the combination of environmental and spatial factors is not well defined and further studies are needed to obtain spatial distribution patterns of the metacommunities [7,21]. Based on this theoretical knowledge, the obtained results are expected to be suitable for the development of management policies on wetland protection and biodiversity conservation [22]. In this way, knowledge about the effects of local environmental (nutrient concentration or habitat complexity, among others) and the regional characteristics at a spatial level (land uses in hydrographic basins, neighbouring wetlands) of Mediterranean wetlands is important to provide information on changes in the structure of the zooplankton metacommunity and the underlying mechanisms [23].

Under these assumptions, it is expected that the zooplankton community structure of wetlands located in agricultural landscapes is the result of different processes operating at local and regional scales. The effect of local variables (limnological features and land uses in the drainage basin) and regional spatial variables on the structuring of the zooplankton community were studied. In this sense, the proposed hypothesis is that local variables are the main mechanism in the structuring of the zooplankton metacommunity in Mediterranean agricultural landscapes.

2. Materials and Methods

2.1. Study Area

We selected 24 wetlands located in the Alto Guadalquivir region, in southern Spain (Figure 1). This region (14,020 km²) is characterized by a Mediterranean climate, where temperatures and precipitations change seasonally, with a dry season and high temperatures in summer and a wet season and low temperatures in autumn-winter. These seasonal changes result in drastic water level fluctuations, and consequently, the majority of wetlands dry out in the summer season.

The Alto Guadalquivir wetlands are strongly connected, given that the maximum distance between them is less than 171 km, with a minimum distance of 1 km and an average distance of 55.9 km. They have agriculture activities in their drainage basin [11], which have been of great importance in their degradation [12,24,25]. The above-mentioned wetland selection includes an adequate example of the limnological variables and land use heterogeneity that are present in the wetlands of the study area [13]. In addition, they have an important regional diversity of zooplankton species [26].



Figure 1. Location of studied wetlands. Wetland's code: 1. Ardal; 2. Argamasilla; 3. Brujuelo; 4. Casillas; 5. Castillo; 6. Chinche; 7. Garcíez; 8. Grande; 9. Hituelo; 10. Honda; 11. Mojones; 12. Naranjeros; 13. Navas; 14. Orcera; 15. Pedernoso; 16. Perales; 17. Prados del Moral; 18. Quinta; 19. Ranal; 20. Rincón del Muerto; 21. Santisteban; 22. Siles; 23. Tobaruela; and 24. Villardompardo.

2.2. Data Analysis

Three types of variables were used: (i) biological variables that contain a presenceabsence data matrix; (ii) local environmental variables, divided into limnological and land use variables; and (iii) spatial variables. The first two groups of variables were obtained from previously published data [11,13,24,26,27]. This information comprises a zooplankton species list (Table 1) and 16 variables related to wetland morphology, catchment characteristics and watershed land uses (see Table 2).

The spatial variables were calculated with Moran's Eigenvector Maps analysis (MEM). This analysis produces a set of orthogonal spatial variables derived from geographical wetlands coordinates [28]. The resulting 23 MEMs represent different spatial variables, from the broadest scale (MEM1-MEM4) associated with environmental drivers, to the finest scale (MEM5-MEM23) related to spatial drivers [7,29]. The associated MEM 's eigenvalues were used to join the spatial variables in both categories: broad scale and fine scale. The broad scale has positive eigenvalues (geographically distant wetlands), and the fine scale has negative eigenvalues (wetlands close to each other) [28]. The inclusion of the spatial component as a surrogate in the analysis of metacommunities allows for the uncovering of the underlying ecological processes that are difficult to measure in field studies [30,31]. Special attention should be paid to the distinction between the broad scale (dispersal/colonisation limitations) and the fine scale (community dynamics/biotic interactions), which is an important aspect that is directly related to the interaction between different ecological processes [31].

Species	Wetlands	Species	Wetlands		
Branchiopods		Pleuroxus aduncus	18		
Alona azorica	1,7	Pleuroxus letourneuxi	6, 10, 15, 18, 21		
Alona elegans	13	Sida crystallina	9		
Alona iberica	16	Simocephalus exspinosus	2, 9, 13, 18		
Alona quadrangularis	8, 9, 12	Simocephalus vetulus	1, 5, 14, 15, 16, 21, 22		
Alona rectangula	2, 5, 21, 24	Tanymastix stagnalis	16		
Alona salina	18	Tretocephala ambigua	1		
Artemia sp.	20	Triops cancriformis	1		
Bosmina longirostris	2, 8, 9, 18, 23	Copepods			
Branchipus schafferi	1	Cyclops sp. 1	18		
Cerioaphnia pulchella	22	Cyclops sp. 2	15, 16, 21, 22		
Ceriodaphnia dubia	14, 15, 24	Acanthocyclops sp.	4,9		
Ceriodaphnia laticaudata	4, 5, 16, 19, 23	Acanthocyclops vernalis	7, 8, 12, 14, 17		
Ceriodaphnia quadrangula	1, 5, 9, 13, 14, 15, 17, 18, 21	Arctodiaptomus salinus	3, 10, 18, 20		
Ceriodaphnia reticulata	2,3	Arctodiaptomus wierzejskii	2, 9, 19		
Chirocephalus diaphanus	1, 4, 5, 11, 15, 17, 21, 22	Canthocamptus microstaphilinus	5		
Chydorus sphaericus	14	Canthocamptus staphylinus	14, 15, 16		
Daphnia curvirostris	5	Cletocamptus retrogressus	3, 10, 12, 13, 18, 20, 21		
Daphnia hispanica	5, 16, 21	Copidodiaptomus numidicus	8		
Daphnia magna	2, 6, 7, 8, 9, 12, 18, 19, 23, 24	Cyclops abyssorum	9		
Daphnia mediterranea	10, 20	Cyclops strenuus	1, 2		
Daphnia parvula	23	Diacyclops bicuspidatus	24		
Dunhevedia crassa	2, 9, 16, 17	Diaptomus cyaneus	5, 14, 15		
Estatheroporus gauthieri	5, 22	Hemidiaptomus robaui	16		
Leidigia Leydigii	8	Macrocyclops albidus	22		
Leydigia acanthocercoides	5	Megacyclops viridis	6, 24		
Macrothrix hirsuticornis	2, 4, 6, 9, 13, 18	Metacyclops minutus	1, 3, 4, 5, 8, 10, 11, 13, 15, 16, 17, 19, 21		
Macrothrix laticornis	5, 16	Metacyclops planuus	9, 12		
Moina brachiata	1, 9, 21	Microcyclops rubellus	9, 21		
Moina micrura	5, 8, 16, 21	Mixodiaptomus incrassatus	14, 16		
Moina salina	20	Neolovenula alluaudi	4, 5, 9, 12, 22, 24		

