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What Are the Relationships between Plankton and Macroinvertebrates in Reservoir Systems?

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Abstract: Macroinvertebrates and plankton play crucial roles in reservoir food webs; however, their relationships have received limited attention. This study investigates the associations between plankton and macroinvertebrates in fifty selected reservoirs. During the spring season, significant concordances were observed in species richness between phytoplankton and zooplankton, as well as between zooplankton and macroinvertebrates. In contrast, during the summer season, the concordance in species richness between phytoplankton and macroinvertebrates was higher compared to other assemblages. Although macroinvertebrates showed a strong connection with phytoplankton in terms of species richness in both seasons, the congruencies were not statistically significant. Partial least squares regression (PLSR) analysis revealed that the densities of phytoplankton, Chlorophyta, Cyanophyta, and protozoans significantly influenced the total macroinvertebrate density in both seasons. Additionally, the densities of mollusks and aquatic insects were affected by the densities of Chlorophyta and Cyanophyta, while the density of oligochaetes was influenced by the density of Chlorophyta. These findings indicated that phytoplankton and zooplankton serve as primary food sources for macroinvertebrates, highlighting the close relationship between plankton and macroinvertebrates in reservoir systems. Moreover, the results of formative measurement models indicated a strong association between zooplankton and macroinvertebrates during the spring, whereas phytoplankton and macroinvertebrates exhibited a close association during the summer. The substantial concordance in density between phytoplankton and zooplankton revealed by the formative measurement models confirmed that assemblages with similar body sizes exhibit stronger concordance compared to those with significant differences in body size.

Keywords: macroinvertebrates; plankton; concordance; reservoirs; PLSR; formative measurement models

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1. Introduction

Identification of potential surrogate groups is crucial in aquatic bio-monitoring programs to facilitate integrated management and conservation of aquatic biota, especially when there is a lack of taxonomic knowledge and limited funding. The effectiveness of a potential surrogate group lies in its ability to represent other taxonomic groups, and this requires consistent patterns of community structure among different taxonomic groups across various sites [1,2]. Exploring the potential mechanism causing concordance across different groups, checking among-taxon congruence, and evaluating the reliability of surrogate groups can provide vital insights into community organization and help to prevent erroneous conclusions and conservation efforts [1,2]. Congruent patterns among taxonomic groups are believed to be shaped by biotic interactions, including trophic cascades [1,3].

Studies have demonstrated that biological interactions can influence the concordance of different assemblages, leading to diverse responses to environmental variables [4,5].

In practical applications, a potential surrogate group not only enables the detection of significant changes in environmental conditions but also aids in reconstructing the spatial patterns exhibited by different biological groups [6]. Several studies have reported relatively strong concordance among seemingly disparate species, such as benthic macroinvertebrates and fish [7], as well as aquatic birds and fish [2]. It has been observed that taxa with similar body sizes exhibit higher concordance in assemblage structure patterns [8,9], and species richness correlations are stronger among organisms with increasingly similar body sizes compared to those with greater differences in body sizes [10]. For instance, in a near-pristine floodplain, the Araguaia River floodplain in Central Brazil, most pairs of zooplankton assemblages (Cladocera, Copepoda, Rotifera, and protozoans) displayed considerable concordance and exhibited similar responses to environmental gradients [6]. Conversely, due to weak connectivity between benthic and pelagic habitats in flatland ponds, the benthic and pelagic assemblages demonstrated low concordance, with species responding individually to environmental variation [11]. In shallow lakes in Minnesota, USA, a strong co-correspondence was observed between fish and macrophytes, whereas associations among zooplankton, macroinvertebrates, and fish were weaker [12].

The food web in reservoirs comprises plankton, macroinvertebrates, fish, and aquatic plants, and understanding the relationships between these assemblages is crucial for developing strategies to maintain high water quality and maximize conservation benefits [12]. The benthic–pelagic coupling plays a vital role in nutrient loading, primary productivity, assemblage structure, and diversity. However, the degree of concordance between pelagic and benthic assemblages has received limited exploration, despite its potential to provide important insights into the functioning of aquatic systems [11]. In aquatic ecosystems, macroinvertebrates and plankton are essential components of food webs [12]. This study focuses on investigating the relationships between plankton and macroinvertebrates in Chinese reservoirs, as well as assessing their concordance, and addresses the following questions: (1) is there a significant concordance in species richness among different biological groups? (2) What are the associations between these biological groups in terms of densities? (3) Does the aforementioned relationship vary with the season?

