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Temporal trends of scientific literature about zooplankton community

Tendências temporais na literatura científica sobre a comunidade zooplanctônica

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Abstract

Zooplankton plays a key role in aquatic food chains. In the present study we aimed to evaluate the trends of zooplankton studies in the scientific literature published between 1991 and 2015 and also to answer the following questions: (i) Has the number of studies increased? (ii) Which are the main countries and journals that publish papers about zooplankton? (iii) Is it possible to identify temporal trends? We used the ISI Web of Science database to find articles that had the word "*zooplankton*" or its groups ("*copepods*", "*cladocerans*", "*rotifers*", "*testate amoebae*") in their title, abstract or keywords. The number of zooplankton publications increased over the years, but, when we removed the effect of total publications, the number of publications on copepods decreased, while publications on testate amoebae increased. The country with the most published studies was the USA and the journal was the *Hydrobiologia*. The keywords formed four groups, evidencing a temporal change in the main interest of the studies on zooplankton community. The oldest articles showed the interest of researches in zooplankton species description. In subsequent years, the main concern was still species description, but also ecology and other aspects. Recently, studies concerned to environmental issues, preservation and sustainability became more frequent.

Keywords: systematic review, scientific interest, limnology, water, food chain.

Resumo

O zooplâncton desempenha um papel chave nas cadeias alimentares aquáticas. No presente estudo, nosso objetivo foi avaliar tendências dos estudos com zooplâncton na literatura científica entre 1991 e 2015 e também responder às seguintes questões: (i) O número de estudos aumentou? (ii) Quais são os principais países e revistas que publicam trabalhos científicos sobre zooplâncton? (iii) É possível identificar tendências temporais? Utilizamos a base de dados *ISI Web of Science* para encontrar artigos que tinham em seu título, resumo ou palavras-chave a expressão "*zooplankton*" ou seus grupos ("*copepods*", "*cladocerans*", "*rotifers*", "*testate amoebae*"). O número de publicações com zooplâncton aumentou ao longo dos anos, mas, quando removemos o efeito do total de publicações, o número de publicações com copépodes diminuiu, enquanto as publicações sobre amebas testáceas aumentaram. O país que mais publicou trabalhos foi os EUA e a revista, *Hydrobiologia*. As palavras-chave formaram quatro grupos, evidenciando mudanças temporais no principal interesse dos estudos com comunidades zooplanctônicas. Os artigos mais antigos mostraram o interesse dos pesquisadores na descrição de espécies. Nos anos subsequentes, a principal preocupação foi também a análise descritiva, mas também a ecologia e outros aspectos. Recentemente, estudos relacionados com questões ambientais, preservação e sustentabilidade tornaram-se mais frequentes.

Palavras-chave: revisão sistemática, interesse científico, limnologia, água, cadeia alimentar.

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Introduction

Plankton is a vital component of marine and freshwater water-column ecosystems (Brierley, 2017). Within food webs, zooplankton is a link between primary producers and higher trophic levels (such as fish) and it is also a recycler that transform particulate matter and nutrients into dissolved pools (Steinberg and Landry, 2017). Zooplankton supports the microbial community through the regeneration of nitrogen in its excretion, what helps support bacterial and phytoplankton production. Microbes also colonize zooplankton fecal pellets and carcasses, making them rich sources of organic carbon for detrital feeders (Ruhl and Smith, 2004; Richardson, 2008).

In addition, this community is an excellent model for studies on the response of animals to diverse stressors because they have short generation times (typically from weeks to months), making them amenable to rapid evolutionary change (Hairston-Jr *et al*., 1999). This situation happens because stressors, such as climate change and anthropic pressure, affect zooplankton abundance, biogeography, size structure, life cycles (Richardson, 2008; Mackas *et al*., 2012), and may also change it phenotypically (with alterations in their physiology or behavior) or evolutionarily (with a shift in genetic populations composition) (Dam, 2013). For this reason, understanding the various roles of zooplankton and predicting future changes in the community are becoming increasingly important (Steinberg and Landry, 2017).