Table 1. Zooplankton species in the studied wetlands. Wetlands are coded according to the caption of Figure 1.

Two different and complementary approaches can be used to evaluate patterns of spatial variation [32,33]. The pattern approach was evaluated by elements of metacommunity structure (EMS), which determine the best-fitting metacommunity pattern in relation to species assemblages [6,34–36]. For this purpose, we used a presence-absence matrix of sites by taxa, ordered by a reciprocal averaging (Table S1) that maximises the proximity of species with similar distribution and sites with similar species compositions [37]. This analysis is based on three metrics: coherence, turnover and boundary clumping. Its application makes it possible to identify with greater precision the structure of the metacommunity that fits the data and the associated structuring mechanism [35]. Coherence evaluates the response of the species to the gradient and is measured by calculating the number of embedded absences in the ordinated matrix—interruptions in the distributions of species or in the composition of sites—and by subsequently comparing it with the empirically observed value of embedded absences from randomisations. Turnover indicates the number of times one species replaces another species between two sites, and it is measured by counting the number of replacements in an ordinated matrix. Finally, the boundary clumping index represents a measure of species occurrences among sites, being evaluated by the significance of Morisita's dispersion index. All calculations were performed using R software with the metacom package [38].

Table 2. Characteristics of the studied wetlands. Alt: altitude (m); D: maximum wetland depth (m); A: wetland surface (ha); Temp: mean annual temperature (°C); M: water mineralisation—according to Hammer's classification—(1) freshwater and subsaline waters; (2) hyposaline and mesosaline waters; (3) hypersaline waters; T: water turbidity—(1) turbid waters; (2) semi-transparent waters (3) clear waters; WVH: wetland vegetation heterogeneity—(0) without vegetation; (1) only with shoreline vegetation; (2) only with submerged vegetation; (3) with shoreline and submerged vegetation; H: Hydroperiod length—(1) temporal short cycle (< 5 months); (2) temporal large cycle (> 5 months); (3) permanent; WS/S: watershed surface area: wetland surface area; O: olive tree cultivation (ha); PT: herbaceous crops or/and pasture (ha); SF: scrubland and forest (ha); Ur: urban areas (ha); N: nitrogen enrichment from the activities in watershed; and P: phosphorus enrichment from the activities in watershed. The unit represents kg of nitrogen and phosphorus according to [39].

Wetland	Geographical Coordinates	Alt	D	Α	Temp	Μ	Т	WVH	н	WS/S	0	Pt	SF	Ur	Ν	Р
Ardal	38.1372/-3.5942	400	0.75	0.50	12.00	1	3	3	TSC	36.40	0.00	0.00	18.20	0.00	10.92	0.64
Argamasilla	37.8727/-3.5334	484	2.20	4.80	15.20	1	3	3	TLC	9.02	41.40	0.00	1.90	0.00	1559.85	133.58
Brujuelo	37.8641/-3.6719	458	2.12	4.20	18.79	2	3	2	TLC	37.21	145.10	3.30	7.50	0.40	5486.67	469.53
Casillas	37.8004 / -4.0203	442	2.58	2.70	21.30	1	2	2	TLC	8.41	22.70	0.00	0.00	0.00	854.66	73.21
Castillo	38.4670/-2.7359	780	1.80	0.60	14.50	1	3	3	TLC	29.50	9.85	4.96	2.89	0.00	401.38	33.85
Chinche	37.6140/-4.1532	452	1.07	4.70	18.00	2	3	3	TLC	17.57	80.70	1.90	0.00	0.00	3049.38	261.02
Garcíez	37.8445/-3.8684	441	3.55	7.90	15.50	2	2	3	Р	13.08	96.20	0.00	1.70	5.40	3622.95	310.30
Grande	37.9320/-3.5581	368	3.50	22.90	18.35	1	2	1	Р	5.32	121.90	0.00	0.00	0.00	4589.54	393.13
Hituelo	37.7550/-4.0627	476	2.64	3.80	15.60	1	3	3	TLC	7.63	28.60	0.00	0.40	0.00	1077.03	92.25
Honda	37.5979/-4.1437	446	3.16	9.90	12.30	3	3	3	Р	8.71	83.60	0.70	1.90	0.00	3152.74	269.96
Mojones	37.7368/-4.0425	493	1.22	4.50	12.10	1	1	0	TSC	22.23	98.51	1.52	0.00	0.00	3717.73	318.30
Naranjeros	37.7442/-4.0295	508	4.56	5.20	14.90	1	2	3	Р	20.37	101.80	3.20	0.30	0.60	3851.53	329.60
Navas	37.8183/-4.0810	378	2.23	3.50	16.80	1	3	3	TSC	19.31	52.10	15.50	0.00	0.00	2051.54	174.22
Orcera	38.3257/-2.6021	1270	1.73	0.50	14.50	1	3	3	TLC	169.80	0.00	0.00	84.90	0.00	50.94	2.97
Pedernoso	38.3741/-2.9958	724	1.10	1.40	12.80	1	2	3	TLC	10.64	7.90	4.90	2.10	0.00	327.14	27.51
Perales	38.3775/-3.0508	757	1.05	5.20	14.30	1	3	3	TLC	2.73	5.40	7.70	1.10	0.00	248.67	20.53
Prados del Moral	37.8481/-3.8007	389	1.20	4.80	22.50	2	3	2	TSC	5.26	15.30	0.00	0.90	0.00	576.59	49.37
Quinta	38.1373/-4.2867	289	3.15	7.70	15.80	2	3	3	TLC	9.19	51.50	19.20	0.10	0.00	2050.49	173.77
Ranal	37.8727/-4.0689	340	0.81	10.70	19.75	1	1	0	TLC	18.23	182.90	12.20	0.00	0.00	6957.01	594.73
Rincón del Muerto	37.8641/-4.2759	265	1.66	4.20	15.20	3	3	2	TLC	10.45	39.20	4.50	0.00	0.20	1502.00	128.22
Santisteban	37.8004/-3.2096	637	0.90	3.00	13.40	1	2	3	TSC	8.60	0.00	24.10	0.00	1.70	139.90	9.64
Siles	38.4671/-2.5095	1280	2.34	1.30	14.30	1	3	3	Р	230.77	0.00	40.50	259.50	0.00	390.80	25.28
Tobaruela	37.6140/-3.6558	363	0.60	1.70	11.80	1	3	3	TSC	52.47	70.68	18.52	0.00	0.00	2768.61	235.35
Villardompardo	37.8445/-3.9741	360	3.18	1.70	10.80	1	2	3	TSC	35.00	54.90	0.00	4.60	0.00	2069.75	177.21