2. Material and Methods

2.1. Study Areas

In Jiangsu Province, China, a total of 908 reservoirs have been developed, including 6 large reservoirs (storage capacity > 11 × 10^8 m^3), 42 medium-sized reservoirs (storage capacity > 1 × 10^7 m^3), and 860 small reservoirs (storage capacity < 1 × 10^7 m^3) [13]. For the purpose of assessing the water ecological environments, a survey was conducted from 1998 to 1999, covering 50 reservoirs. Among them, there were 6 large reservoirs, 42 medium-sized reservoirs, and 2 small reservoirs (Figure 1 and Appendix A).

2.2. Data Collection

Two samplings were conducted in the spring and summer seasons for all except two reservoirs (Table 1). The selection of biological sampling sites within the reservoirs was based on random sampling, taking into consideration the geomorphological characteristics. Modified Peterson Grabs (sample area 0.0625 m^2) were used to collect macroinvertebrate samples; two samples were taken at each sampling site and sieved onboard through a 420 µm mesh sieve and preserved in 4% formalin solution. Plankton samples were collected by plexiglass samplers (volume 5L) and preserved in Lugol solution. Mollusks among the macroinvertebrates were identified to the species level, aquatic insects and oligochaetes were identified to the genus level, and other macroinvertebrates were identified to the lowest possible taxonomic level [14]; phytoplankton specimens were consistently identified at the genus level [15]; zooplankton specimens were identified at either the species or genus level [16–18].

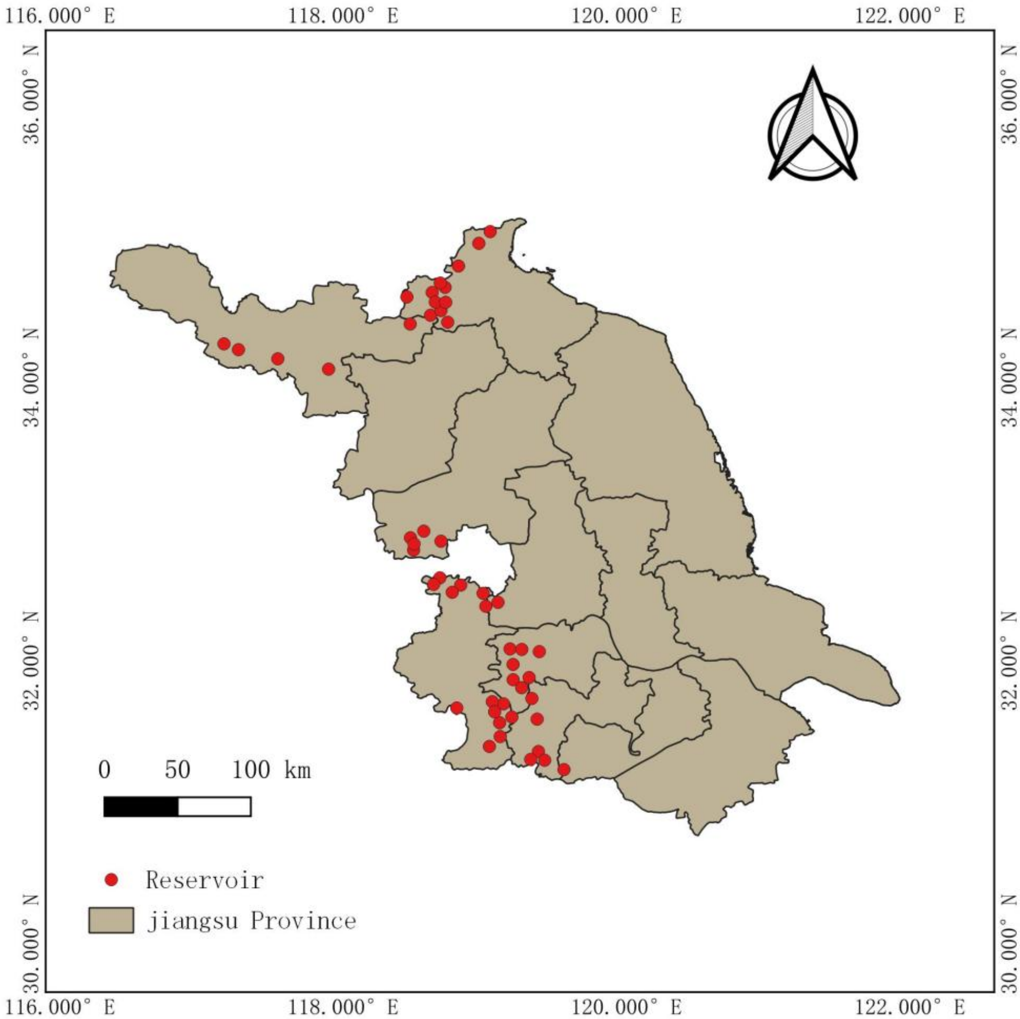

Figure 1. Locations of surveyed reservoirs in Jiangsu Province, China.