It is possible to find several papers related to zooplankton in scientific literature, with the most diverse approaches and applications, besides several ecological studies, because zooplankton is recognized to be an ideal community to examine factors structuring plankton communities, whether spatial or environmental factors (Dallas and Drake, 2014). There are also some studies related to the community structure and composition, densities and spatial distribution that are essential to subsidize several other studies applied to zooplankton. Also, descriptive zooplankton species studies are easily found in scientific literature because they are considered the first step in exploring biological data. Once species are described, more detailed studies are able to look at populations, genetic, and biochemical diversity (Costello *et al*., 2013).

The assessment of scientific production is an important issue for the academic community (White *et al*., 2005; Carneiro *et al*., 2008; Quixabeira *et al*., 2010) in order to identify trends in the interest of studies and improve the understanding of scientific asymmetries that occur among different regions in the world (Meneghini *et al*., 2008). Therefore, a systematic review becomes an interesting way to understand the state-of-art and to guide future studies on this group.

Thus, considering the great interest in the zooplankton community and the importance of evaluating the scientific production by the academic community, we aimed to present a systematic analysis verifying trends in zooplankton studies through the scientific literature published from 1991 to 2015. We also aimed to answer the following questions: (i) Has the number of studies on zooplankton community increased over the years? (ii) Which are the main countries and journals that publish scientific studies about this group? (iii) Is it possible to identify temporal trends in zooplankton studies?

Material and methods

We used the Thomson ISI Web of Science database (ISI WoS, 2016) to search for articles published from 1991 to 2015. We chose the year 1991 as the initial by the fact that, although this database has studies indexed since 1945, the abstracts are only available for articles published from 1991. We selected the Web of Science™ Main Collection to avoid results with duplicity of articles. We carried out five separated searches in the database, delimited as follows: (i) articles that had in the title, keywords and/or abstract the terms "*zooplank**" OR "*cladocer**" OR "*copepod**" OR "*testa* amoebae*" OR "*rotifer**"; (ii) only the term "*cladocer**"; (iii) only the term "*copepod**"; (iv) only the term "*testa* amoebae*" and (v) only the term "*rotifer**" (the asterisk is a boolean vector that includes derivations). The output of each search were text files organized by years, which were then inserted individually into the free HistCite™ software (HistCite, 2016) to extract the publication year, country of the first author, the name of the first author, the journal names, the keywords/words of the title and the abstract of each article. Then, we did some spreadsheets containing the following information: total number of articles published annually on total zooplankton and each group individually; total number of publications annually, data available in the database consulted (this last information is available in the database itself); number of publications by country; number of publications by journals annually and total number of publication within the investigated period.

We performed a Pearson's correlation analysis between the years and the total number of publications on all areas found in the database as a measure of the global scientific literature production. Then, we performed Pearson's correlation analysis between the years and the number of articles on total zooplankton and on each group separately to determine the trends of studies on zooplankton over the years. Before the analysis, we standardized the data over time by dividing the number of articles on total zooplankton (or on each group individually) by the total number of articles on all areas published in the database yearly, multiplying the result by 100. This procedure ensures that the temporal trend detected is not only a consequence of the global increase in scientific literature (Carneiro *et al*., 2008).

We performed a Principal Components Analysis (PCA) (Legendre and Legendre, 2012) to analyze the temporal trends of the keywords/title words. The data set used in this analysis referred only to the first search (with all zooplankton groups). We grouped words with similar meanings and excluded from the analysis the words used in the search (zooplankton and its groups), besides the names of the study areas and species. In order to remove the influence of the science growth (total number of articles published annually) the data analyzed in PCA referred to the proportion of the number of articles with a specific word by the total number of articles occurring in the same year, multiplying the result by 1000. We performed the PCA using the *rda* function, *vegan* package, R Program (R Core Team, 2018). The choice of axes criterion adopted was the broken-stick (two axes). To reduce the number of words and produce a legible graph, only the words that contributed most to the formation of axes were plotted (*loadings* ≥ 0.70 or ≤ -0.70). After that, we performed a qualitative analysis of some article abstracts to corroborate and discuss the words that were more associated with the years. A table summarizing this qualitative analysis is presented as a supplementary material (see Appendix A).

Then, we performed a cluster analysis to verify clusters of years with respect to their composition of keywords/title words and the existence of temporal tendencies in groups within the publication years, using *hclust* function of *vegan* package (Oksanen *et al*., 2016), R program (R Core Team, 2018). The data included in this analysis was the same as those analyzed in the PCA, standardized by time. The cluster analysis was constructed from a Euclidean distance matrix using the Complete Connection Method (Legendre and Legendre, 2012).