The mechanistic approach was obtained by performing a redundancy analysis (RDA) and a variation partitioning, which enables the identification of the main variables (environmental and spatial) that explain the distribution variation of zooplankton species. The advantage of this analysis is that it provides comparable results to describe the information obtained with different types of variables. The explanatory variables were selected by a forward selection procedure according to the criteria established by Blanchet and collaborators [40]. After selecting the variables in RDA, variation partitioning was employed to quantify the relative contribution of environmental and spatial variables, at the broad and fine scale, in structuring zooplankton metacommunities [41]. This analysis decomposed the variance (as adjusted R^2) explained solely by a set of pure explanatory variables and the shared variance explained among them [42].

To further study the effects of local and regional variables, the entire zooplankton community was analysed, and divided into branchiopods and copepods species [43]. The environmental variables were transformed (log x+1) to reduce the effect of different scales measured. Species presence-absence data were Hellinger transformed [44]. For all analyses, R software was used (version 4.2.1) [45]. To obtain spatial variables, the R *adespatial* package was used [46], while the *vegan* package was used for the rest of the analyses (RDA and variation partitioning) [47].

3. Results

A total of 60 species were collected, with 22 species of copepods and 38 species of branchiopods (Table 1). Species richness ranged from 2 to 15 species per wetland, with an average number and standard deviation of 7.38 ± 3.70 , and a large proportion of species present in a single wetland (40%). The most common brachiopod species were *Ceriodaphnia quadrangula*, *Chirocephalus diapahnus*, *Daphnia magna* and *Simocephalus vetulus*; and the most common copepod were *Cletocamptus retrogressus*, *Metacyclops minutus* and *Neolovenula alluaudi*.

Elements of metacommunity structure (EMS) for total zooplankton species showed a significant positive coherence with fewer embedded absences (Abs = 472) than expected by chance (simMean = 941), and with a significant negative turnover with lower number of replacements (Rep = 17159) than expected by chance (simMean = 19874). For the branchiopod species, a significant positive coherence (Abs = 280; simMean = 489) and negative turnover (Rep = 5254; simMean = 7022) were found. For the copepod species, a significant positive coherence (Abs = 256) and negative turnover (Rep = 195303; simMean = 2412) were also found. Thus, in all cases, the metacommunity had a nested structure, in which species-poor wetlands were a subset of species-richer wetlands. The values of boundary clumping are not shown since, in all cases, turnover was negative. In this situation, coherence and turnover values were enough to determine the metacommunity structure [36].

The RDA analysis (Table 3) for total zooplankton species generated three significant environmental variables, i.e., olive tree cultivation (O), mineralisation (M) and wetland vegetation heterogeneity (WVH), and five spatial variables related to geographical coordinates: three in a broad scale (MEM1, MEM2 and MEM4) and two in a fine scale (MEM6 and MEM15). For the branchiopod species, the selected environmental variables were phosphorous enrichment (P), mineralisation (M) and turbidity (T), and two broad spatial variables (MEM1 and MEM2). For the copepod species, four environmental variables related to mineralisation (M), depth (D), pasture (Pt) and altitude (Alt), and four spatial variables, two in the broad scale (MEM1 and MEM2) and the other two in the fine scale (MEM15 and MEM23), were selected.

Title 1	Fraction	df	Adj.R ²	р	Variables
	Е	3	0.14		O, M and WVH
Total zooplankton species	F	2	0.06		MEM6 and MEM15
	В	3	0.10		MEM1, MEM2 and MEM4
	$E \cap F$	0	0.02		O, M, WVH, MEM6 and MEM15
	$E \cap B$	0	0.06		O, M, WVH, MEM1, MEM2 and MEM4
Branchiopods species	Е	3	0.14		P, M and T
	В	2	0.07		MEM1 and MEM2
	$E \cap B$	0	0.04		P, M, T, MEM1 and MEM2
Copepods species	Е	4	0.18		M, D, Pt and Alt
	В	2	0.08		MEM1 and MEM2
	F	2	0.08		MEM15 and MEM23
	$E \cap F$	0	0.04		M, D, Pt, Alt, MEM1 and MEM2
	$E \cap B$	0	0.08		M, D, Pt, Alt, MEM1 and MEM2
	$F \cap B$	0	0.001		MEM1, MEM2, MEM15 and MEM23

Table 3. Results of RDA and variation partitioning showing the contributions of environmental and spatial variables (fine and broad scale) for total zooplankton, branchiopods and copepods species.