Table 1. Physical and chemical parameters of water in reservoirs of Jiangsu Province. Note: same letter represents the difference is not significant, whereas different letter indicates significant difference.

Season	Water Temperature (°C)	Transparency (cm)	pH	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Spring	22.2 (17.5–27.5) ^{a}	131.4 (20–420) ^{a}	8.2 (7.7–9.2) ^{a}	1.22 (0.31–2.88) ^{a}	0.225 (0.020–5.830) ^{a}
Summer	29.0 (25.0–32.5) ^{b}	103.4 (30–300) ^{b}	8.4 (7.8–9.1) ^{b}	0.98 (0.20–8.27) ^{b}	0.146 (0.026–0.773) ^{a}

2.3. Data Analysis

Partial least squares regression (PLSR) was employed to investigate the relationships between plankton and macroinvertebrate densities. The PLSR method addresses multicollinearity by reducing the number of variables to one or several latent components (factors), and the significance of these components is determined using cross-validation. Predictor variables with weights greater than 0.20 are considered influential [19]. In this study, PLSR analysis was performed using SPSS version 20. Principal coordinates analysis (PCoA) was conducted using presence–absence data (0–1) of phytoplankton, zooplankton, and macroinvertebrates collected during different seasons. The PCoA was used to ordinate the samples and calculate compositional dissimilarities between reservoirs using the Bray–Curtis coefficient. To assess the concordance strength between pairs of assemblages for each season, PCoA scores from each assemblage were subjected to a Procrustes analysis [3,20]. Residual sum-of-squares statistics (m^2) derived from the Procrustes analysis were transformed into r_p by calculating $r_p = \sqrt{1 - m^2}$ to quantify and test the similarity between the ordination patterns generated by the compared assemblages [6,21]. PCoA and Procrustes analyses were performed using the "vegan" and "labdsv" packages in R. Partial Least Square Structural Equation Modeling (PLS-SEM) was employed to examine the relationships between plankton and macroinvertebrate assemblages by constructing proposed research models. PLS-SEM is a non-parametric analysis that does not rely on distributional assumptions. This approach is suitable for testing complex causal models with small sample sizes and has less stringent assumptions about the normality of data compared to other methods [22,23]. PLS-SEM analyses were conducted using SmartPLS version 3.0 software.

3. Results

3.1. Water Parameters

The water parameters of water in reservoirs in Jiangsu province are shown in Table 1. The water temperature and pH of reservoirs during the summer were significantly higher than in the spring by Mann–Whitney test (p < 0.05). However, the transparency and total nitrogen levels are significantly lower during the summer compared to the spring (Mann-Whitney test, p < 0.05). Meanwhile, there is no significant difference in total nitrogen levels between the two seasons (Mann–Whitney test, p > 0.05).

3.2. Characteristics of Different Assemblages

During both seasons, a total of 58 phytoplankton taxa were collected, with 51 taxa observed in the spring and 47 taxa in the summer. Common taxa in the spring included *Cryptomonas* sp., *Cyclotella* sp., *Synedra* sp., *Pediastrum* sp., *Ceratium* sp., *Navicula* sp., *Melosira* sp., and Phormidiaceae spp. In the summer, common taxa were *Navicula* sp., *Cryptomonas* sp., Phormidiaceae spp., *Melosira* sp., *Microcystis* sp., *Synedra* sp., *Cyclotella* sp., *Pediastrum* sp., *Oscillatoria* sp., and *Scenedesmus obliquus.*

A total of 264 zooplankton taxa were collected during both seasons, with 212 taxa found in the spring and 104 taxa in the summer. Common taxa in the spring included *Sinocalanus dorrii*, *Polyarthra trigla*, *Tintinnidium fluviatile*, *Bosmina longirostris*, *Daphnia hyalina*, *Bosmina* sp., *Diaphanosoma brachyurum*, *Halteria grandinella*, and *Keratella cochlearis*. In the summer, common taxa were *Polyarthra trigla*, *Cyclops vicinus*, *Bosmina* sp., *Stribilidium* sp., *Sinocalanus dorrii*, *Anuraeopsis fissa*, *Tintinnidium fluviatile*, *Halteria grandinella*, *Keratella cochlearis*, *Tintionnopsis* sp., *Trichocerca* sp., *Trichocerca pusilla*, *Mesocyclops leuckarti*, *Diaphanosoma leuchtenbergianum*, *Difflugia* sp., *Brachionus angularis*, *Urotricha* sp., *Pompholyx sulcata*, *Filinia* sp., and *Diurella stylata*.