All graphs presented in this study were made in Statistica Software (StatSoft, 2001), except for the dendrogram that was made in the R Program (R Core Team, 2016).

Results

We observed a clear and significant growth in the global trend of publications in the database ($r = 0.96$, $P<0.001$; Figure 1A), except for the last year analyzed (2015), in which we observed an evident decrease in the number of publications. The search of articles containing, in their title, abstract and/or keywords, the word zooplankton (and variations) or any of its groups (cladocerans, copepods, rotifers and testate amoebae – and variations) resulted in 37,801 publications (Figure 1B). In the subsequent searches we obtained 5,627 articles on cladocerans (Figure 1C), 16,244 articles on copepods (Figure 1D), 5,378 articles on rotifers (Figure 1E) and only 708 articles on testate amoebae Figure 1F).

Before we removed the effect of total publications, we found a similar increase in publications on zooplankton community and its groups: total zooplankton ($r = 0.97$, $P<0.001$); cladocerans ($r = 0.90$, $P<0.001$); copepods ($r = 0.97$, $P<0.001$); rotifers ($r = 0.81$, $P<0.001$) and testate amoebae ($r = 0.90$, $P<0.001$). The growth rate of publications related to total zooplankton was more than 113% through the years, from 966 publications in 1991 to over than 2000 publications in 2013 and 2014. This same increase pattern was detected when analyzing all zooplankton groups, with 48.74% of growth rate for publications on cladocerans, 98.82% on copepods, 110.94% on rotifers and 425% on testate amoebae.

We expected to find this same pattern of linear growth on zooplankton publications before and after removing the effect of the total number of publication. However, after removing the effect of the total number of publication, testate amoebae were the only group that showed similar linear pattern of growth over the years (Figure 1F, $r = 0.90$, $P<0.01$). The correlations between the years and the number of publication on total zooplankton, cladocerans and rotifers were not significant in a linear model (Figure 1B, C and E, respectively, $P > 0.05$). In regard to copepods, there was a negative and significant correlation between the years and the number of publications (Figure 1D, $r = -0.56$, $P < 0.01$) mainly attributable to the period from 1998 to 2014, in which there was a clear decrease in the number of publications. The highest number of publication on copepods was achieved in 1998 and the smallest was achieved in 2014.

The United States was the country with the highest number of published papers on zooplankton and its groups from 1991 to 2015 (23.7% of published articles) (Figure 2), followed by Canada (8%), the United Kingdom (7.5%) and Germany (6.7%). Japan occupies the 6th position (5%), China occupies the 10th position (3.6%) and Brazil occupies the 13th position (2.7%).

A total of 2,096 journals published articles on zooplankton sometime between 1991 and 2015. Among them, the most representative were: Hydrobiologia (2,537 articles, 6.7% of total publications), Marine Ecology Progress (1,684 articles, 4.4%), Journal of Plankton Research (1,585 articles, 4.2%), Limnology and Oceanography (925 articles, 2.4%) and Freshwater Biology (763 articles, 2%) (Figure 2). The first 44 journals (2.1% of the total) accounted for more than 50% of all publications during the period studied and the other 97.9% of journals were responsible for the other 50% of all publications.

The region that most published studies related to zooplankton was North America (Figure 3), mainly because of contributions from the United States and Canada. It was followed by the European continent, with contributions from the United Kingdom, Czech Republic, Denmark, Norway and Sweden. The Asian continent relied on the