The results of the partitioning variation and the proportion of the explained variance (adjusted R^2) are summarised in Figure 2 and Table 3. In all groups, environmental or local variables (mineralisation and watershed land uses) were the main variables to explain the metacommunity structure. Regional or spatial variables had a different influence. For total zooplankton species, they were associated at the broad and fine scale, while for the branchiopods, they were associated at the broad scale. In the case of copepod species, they were associated at both scales.



Figure 2. Venn diagram of the variation partitioning among environmental (Environ) and spatial variables (fine and broad scale) for total zooplankton (**a**), branchiopods (**b**) and copepods (**c**). Adjusted R^2 is shown. Values < 0 are not shown.

4. Discussion

The patterns observed in metacommunities are the consequence of several processes that occur at multiple scales [48]. Understanding the processes involved and the resulting species distribution patterns allows researchers to test changes in organisms at the local and regional scale [43].

The results obtained in Alto Guadalquivir wetlands, used to determine the best fitting for the zooplankton pattern by the determination of EMS, indicate a nested metacommunity, in which species-poor assemblages are subsets of larger assemblages. This type of metacommunity has been reported previously for aquatic invertebrates [43,49] as a consequence of different dispersal abilities or environmental gradients [50,51]. However, EMS only reports information on the observed patterns, but not on the mechanisms that produce these patterns. The inclusion of variation partitioning allows for the determination of the local environmental and spatial variables that structured the metacommunities [4,7,52,53]. These results indicate that the structure of the zooplankton metacommunity in Alto Guadalquivir wetlands depends on eight local environmental variables (Alt, D, M, T, WVH, O, Pt, P) and six spatial variables (MEM1, MEM2, MEM4, MEM6, MEM15, MEM23). The low percentages of explained variance obtained (Figure 2) are consistent with other studies on zooplankton metacommunities [21,43,54], suggesting that other processes not measured at the metacommunity level (competition, predation, etc.) are also involved in structuring the zooplankton metacommunity [55].

As is shown in Table 2, total zooplankton, branchiopods and copepods are affected by different environmental variables, with mineralisation appearing in all three groups. Previous results in the study area indicate that mineralisation is essential for the structuring of zooplankton communities. An increase in mineralisation has a negative effect on zooplankton species richness [27,56], surely as a consequence of the well-known effect on biota stress, which reduces growth and reproduction rates [57]. In the same way, an increment in eutrophication, as a consequence of the high percentage of agricultural activities in the drainage basin (olive tree cultivation), also affects the zooplankton community [13], with a reduction in the total number of species. This result is supported by the high catchment:wetland ratio (WS/S) in Mediterranean wetlands [58], which implies a deep interaction between wetlands and surrounding terrestrial habitat. This idea also explains the results obtained for the other two zooplanktonic groups (Table 2). Gilbert and collaborators [13] reported that most copepod species are distributed in less impacted wetlands, located at high altitude, depth and with a higher proportion of pastures in their drainage basins. In contrast, most of the branchiopod species are found in impacted wetlands, with higher turbidity and nutrient enrichment (phosphorus), as a consequence of nutrient runoff [59].

The environmental and landscape homogenisation, as a consequence of agricultural practices in the study area, could be related to a low species sorting [60], since it reduces the potential number of sites in which the species can inhabit and consequently increases nestedness [52,53,61]. This result is shown in the variables extracted in the RDA analysis, which suggest a joint influence of environmental and land use variables.

Despite the small size of our study area, it is possible to detect spatial effects on metacommunity structure, which also enables the detection of patterns within each zooplankton group considered. Our results reveal that the mechanisms for structuring metacommunities differ according to the taxonomic groups studied and the landscape context, which has been previously mentioned in other studies [6,52,62]. Branchiopods and copepods are passive dispersers with resting forms that favour their dispersion across landscape. Therefore, the colonisation processes and the community development (community succession) are important features involved in the structuring of the zooplankton metacommunity. When temporary agricultural wetlands are filled up, they provide an empty, suitable habitat for colonisation and population growth, with the first colonisers being mainly branchiopods and some cyclopoid copepods [63]. This situation usually generates high abundances, which means that together with the homogeneity of available habitats [9], the metacommunity is controlled by the dispersal capacity between wetlands (mass effect). In this sense, species with a greater tolerance and high dispersal ability will occur in a greater number of wetlands. In addition, the eutrophic conditions of Alto Guadalquivir wetlands also favour the presence of generalist species [63]. On the contrary, when the wetland is drying up, the availability of resources and the habitat conditions determine a greater environmental heterogeneity and favour the appearance of the majority of copepod species [63]. In this context, the dispersal capacity loses importance and the metacommunity structure is controlled by species sorting [64]. These species only reach the closest wetlands, being affected by their tolerance to the environmental conditions [65].

The relative abundance of each group (branchiopods or copepods) is also important to understand their dispersal and the consequences of such dispersal in the structuring of the metacommunity [66–68]. In this context, high abundances of individuals are related to mass effect processes, while low abundances are related to dispersal limitation. Our previous results indicate that branchiopod species appear with high abundances in Alto Guadalquivir wetlands [63]; therefore, the mass effect dominates their dispersion on the broad scale. On the other hand, in copepod species (with less abundances), there is a dispersal limitation; indicating that, for this group, the dispersion between nearby wetlands is favoured (fine scale).