During both seasons, a total of 73 macroinvertebrate taxa were collected, with 64 taxa found in the spring and 50 taxa in the summer. Common taxa in the spring included *Branchiura* sp., *Cryptochironomus* sp., *Limnodrilus* sp., *Tanypus* sp., and *Procladius* sp., while common taxa in the summer were *Branchiura* sp., *Limnodrilus* sp., and *Aulodrilus* sp.

3.3. Concordance in Different Assemblages

Procrustes analysis revealed significant concordances between phytoplankton and zooplankton, as well as zooplankton and macroinvertebrates during the spring season. However, the concordance between phytoplankton and macroinvertebrates was relatively weak in the spring compared to other pairs of assemblages. Interestingly, in the summer season, the concordance between phytoplankton and macroinvertebrates was higher than that observed between other pairs of assemblages (Table 2).

3.4. Relationships among Different Assemblages

In this study, Table 3 presents the variables related to plankton and macroinvertebrates used in the models, along with their specific interpretation. To describe the causal relationships between plankton and macroinvertebrate densities, eight models based on PLSR were constructed using data from both the spring and summer seasons. Among the latent factors, the first factor in each model, with higher explanation ratios compared to other factors, was considered a reliable, independent variable for predicting the dependent variable (Table 4).

Table 2. Results of Procrustes analyses for evaluating relationships between pairs of taxonomic groups in the spring and summer. Note: Bold represents significant concordances between pairs.

Seasons	Pairs of Assemblages	r_p	p
Spring	Phytoplankton vs. Macroinvertebrate	0.260	0.083
	Phytoplankton vs. Zooplankton	**0.365**	**0.003**
	Zooplankton vs. Macroinvertebrate	**0.342**	**0.014**
Summer	Phytoplankton vs. Macroinvertebrate	0.225	0.185
	Phytoplankton vs. Zooplankton	0.156	0.536
	Zooplankton vs. Macroinvertebrate	0.164	0.510

Table 3. Definitions of the variables used in the PLSR and SEM-PLS models.

Variable	Specific Interpretation
DenMollusk	Density of mollusks
DenInsects	Density of insects
DenOligochaetes	Density of oligochaetes
DenTotal	Density of macroinvertebrate
DenPhytoplankton	Density of phytoplankton
DenPyrrophyta	Density of Pyrrophyta
DenEuglenophyta	Density of Euglenophyta
DenBacillariophyta	Density of bacillariophyta
DenCryptophyta	Density of Cryptophyta
DenChrysophyta	Density of Chrysophyta
DenChlorophyta	Density of Chlorophyta
DenCyanophyta	Density of Cyanophyta
DenZooplankton	Density of zooplankton
DenProtozoan	Density of protozoan
DenCopepods	Density of copepods
DenRotifer	Density of rotifer
DenCladoceran	Density of cladoceran

Table 4. The variance proportion of the independent (X) and dependent (Y) variables explained by the latent factor 1 in the PLSR model in spring and summer, respectively.

Seasons	Explained Y	$R_X{}^2$	$R_Y{}^2$	Adjusted R^2
Spring	DenMollusk	0.181	0.161	0.143
	DenInsects	0.286	0.175	0.157
	DenOligochaetes	0.322	0.165	0.147
	DenTotal	0.300	0.170	0.152
Summer	DenMollusk	0.195	0.309	0.294
	DenInsects	0.360	0.350	0.337
	DenOligochaetes	0.242	0.287	0.273
	DenTotal	0.359	0.349	0.336

Based on the weights of each variable in the first latent factor of each model, the following reasonable conclusions can be drawn: (1) in the spring, the densities of phytoplankton, Chlorophyta, Cyanophyta, zooplankton, and copepods were good predictors of mollusk density. Insect density was influenced by the densities of Euglenophyta, Cryptophyta, Chlorophyta, Cyanophyta, and rotifers. The densities of phytoplankton, Euglenophyta, Cryptophyta, Chlorophyta, Cyanophyta, zooplankton, protozoa, and cladocerans could affect oligochaete density. Moreover, the total density of macroinvertebrates was influenced by the densities of phytoplankton, Euglenophyta, Cryptophyta, Chlorophyta, Cyanophyta, and protozoa. (2) In the summer, the density of mollusks was influenced by the densities of Euglenophyta, Cryptophyta, Chrysophyta, Chlorophyta, Cyanophyta, and rotifers. The densities of phytoplankton, Bacillariophyta, Chlorophyta, Cyanophyta, zooplankton, protozoa, and rotifers were good predictors of insect densities. The densities of Pyrrophyta, Chlorophyta, copepods, and rotifers could affect oligochaete density. Furthermore, the total density of macroinvertebrates was influenced by the densities of phytoplankton, Bacillariophyta, Chlorophyta, Cyanophyta, zooplankton, protozoa, and rotifers (Table 5).