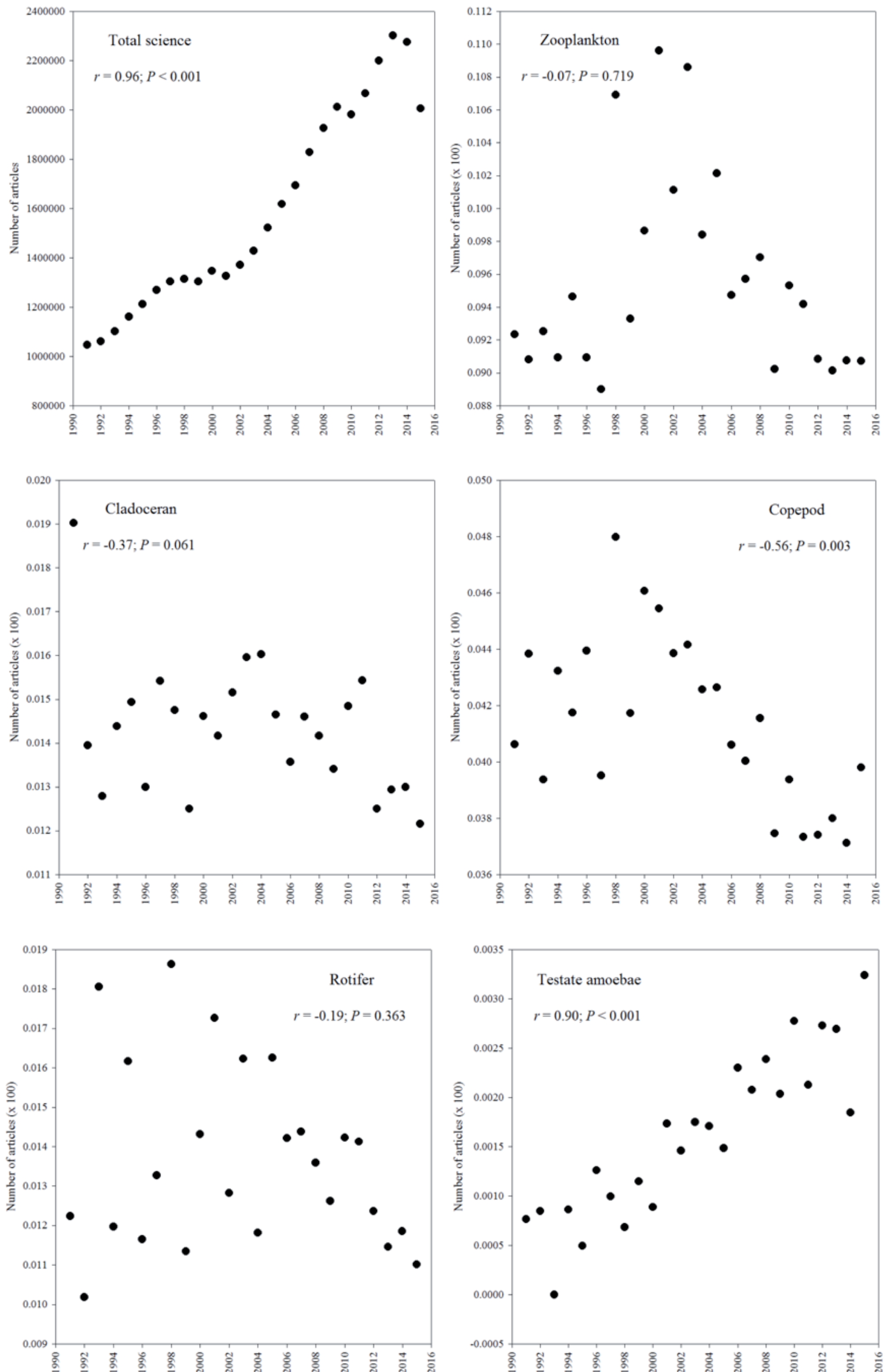

Figure 1. Number of publications by year: A: total of articles published in the Thomson ISI Web of Science database, representing the science growth; B-F: articles on zooplankton (B), cladocerans (C), copepods (D), rotifers (E) and testate amoebae (F). From B to F we removed the effect of total scientific publications in the database.