5. Conclusions

Considering the low percentage of explained variance (see Figure 2), it is necessary to point out that, in order to understand the functioning of our zooplanktonic metacommunity, it is necessary to evaluate, as other authors have suggested, other mechanisms, such as biotic interactions, competition between species, pressure of predators, priority effects and stochastic colonisations [69]. However, the obtained results allow us to draw interesting conclusions that can be applied in management and conservation plans for our wetlands. Our findings support the argument that nested patterns may result from the anthropogenisation of the landscape (land uses), and not only from limnological and spatial factors [53]. Knowledge of the structure of the metacommunity and the mechanisms involved in it are essential to predict future changes generated in them as a consequence of anthropic pressures. In this sense, the use of the zooplankton metacommunity has allowed for the determination of the importance of both spatial scales (broad scale and fine scale) on the conservation of the Alto Guadalquivir wetlands. Our results indicate that it is necessary to protect a wide range of wetlands that are vastly distributed throughout the territory, with broad environmental conditions. This will enable the presence of a large diversity of species (branchiopods and copepods) in these protected areas, which will guarantee their conservation in the future, since the flux of species among wetlands favours the maintenance of local diversity. Moreover, it is important to note that Mediterranean wetlands have been considered unique, due to the presence of exclusive communities [15,70], which act as a refuge for endemic species [71] and as important hotspots of aquatic biodiversity [72,73]. In addition, this reinforces the proposals previously made by our research group for the conservation of these wetlands, both using the zooplankton community [27], and the communities of amphibians [24], birds and wetland vegetation [74]. The present study conducted with metacommunities reinforces the proposed conservation of a pond network in our study area, an aspect that should definitely be taken into account by policy makers in order to safeguard our wetlands and the rich diversity they support.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d15030362/s1, Table S1: Zooplankton species presence-absence in the studied wetlands, Data taken from [27].

Author Contributions: Conceptualization, J.D.G. and F.G.; methodology, J.D.G. and F.G.; software, J.D.G. and F.J.M.; validation, J.D.G., F.J.M. and F.G.; formal analysis, J.D.G. and F.J.M.; investigation, J.D.G. and F.G; resources, F.G.; data curation, J.D.G., F.J.M. and F.G.; writing—original draft preparation, J.D.G., F.J.M. and F.G.; writing—review and editing, J.D.G., F.J.M. and F.G.; visualization, J.D.G., F.J.M. and F.G.; supervision, F.J.M. and F.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article.

Acknowledgments: Our thanks to the Consejería de Medio Ambiente (Junta de Andalucía) for permission to take samples in the Alto Guadalquivir wetlands. We also thanks to three anonymous referees for their valuable comments to improve the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