Table 5. The weights of independent variables in the latent factor 1 in the PLSR models. Note: the weights with absolute values higher than 0.20 were in bold.

	Spring				Summer			
	DenMollusk	**DenInsects**	**DenOligochaetes**	**DenTotal**	**DenMollusk**	**DenInsects**	**DenOligochaetes**	**DenTotal**
DenPhytoplankton	**−0.270**	0.196	**0.324**	**0.222**	−0.200	**0.444**	0.123	**0.421**
DenPyrrophyta	−0.196	−0.110	0.069	−0.096	0.076	−0.133	**0.289**	−0.081
DenEuglenophyta	−0.133	**0.551**	**0.378**	**0.517**	**0.265**	0.036	0.071	0.037
DenBacillariophyta	−0.191	−0.024	0.173	0.018	−0.153	**0.329**	0.018	**0.301**
DenCryptophyta	−0.055	**0.441**	**0.347**	**0.434**	**0.253**	0.117	−0.156	0.079
DenChrysophyta	−0.098	−0.14	0.023	−0.123	**0.783**	−0.048	0.003	−0.035
DenChlorophyta	**−0.233**	**0.467**	**0.505**	**0.499**	**−0.248**	**0.312**	**0.866**	**0.424**
DenCyanophyta	**−0.249**	**0.341**	**0.291**	**0.319**	**−0.230**	**0.421**	0.083	**0.393**
DenZooplankton	**0.246**	0.073	**0.245**	0.149	−0.054	**0.255**	0.015	**0.241**
DenProtozoan	−0.032	0.196	**0.273**	**0.245**	−0.033	**0.221**	−0.008	**0.206**
DenCopepods	**0.398**	0.034	0.178	0.091	0.096	−0.040	**−0.208**	−0.062
DenRotifer	**0.691**	**−0.216**	0.069	−0.121	**−0.226**	**0.518**	**0.264**	**0.527**
DenCladoceran	−0.093	−0.071	**−0.291**	−0.118	−0.065	−0.038	0.017	−0.031

In total, the densities of phytoplankton, Chlorophyta, Cyanophyta, and protozoa were identified as the most important factors influencing macroinvertebrate densities in both seasons. In other words, increased macroinvertebrate populations were associated with higher densities of phytoplankton, Chlorophyta, Cyanophyta, and protozoa. Additionally, Chlorophyta and Cyanophyta densities played key roles in mollusk density; Chlorophyta and Cyanophyta densities were important factors in predicting aquatic insect density; and Chlorophyta density was the most influential factor in oligochaete density (Table 5).

To explore the relationships between plankton and macroinvertebrates, formative measurement models based on PLS-SEM were constructed using data from the spring and summer seasons. Three latent variables were used to represent different assemblages, and the densities of different groups served as indicators in the proposed research model (Figure 2). Path coefficients between endogenous (dependent) and exogenous (independent) variables were calculated, and the significance test on these coefficients was performed by using bootstrapping and resampling techniques (Table 6 and Figure 3). In the spring, the path coefficient between zooplankton and macroinvertebrates was the highest (0.61), indicating a strong correspondence between these two assemblages. On the other hand, in the summer, the path coefficient between phytoplankton and zooplankton was found to be significant ($p < 0.01$), indicating a much closer relationship between these two groups compared to other pairs. The results of path coefficients and bootstrapping analysis demonstrate a robust concordance between phytoplankton and zooplankton in both seasons. Furthermore, in the spring, zooplankton exhibited a stronger influence on macroinvertebrates, while in the summer, phytoplankton exerted a more pronounced impact on macroinvertebrates (Table 6 and Figure 3).