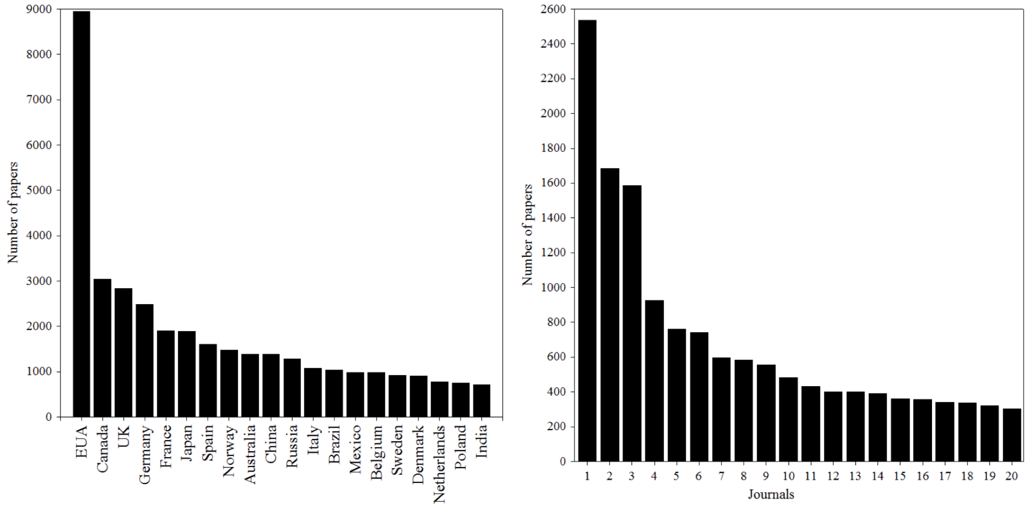

Figure 2. The top twenty countries (left) and the top twenty journals (right) with the highest cumulative numbers of published articles on zooplankton from 1991 to 2015. The numbers in the chart on the right refer to journals: (1) *Hydrobiologia*, (2) *Marine Ecology Progress Series*, (3) *Journal of Plankton Research*, (4) *Limnology and Oceanography*, (5) *Freshwater Biology*, (6) *Marine Biology*, (7) *Aquaculture*, (8) *Canadian Journal of Fisheries and Aquatic Sciences*, (9) *Deep-Sea Research Part II-Topical Studies in Oceanography*, (10) *Journal of Experimental Marine Biology and Ecology*, (11) *Crustaceana*, (12) *Ices Journal of Marine Science*, (13) *Journal of Marine Systems*, (14) *Polar Biology*, (15) *Progress in Oceanography*, (16) *Plos One*, (17) *Estuarine Coastal and Shelf Science*, (18) *Environmental Toxicology and Chemistry*, (19) *Archiv für Hydrobiologie*, (20) *Ecology*.

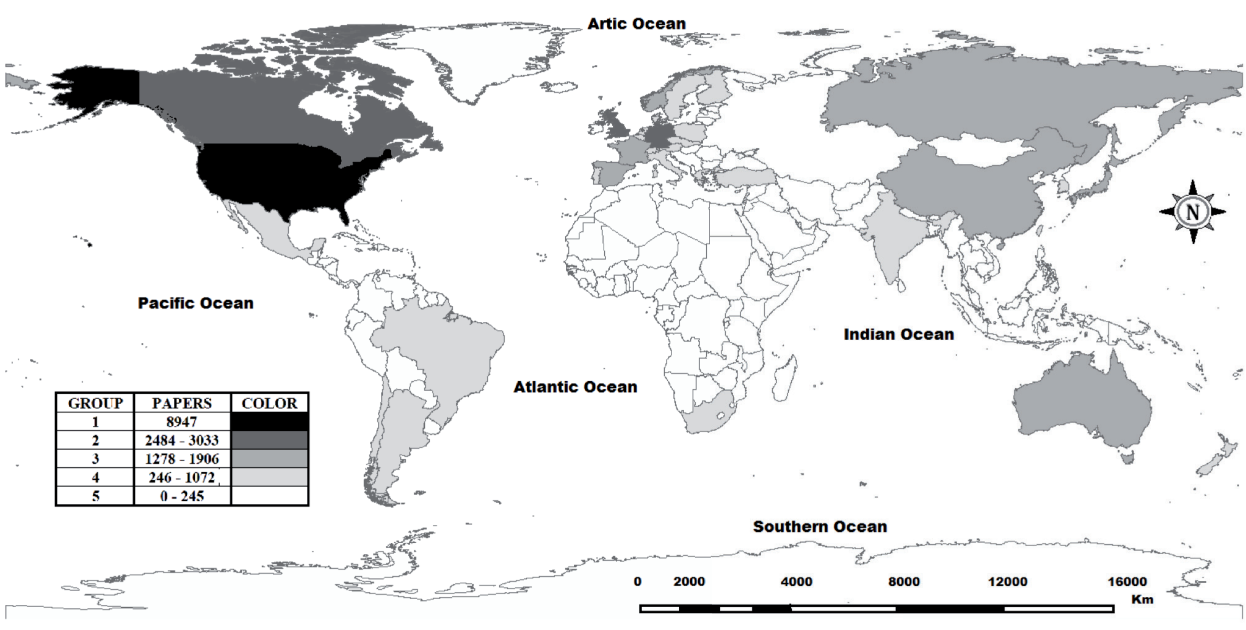

Figure 3. Geographic distribution of global scientific production on zooplankton community from 1991 to 2015.

publications of Russia, China and Japan. In Oceania there was only contribution from Australia. The most significant contributions from South America were from Brazil, Chile and Argentina. The African continent had few publications, with most articles published by South Africa.