- 1. Dray, S.; Pélissier, R.; Couteron, P.; Fortin, M.J.; Legendre, P.; Peres-Neto, P.R.; Bellier, E.; Bivand, R.; Blanchet, F.G.; De Cáceres, M.; et al. Community ecology in the age of multivariate multiscale spatial analysis. *Ecol. Monogr.* **2012**, *82*, 257–275. [CrossRef]
- 2. Levin, S.A. The problem of pattern and scale in ecology. *Ecology* 2012, 73, 1943–1967. [CrossRef]
- 3. Leibold, M.A.; Holyoak, M.; Mouquet, N.; Amarasekare, P.; Chase, J.M.; Hoopes, M.F.; Holt, R.D.; Shurin, J.B.; Law, R.; Tilman, D.; et al. The metacommunity concept: A framework for multi-scale community ecology. *Ecol. Lett.* **2004**, *7*, 601–613. [CrossRef]
- Gascón, S.; Arranz, I.; Cañedo-Argüelles, M.; Nebra, A.R.A.; Rieradevall, M.; Caiola, N.; Sala, J.; Ibàñez, C.; Quintana, X.D.; Boix, D. Environmental filtering determines metacommunity structure in wetland microcrustaceans. *Oecologia* 2016, 181, 193–205. [CrossRef]
- 5. Alves, A.T.; Petsch, D.K.; Barros, F. Drivers of benthic metacommunity structure along tropical estuaries. *Sci. Rep.* **2020**, *10*, 1739. [CrossRef]
- 6. Heino, J.; Nokela, T.; Soininen, J.; Tolkkinen, M.; Virtanen, L.; Virtanen, R. Elements of metacommunity structure and communityenvironment relationships in stream organisms. *Freshw. Biol.* **2015**, *60*, 973–988. [CrossRef]
- 7. Castillo-Escrivà, A.; Valls, L.; Rochera, C.; Camacho, A.; Mesquita-Joanes, F. Spatial and environmental analysis of an ostracod metacommunity from endorheic lakes. *Aquat. Sci.* **2016**, *78*, 707–716. [CrossRef]
- Angeler, D.G.; Viedma, O.; Sánchez-Carrillo, S.; Álvarez-Cobelas, M. Conservation issues of temporary wetland Branchiopoda (Anostraca, Notostraca: Crustacea) in a semiarid agricultural landscape: What spatial scales are relevant? *Biol. Conserv.* 2008, 141, 1224–1234. [CrossRef]
- 9. Angeler, D.G.; Viedma, O.; Cirujano, S.; Alvarez-Cobelas, M.; Sánchez-Carrillo, S. Microinvertebrate and plant beta diversity in dry soils of a semiarid agricultural wetland complex. *Mar. Freshw. Res.* **2015**, *59*, 418–428. [CrossRef]
- 10. Lougheed, V.L.; McIntosh, M.D.; Parker, C.A.; Stevenson, R.J. Wetland degradation leads to homogenization of the biota at local and landscape scales. *Freshw. Biol.* **2008**, *53*, 2402–2413. [CrossRef]
- 11. Ortega, F.; Parra, G.; Guerrero, F. 2006. Usos del suelo en las cuencas hidrográficas de los humedales del Alto Guadalquivir: Importancia de una adecuada gestión. *Limnetica* 2006, 25, 723–732. [CrossRef]
- 12. Gilbert, J.D.; Guerrero, F.; Jiménez-Melero, R.; de Vicente, I. Is the bioproduction number a good index of the trophic state in Mediterranean wetlands? *Knowl. Manag. Aquat. Ecosyst.* **2015**, *416*, 5. [CrossRef]
- 13. Gilbert, J.D.; de Vicente, I.; Ortega, F.; García-Muñoz, E.; Jiménez-Melero, R.; Parra, G.; Guerrero, F. Linking watershed land uses and crustacean assemblages in Mediterranean wetlands. *Hydrobiologia* **2017**, *799*, 181–191. [CrossRef]
- García de Lomas, J.; García, C.M.; Hortas, F.; Prunier, F.; Boix, D.; Sala, J.; León, D.; Serrano, L.; Prenda, J.; Gilbert, J.D.; et al. Linderiella baetica Alonso & García-de-Lomas 2009 (crustácea, Branchiopoda, Anostraca): On the verge of extinction? Rev. Soc. Gad. Hist. Nat. 2016, 10, 15–26.
- Marrone, F.; Ortega, F.; Mesquita-Joanes, F.; Guerrero, F. On the Occurrence of *Metadiaptomus chevreuxi* (Calanoida, Diaptomidae, Paradiaptominae) in the Iberian Peninsula, With Notes on the Ecology and Distribution of its European Populations. *Water* 2020, 12, 1989. [CrossRef]
- Jeppesen, E.; Nõges, P.; Davidson, T.A.; Haberman, J.; Nõges, T.; Blank, K.; Lauridsen, T.L.; Søndergaard, M.; Sayer, C.; Laugaste, R.; et al. Zooplankton as indicators in lakes: A scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). *Hydrobiologia* 2011, 676, 279–297. [CrossRef]
- 17. Bohonak, A.J.; Jenkins, D.G. Ecological and evolutionary significance of dispersal by freshwater invertebrates. *Ecol. Lett.* **2003**, *6*, 783–796. [CrossRef]
- Moreno, E.; Pérez-Martínez, C.; Conde-Porcuna, J.M. Dispersal of zooplankton dormant propagules by wind and rain in two aquatic systems. *Limnetica* 2016, 35, 323–336.
- Frisch, D.; Moreno-Ostos, E.; Green, A.J. Species richness and distribution of copepods and cladocerans in temporary ponds of Doñana Natural Park. *Hydrobiologia* 2006, 556, 327–340. [CrossRef]
- 20. Marrone, F.; Barone, R.; Naselli Flores, L. Ecological characterization and cladocerans, calanoid copepods and large branchiopods of temporary ponds in a Mediterranean island (Sicily, Southern Italy). *Chem. Ecol.* **2006**, 22, 181–190. [CrossRef]
- De Bie, T.; De Meester, L.; Brendonck, L.; Martens, K.; Godeeris, B.; Ercken, D.; Hampel, H.; Denys, L.; Vanhecke, L.; Van der Gucht, K.; et al. Body size and dispersal mode as key traits determining metacommunity structure of aquatic organisms. *Ecol. Lett.* 2012, 15, 740–747. [CrossRef] [PubMed]
- 22. Farber, S.; Costanza, R.; Childers, D.L.; Erickson, J.; Gross, K.; Grove, M.; Hopkinson, C.S.; Kahn, J.; Pincetl, S.; Troy, A. Linking ecology and economics for ecosystem management. *Bioscience* 2006, *56*, 121–133. [CrossRef]