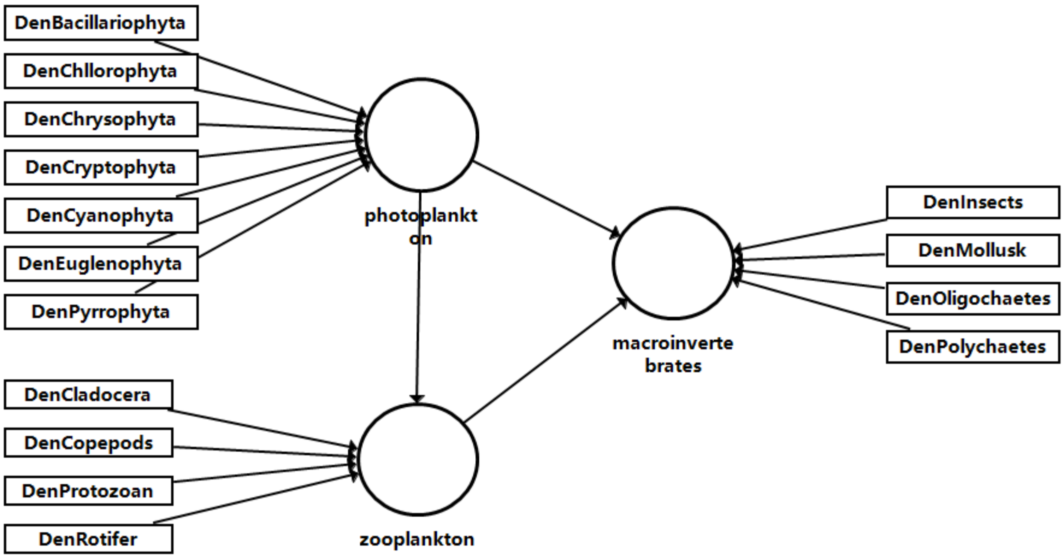

Figure 2. Diagram of the proposed research model for exploring the relationships between plankton and macroinvertebrates.

Table 6. The path coefficients between latent variables and the significance of path coefficients using bootstrapping technique.

Seasons	Pairs of Assemblages	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p* Values
Spring	Phytoplankton->Macroinvertebrate	−0.22	0.27	0.59	0.38	0.71
	Phytoplankton->Zooplankton	0.49	0.60	0.32	1.54	0.13
	Zooplankton->Macroinvertebrate	0.61	0.23	0.45	1.35	0.18
Summer	Phytoplankton->Macroinvertebrate	0.62	0.47	0.57	1.09	0.27
	Phytoplankton->Zooplankton	0.74	0.77	0.13	5.72	<0.001
	Zooplankton->Macroinvertebrate	0.19	0.17	0.35	0.55	0.58

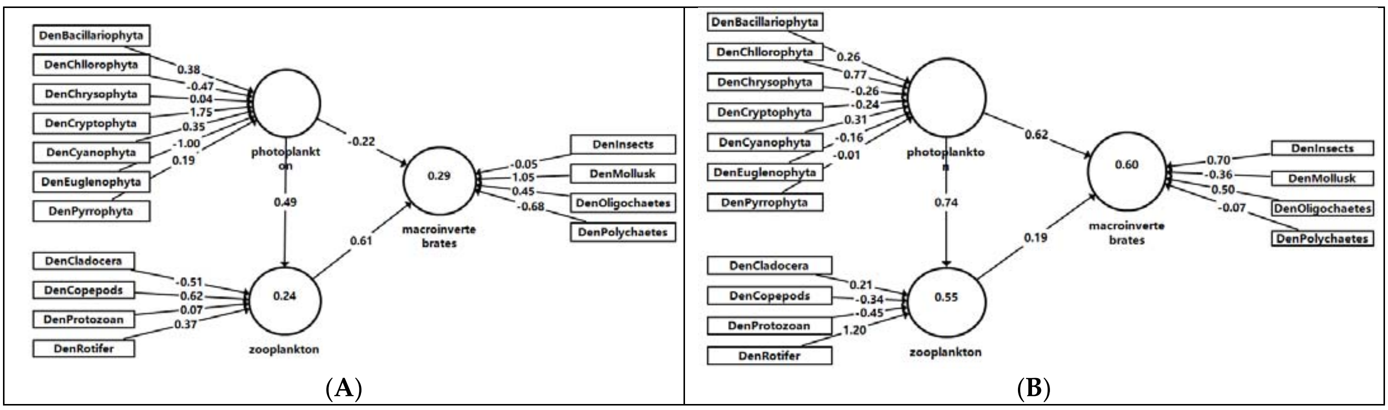

Figure 3. The SmartPLS results of the proposed research model based on the spring data. Note: (**A**)—spring, (**B**)—summer.

4. Discussion

In both the spring and summer seasons, several phytoplankton taxa, namely *Cryptomonas* sp., *Cyclotella* sp., *Synedra* sp., *Pediastrum* sp., *Melosira* sp., and Phormidiaceae spp., were found to be widespread across the reservoirs [24,25]. Similarly, certain zooplankton taxa such as *Sinocalanus dorrii*, *Polyarthra trigla*, *Tintinnidium fluviatile*, *Bosmina* sp., *Halteria grandinella*, and *Keratella cochlearis* were observed to be present in the reservoirs during both seasons [26,27]. Moreover, *Branchiura* sp.and *Limnodrilus* sp. were common macroinvertebrate taxa found in the reservoirs throughout the study period. These taxa collectively represent the characteristics of the reservoirs and are consistently present across different reservoirs.