The years were grouped into four distinct groups, according to 48 keywords/title words (Figure 4; Table 1). In group A there is only the year 1995 because it was more distinct from the others. In group B there are the years 1991, 1992, 1993, 1994, 1996, 1997, 1999 and 2000. In

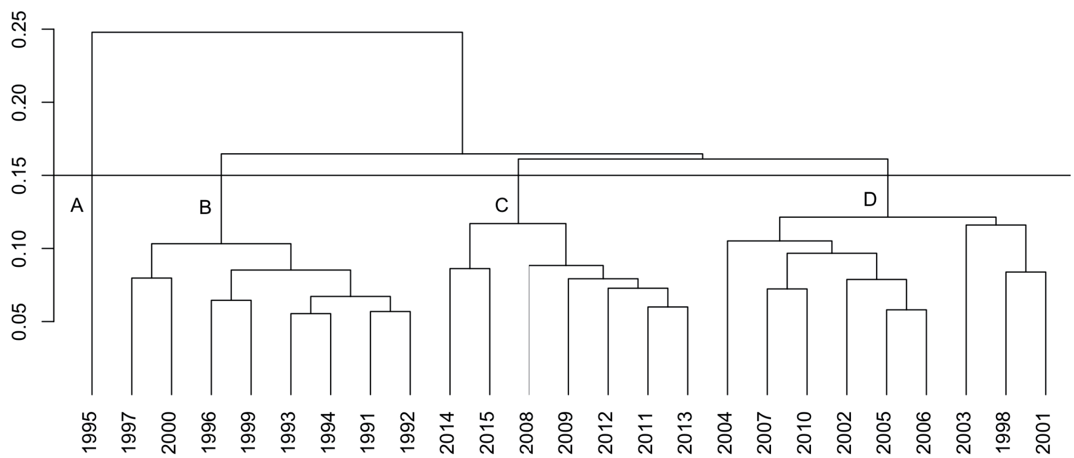

Figure 4. Dendrogram for cluster analysis using the main keywords/title words of articles on zooplankton published in the ISI Web of Science database from 1991 to 2015. Cophenetic Correlation Coefficient = 0.80.

Table 1. *Loadings* of words obtained in PCA. In bold are the words most positively or negatively related to axis 1 or axis 2 (values ≥ 0.70 or ≤ -070) and plotted in Figure 5 (right).

N°	WORD	PC1	PC2	N°	WORD	PC1	PC2	N°	WORD	PC1	PC2
1	**Environment**	**0.704**	-0.108	**17**	**Effects**	**0.773**	0.263	33	Biomass	-0.092	0.409
2	**Eutrophication**	**0.835**	-0.207	**18**	**Dynamics**	**0.828**	0.041	34	Diel	-0.272	0.531
3	**Ecology/Ecological**	**0.842**	-0.218	**19**	**Ecosystem**	**0.713**	0.018	35	Distribution	0.449	0.597
4	**Use**	**0.766**	-0.199	20	Acidification	0.640	-0.164	36	Impact	0.530	-0.144
5	**Change**	**0.871**	-0.349	21	Fish	0.631	0.655	37	Life	0.210	0.507
6	**Analysis**	**0.867**	-0.233	22	Composition	0.642	0.159	38	Morphology	-0.031	0.356
7	**Diversity**	**0.836**	-0.382	23	Development	0.070	0.692	39	New	0.321	0.493
8	**Climate**	**0.763**	-0.570	24	Isotope	0.550	-0.687	40	Nutrient	0.488	0.388
9	**Behavior**	**-0.779**	0.432	25	Models	0.679	0.205	41	Parasite	-0.098	0.103
10	**Grazing**	-0.189	**0.725**	26	Pelagic	0.635	0.246	42	Patterns	0.414	0.214
11	**Rate**	-0.061	**0.714**	27	Reproduction	0.324	-0.172	43	Predation	-0.042	0.366
12	**Production**	0.085	**0.859**	28	Structure	0.668	0.213	44	Relation	-0.477	0.463
13	**Growth**	0.495	**0.703**	29	Temperature	0.600	0.037	45	Response	0.432	-0.176
14	**Food/Feeding**	0.617	**0.706**	30	Vertical	0.140	0.668	46	Seasonal	0.449	0.496
15	**Carbon**	**0.789**	0.119	31	Abundance	0.571	0.419	47	Shallow	0.462	-0.008
16	**Toxicity**	**0.723**	0.111	32	Bacteria	-0.546	0.405	48	Size	-0.138	0.594