- 23. Castillo-Escrivà, A.; Mesquita-Joanes, F.; Rueda, J. Effects of the temporal scale of observation on the analysis of aquatic invertebrate metacommunities. *Front. Ecol. Evol.* **2020**, *8*, 561838. [CrossRef]
- 24. García-Muñoz, E.; Gilbert, J.D.; Parra, G.; Guerrero, F. Wetlands classification for amphibian conservation in Mediterranean landscapes. *Biodivers. Conserv.* 2010, *19*, 901–911. [CrossRef]
- 25. de Castro Expósito, A.; García-Muñoz, E.; Guerrero, F. Reptile diversity in a Mediterranean wetland (Alto Guadalquivir region, southeastern Spain): Are they affected by human impacts? *Acta Herpetol.* **2021**, *16*, 27–36. [CrossRef]
- 26. Gilbert, J.D.; de Vicente, I.; Jiménez-Melero, R.; Parra, G.; Guerrero, F. Selecting priority conservation areas based on zooplankton diversity: The case of Mediterranean wetlands. *Mar. Freshw. Res.* 2014, 65, 857–871. [CrossRef]
- 27. Gilbert, J.D.; de Vicente, I.; Ortega, F.; Jiménez-Melero, R.; Parra, G.; Guerrero, F. A comprehensive evaluation of the crustacean assemblages in southern Iberian Mediterranean wetlands. *J. Limnol.* **2015**, *74*, 169–181. [CrossRef]
- Dray, S.; Legendre, P.; Peres-Neto, P.R. Spatial modeling: A comprehensive framework for principal coordinate analysis of neighbor matrices (PCNM). *Ecol. Modell.* 2006, 196, 483–493. [CrossRef]
- 29. Borcard, D.; Legendre, P.; Avois-Jacquet, C.; Tuomisto, H. Dissecting the spatial structure of ecological data at multiple scales. *Ecology* **2004**, *85*, 1826–1832. [CrossRef]
- 30. McIntire, E.J.B.; Fajardo, A. Beyond description: The active and effective way to infer processes from spatial patterns. *Ecology* **2009**, *90*, 46–56. [CrossRef]
- 31. Borcard, D.; Gillet, F.; Legendre, P. *Numerical Ecology with R*; Gentleman, R., Hornik, K., Parmigiani, G., Eds.; Springer: New York, NY, USA, 2011; p. 306.
- Cotteine, K. Integrating environmental and spatial processes in ecological community dynamics. *Ecol. Lett.* 2005, *8*, 1175–1182. [CrossRef]
- Valanko, S.; Heino, J.; Westerbom, M.; Viitasalo, M.; Norkko, A. Complex metacommunity structure for benthic invertebrates in a low-diversity coastal system. *Ecol. Evol.* 2015, *5*, 5203–5215. [CrossRef]
- Leibold, M.A.; Mikkelson, G.M. Coherence, species turnover, and boundary clumping: Elements of meta-community structure. Oikos 2002, 97, 237–250. [CrossRef]
- 35. Presley, S.J.; Higgins, C.L.; Willig, M.R. A comprehensive framework for the evaluation of metacommunity structure. *Oikos* 2010, 119, 908–917. [CrossRef]
- Schemera, D.; Podani, J.; Botta-Dukát, Z.; Erős, T. On the reliability of the Elements of Metacommunity Structure framework for separating idealized metacommunity patterns. *Ecol. Indic.* 2018, 85, 853–860. [CrossRef]
- 37. Gauch, H.G. *Multivariate Analysis in Community Ecology*; Beck, E., Birks, H.J.B., Connor, E.F., Eds.; Cambridge University Press: Cambridge, UK, 1982; p. 298.
- 38. Dallas, T.; Presley, S.J. Relative importance of host environment, transmission potential and host phylogeny to the structure of parasite metacommunities. *Oikos* **2014**, *123*, 866–874. [CrossRef]
- Johnes, P.; Moss, B.; Phillips, G. The determination of total nitrogen and total phosphorus concentrations in freshwaters from land use, stock head age and population data: Testing of model for use in conservation and water quality management. *Freshw. Biol.* 1996, 36, 451–473. [CrossRef]
- 40. Blanchet, F.G.; Legendre, P.; Borcard, D. Forward selection of explanatory variables. Ecology 2008, 89, 2623–2632. [CrossRef]
- Legendre, P.; Borcard, D.; Roberts, D.W. Variation partitioning involving orthogonal spatial eigenfunction submodels. *Ecology* 2012, 93, 1234–1240. [CrossRef]
- 42. Borcard, D.; Legendre, P.; Drape, P. Partialling out the spatial component of ecological variation. *Ecology* **1992**, *73*, 1045–1055. [CrossRef]
- Gálvez, A.; Aguilar-Alberola, J.A.; Armengol, X.; Bonilla, F.; Iepure, S.; Monrós, J.S.; Olmo, C.; Rojo, C.; Rueda, J.; Rueda, R.; et al. Environment and Space Rule, but Time Also Matters for the Organization of Tropical Pond Metacommunities. *Front. Ecol. Evol.* 2020, *8*, 558833. [CrossRef]
- 44. Legendre, P.; Gallagher, E.D. Ecologically meaningful transformations for ordination of species data. *Oecologia* **2001**, *129*, 271–280. [CrossRef]
- 45. R Core Team. *R: A Language and Environment for Statistical Computing;* R Foundation for Statistical Computing: Vienna, Austria, 2021; Available online: https://www.R-project.org/ (accessed on 23 June 2022).
- Dray, S.; Bauman, D.; Blanchet, G.; Borcard, D.; Clappe, S.; Guenard, G.; Jombart, T.; Larocque, G.; Legendre, P.; Madi, N.; et al. Adespatial: Multivariate Multiscale Spatial Analysis_R Package Version 0.3-16. 2022. Available online: https: //CRAN.R-project.org/package=adespatial (accessed on 19 October 2022).
- Oksanen, J.; Simpson, G.; Blanchet, F.; Kindt, R.; Legendre, P.; Minchin, P.; O'Hara, R.; Solymos, P.; Stevens, M.; Szoecs, E.; et al. Vegan: Community Ecology Package_R Package Version 2.6-2. 2022. Available online: https://CRAN.R-project.org/package= vegan (accessed on 12 October 2022).
- 48. Menge, B.A.; Olson, A.M. Role of scale and environmental factors in regulation of community structure. *Trends Ecol. Evol.* **1990**, *5*, 52–57. [CrossRef] [PubMed]
- Heino, J.; Soininen, J.; Alahuhta, J.; Lappalainen, J.; Virtanen, R. Metacommunity ecology meets biogeography: Effects of geographical region, spatial dynamics and environmental filtering on community structure in aquatic organisms. *Oecologia* 2017, 183, 121–137. [CrossRef] [PubMed]