Quantifying cross-taxon congruence is a method used to assess the assumption that the diversity of one taxonomic group can serve as an indicator of the diversity of another [10]. In the spring, there were significant concordances in species richness between phytoplankton and zooplankton, as well as between zooplankton and macroinvertebrates. This suggests that monitoring one group would be sufficient to capture the changes in biodiversity of the other group, making it a cost-effective approach for monitoring projects during this season. In the spring, the concordance between phytoplankton and macroinvertebrates was stronger compared to the summer, although it did not reach statistical significance. A meta-analysis of aquatic studies has shown that body size plays a significant role in predicting congruency in species richness patterns [10]. Typically, higher congruence is observed among taxa with similar body sizes, and as the differences in body size increase, the correlations in species richness become weaker [8–10]. In the present study, the significant congruence between phytoplankton and zooplankton, as well as the varying levels of concordance between macroinvertebrates and phytoplankton and between macroinvertebrates and zooplankton, appeared to support these previous findings. These results suggest that the similarity in body size may contribute to the observed congruence patterns in species richness among these taxonomic groups.

Bivalves, such as Corbicula and sphaeriids, along with some unionids, have the ability to filter phytoplankton, bacteria, and particulate organic matter from the water column [28]. Additionally, they can remove organic matter from sediment through deposit feeding. When the biomass of bivalves is substantial relative to the water volume and the hydraulic residence time is long, they can exert control over primary production [28]. Gastropods, on the other hand, consume algae, zooplankton, and organic wastes, thereby serving as a food source for various fish, birds, and even humans [29]. The findings of the PLSR analysis in this study revealed that in the spring, the densities of phytoplankton, Chlorophyta, Cyanophyta, zooplankton, copepods, and rotifers were good predictors of mollusk density. Similarly, in the summer, the densities of Euglenophyta, Cryptophyta, Chrysophyta, Chlorophyta, Cyanophyta, and rotifers influenced mollusk density. These results further supported the idea that the regulation of phytoplankton and zooplankton populations in reservoir systems is connected to food chains and food webs. Chironomids, a group of aquatic insects, play a crucial role in the flow of mass and energy within lacustrine ecosystems [30]. Studies have shown that chironomid larvae can utilize cyanobacterial detritus as a food source in Lake Taihu [31]. In this study, the abundance of insects in the spring was affected by the densities of Euglenophyta, Cryptophyta, Chlorophyta, Cyanophyta, and rotifers. Similarly, in the summer, the densities of phytoplankton, Bacillariophyta, Chlorophyta, Cyanophyta, zooplankton, protozoans, and rotifers influenced insect density. These findings suggested that phytoplankton and zooplankton serve as primary food sources for aquatic insects in reservoir systems. Freshwater oligochaetes primarily rely on bacteria and algae from detrital particles as their major food source. They, in turn, become prey for benthic-feeding fish. The quantity of bacteria and algae present in sediments significantly influences the distribution and abundance of many oligochaete species [32]. In this study, the abundance of oligochaetes in the spring was affected by the abundance of phytoplankton, Euglenophyta, Cryptophyta, Chlorophyta, Cyanophyta, zooplankton, protozoans, and cladocerans. Similarly, in the summer, the abundance of oligochaetes was influenced by the abundance of Pyrrophyta, Chlorophyta, copepods, and rotifers. These findings further confirmed that plankton is an important food source for oligochaetes in reservoirs.

The results of the PLSR analysis revealed that the densities of phytoplankton, Chlorophyta, Cyanophyta, and protozoa had the most significant influence on the total density of macroinvertebrates in both seasons. The densities of mollusks and aquatic insects were also influenced by Chlorophyta and Cyanophyta densities in both seasons. Moreover, Chlorophyta density emerged as the most important factor influencing the density of oligochaetes. These findings suggested that phytoplankton and zooplankton serve as primary food sources for macroinvertebrates, indicating a close link between plankton and macroinvertebrates in reservoirs. The formative measurement models provided further insights, showing a strong association between zooplankton and macroinvertebrates in the spring and a close relationship between phytoplankton and macroinvertebrates in the summer. The substantial concordance observed between phytoplankton and zooplankton densities in both seasons confirmed previous findings that assemblages with similar body sizes tend to exhibit stronger concordance compared to those with significant differences in body size [8,9]. In aquatic monitoring projects, the goal is to assess biodiversity by assuming that the diversity of one taxonomic group can be used to predict the diversity of another, thereby achieving cost-saving benefits [10,33]. The concordance between different organism groups has significant implications for theoretical ecology and biodiversity conservation [4,34,35]. However, it is essential to understand the unique history of each lake before conducting biological assessments and to select suitable indicator groups by exploring the concordance between different assemblages [36]. In this study, considering the close relationships between phytoplankton and zooplankton, selecting either group would be sufficient to achieve the monitoring objectives in future reservoir studies. Furthermore, the seasonal differences in concordance between macroinvertebrates and plankton aligned with the seasonal changes in macroinvertebrates' primary food sources.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to property rights restrictions.

Conflicts of Interest: The authors declare that there are no conflict of interest regarding the submission of this manuscript, and all authors have approved its publication. On behalf of my co-authors, I affirm that the work described in this manuscript represents original research that has not been previously published, nor is it currently under consideration for publication elsewhere, either in its entirety or in part.

Appendix A

Table A1. Brief information on 50 main reservoirs in Jiangsu Province, China.

Reservoirs	Storage Capacity ($\times 10^4$ m^3)	Size	Location	Sampling Period
Daxi	11,300	Large	Changzhou	Spring, Summer
Qiansong	1416	Medium	Changzhou	Spring, Summer
Shahe	10,900	Large	Changzhou	Spring, Summer
Tangma	1236	Medium	Changzhou	Spring, Summer
Guiwu	2620	Medium	Huaian	Spring, Summer
Hongqi	4119	Medium	Huaian	Spring, Summer
Hualong	4131	Medium	Huaian	Spring, Summer
Longwangshan	9099	Medium	Huaian	Spring, Summer
Anfengshan	12,000	Large	Lianyungang	Spring, Summer

Table A1. *Cont.*

Reservoirs	Storage Capacity ($\times 10^4$ m^3)	Size	Location	Sampling Period
Batiaolu	2143	Medium	Lianyungang	Spring, Summer
Changli	1405	Medium	Lianyungang	Spring, Summer
Dashibu	1930	Medium	Lianyungang	Spring, Summer
Fangshan	2218	Medium	Lianyungang	Spring, Summer
Henggou	2529	Medium	Lianyungang	Spring, Summer
Huozhuang	2480	Medium	Lianyungang	Spring, Summer
Shilianghe	53,100	Large	Lianyungang	Spring, Summer
Xiaotashan	28,200	Large	Lianyungang	Spring, Summer
Xishuanghu	1954	Medium	Lianyungang	Spring, Summer
Yushan	1225	Medium	Lianyungang	Spring, Summer
Daheqiao	1692	Medium	Nanjing	Spring, Summer
Daquan	1270	Medium	Nanjing	Spring, Summer
Fangbian	5070	Medium	Nanjing	Spring, Summer
Heiwangba	2216	Medium	Nanjing	Spring, Summer
Jinniushan	9286	Medium	Nanjing	Spring, Summer
Laoyaba	1136	Medium	Nanjing	Spring, Summer
Longdunhe	1124	Medium	Nanjing	Spring, Summer
Sanyou	435	Small	Nanjing	Summer
Shanhong	1048	Medium	Nanjing	Spring, Summer
Shanhu	2357	Medium	Nanjing	Spring, Summer
Wolong	1277	Medium	Nanjing	Spring, Summer
Yaojia	1108.4	Medium	Nanjing	Spring, Summer
Zhaocun	1034.2	Medium	Nanjing	Spring, Summer
Zheshantou	1138	Medium	Nanjing	Spring, Summer
Zhongshan	2868	Medium	Nanjing	Spring, Summer
Hengshan	11,200	Large	Wuxi	Spring, Summer
Cuihuozhuang	3388	Medium	Xuzhou	Spring, Summer
Dalongkou	465	Small	Xuzhou	Spring, Summer
Erhu	4094	Medium	Xuzhou	Summer
Gaotang	3815	Medium	Xuzhou	Spring, Summer
Qingan	6030	Medium	Xuzhou	Spring, Summer
Yunlonghu	4229	Medium	Xuzhou	Spring, Summer
Beishan	8156	Medium	Zhengjiang	Spring, Summer
Ershen	5720	Medium	Zhengjiang	Spring, Summer
Jurong	2859	Medium	Zhengjiang	Spring, Summer
Lintang	1492	Medium	Zhengjiang	Spring, Summer
Lunshan	2704	Medium	Zhengjiang	Spring, Summer
Maodong	1800	Medium	Zhengjiang	Spring, Summer
Maoshan	2178	Medium	Zhengjiang	Spring, Summer
Mudong	1176	Medium	Zhengjiang	Spring, Summer
Yuetang	1789.5	Medium	Zhengjiang	Spring, Summer

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