- 50. Patterson, B.D.; Atmar, A. Nested subsets and the structure of insular mammalian faunas and archipelagos. *Biol. J. Linn. Soc.* **1986**, *28*, 65–82. [CrossRef]
- 51. Heino, J. Metacommunity patterns of highly diverse stream midges: Gradients, chequerboards, and nestedness, or is there only randomness? *Ecol. Entomol.* **2005**, *30*, 590–599. [CrossRef]
- 52. Castillo-Escrivá, A.; Aguilar-Alberola, J.A.; Mesquita-Joanes, F. Spatial and environmental effects on a rock-pool metacommunity depend on landscape setting and dispersal mode. *Freshw. Biol.* **2017**, *62*, 1004–1011. [CrossRef]
- 53. Williams-Subiza, E.; Brand, C.; Miserendino, M.L. Metacommunity structure analysis reveals nested patterns in deconstructed macroinvertebrates assemblages. *Ecol. Entomol.* **2020**, *45*, 1284–1295. [CrossRef]
- Rojo, C.; Mesquita-Joanes, F.; Monrós, J.S.; Armengol, J.; Sasa, M.; Bonilla, F.; Rueda, R.; Benavent-Corai, J.; Piculo, R.; Segura, M.M. Hydrology affects environmental and spatial structuring of microalgal metacommunities in tropical Pacific coast wetlands. *PLoS ONE* 2016, *11*, 0149505. [CrossRef]
- 55. García-Girón, J.; Heino, J.; García-Criado, F.; Fernández-Aláez, C.; Alahuhta, J. Biotic interactions hold the key to understanding metacommunity organisation. *Ecography* **2020**, *43*, 1180–1190. [CrossRef]
- 56. López-González, P.; Guerrero, F.; Castro, M.C. Seasonal fluctuations in the plankton community in a hypersaline temporary lake (Honda, southern Spain). *Int. J. Salt Lake Res.* **1998**, *6*, 353–371. [CrossRef]
- 57. Sarma, S.S.S.; Nandini, S.; Morales-Ventura, J.; Delgado-Martínez, I.; González-Valverde, L. Effects of NaCl salinity on the population dynamics of freshwater zooplankton (rotifers and cladocerans). *Aquat. Ecol.* **2006**, *40*, 349–360. [CrossRef]
- 58. Álvarez Cobelas, M.; Rojo, C.; Angeler, D.G. Mediterranean limnology: Current status, gaps and the future. J. Limnol. 2005, 64, 13–29. [CrossRef]
- 59. Dodson, S.I.; Lillie, R.A. Zooplankton communities of restored depressional wetlands in Wisconsin, USA. *Wetlands* **2001**, *21*, 292–300. [CrossRef]
- 60. Chase, J.M.; Leibold, M.A. *Ecological Niches: Linking Classical and Contemporary Approaches;* The University of Chicago Press: Chicago, IL, USA, 2003; p. 221.
- Gianuca, A.T.; Declerck, S.A.; Lemmens, P.; De Meester, L. Effects of dispersal and environmental heterogeneity on the replacement and nestedness components of β-diversity. *Ecology* 2017, 98, 525–533. [CrossRef]
- 62. Heino, J.; Grönroos, M.; Soininen, J.; Virtanen, R.; Muotka, T. Context dependency and metacommunity structuring in boreal headwater streams. *Oikos* **2012**, *121*, 537–544. [CrossRef]
- 63. Gilbert, J.D.; de Vicente, I.; Ortega, F.; Guerrero, F. Zooplankton community dynamics in temporary Mediterranean wetlands: Which drivers are controlling the seasonal species replacement? *Water* **2021**, *13*, 1447. [CrossRef]
- 64. Fernandes, I.M.; Henriques-Silva, R.; Penha, J.; Zuanon, J.; Peres-Neto, P.R. Spatiotemporal dynamics in a seasonal metacommunity structure is predictable: The case of floodplain-fish communities. *Ecography* **2014**, *37*, 464–475. [CrossRef]
- 65. McAbendroth, L.; Foggo, A.; Rundle, S.D.; Bilton, D.T. Unravelling nestedness and spatial pattern in pond assemblages. *J. Anim. Ecol.* **2005**, 74, 41–49. [CrossRef]
- 66. Jenkins, D.G.; Buikema, A.L. Do similar communities develop in similar sites? A test with zooplankton structure and function. *Ecol. Monogr.* **1998**, *68*, 421–443. [CrossRef]
- 67. Ives, A.R.; Woody, S.T.; Nelson, E.V.; Andrews, J.H. The synergistic effects of stochasticity and dispersal on population densities. *Am. Nat.* 2004, *163*, 375–387. [CrossRef] [PubMed]
- Sciullo, L.; Kolasa, J. Linking local community structure to the dispersal of aquatic invertebrate species in a rock pool metacommunity. *Community Ecol.* 2012, 13, 203–212. [CrossRef]
- 69. Castillo-Escrivà, A.; Valls, L.; Rochera, C.; Camacho, A.; Mesquita-Joanes, F. Disentangling environmental, spatial, and historical effects on ostracod communities in shallow lakes. *Hydrobiologia* **2017**, *786*, 61–72. [CrossRef]
- García de Lomas, J.; Ventura, M.; García, C.M.; Caner, J.; Jiménez-Cantizano, F.A.; Alonso, M.; Hortas, F. First record of *Linderiella jebalae* Boix, Sala, Escoriza & Alonso 2016 (Crustacea, Branchiopoda, Anostraca) in the Iberian Peninsula. Dispersal across the Strait of Gibraltar? *Limnetica* 2023, 42. in press.
- 71. Alonso, M. Fauna Ibérica. Crustacea, Branchiopoda; Museo Nacional de Ciencias Naturales-CSIC: Madrid, Spain, 1996; p. 486.
- 72. Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; da Fonseca, G.A.B.; Kent, J. Biodiversity hotspots for conservation priorities. *Nature* **2000**, 403, 853–858. [CrossRef]
- 73. Céréghino, R.; Ruggiero, A.; Marty, P.; Angélibert, S. Biodiversity and distributions patterns of freshwaters invertebrates in farm ponds of a south-western French agricultural landscape. *Hydrobiologia* **2008**, 597, 43–51. [CrossRef]
- 74. Ortega, F.; Parra, G.; Guerrero, F. Las lagunas del Alto Guadalquivir: Propuestas para su protección y conservación. In *Congreso de Restauración de Ríos y Humedales*, 1st ed.; Cachón, J., Ed.; Ministerio de Fomento-Ministerio de medio Ambiente-CEDEX: Madrid, Spain, 2004; pp. 131–142.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.