group C there are the years 2008, 2009, 2011, 2012, 2013, 2014 and 2015. Finally, in the group D there are the years 1998, 2001, 2002, 2003, 2004, 2005, 2006, 2007 and 2010. It is clear a temporal clustering related to the words, with A and B groups concentrating older years (1991 to 2000), followed by D group (2001 to 2007) and finally the C group which, chronologically, groups the most recent years (2008 to 2015).

Using the PCA (Figure 5), we distinguished words that were more associated with each group temporally. Group A, for example, which only covers the year 1995, was influenced by the word *behavior*. Some articles that contain the word *behavior* in its keywords/title and were published in 1995 deal with the zooplankton behavior related mainly to predation, in addition to the behavior related to daily vertical migration in the water column, mode of locomotion/swimming and its metabolism (qualitative analysis, Appendix A).

Group B, which includes the older years (1991 to 2000), was more influenced by the words *rate, grazing, behavior* and *production*. Regarding the word *rate*, we found articles related to population growth, productivity in the aquatic ecosystem, feeding, carbon cycle, respiration and excretion. The papers with the word *grazing* are related to the preferences and eating habits of zooplankton. Group D (2001 to 2007) was influenced by a greater num-

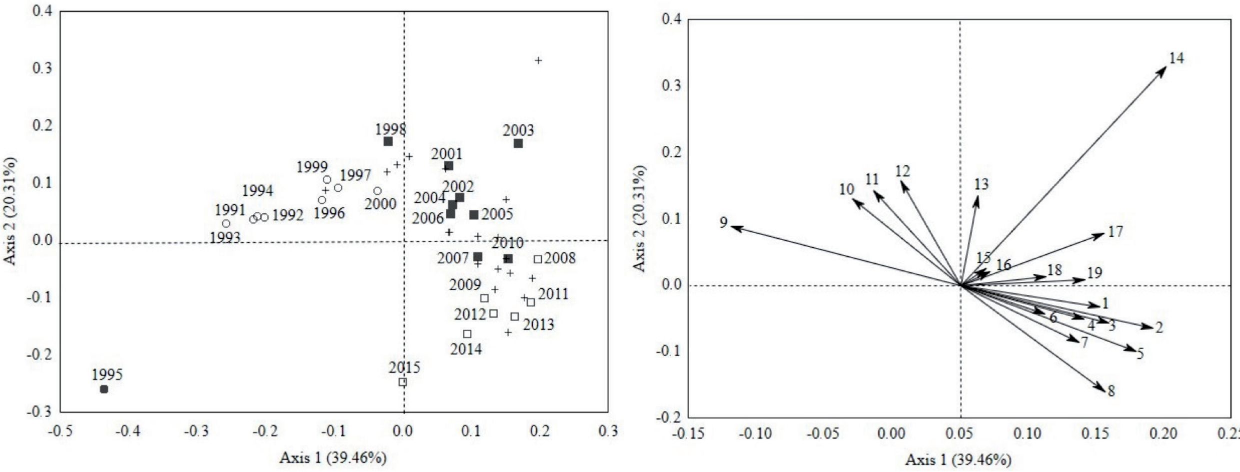

Figure 5. PCA using the keywords/title words that most contributed to the formation of axes 1 and 2 (*loadings* ≥ 0.70 or ≤ -0.70). In the left: *loadings* of years and groups based on the Cluster Analysis – closed circle (group A), open circle (group B), open square (group C), closed square (group D), + sign indicates the position of the words also plotted in the right (*loadings* of words; see Table 1).

ber of words, among them *carbon* (carbon cycle), *food, dynamics* (local and regional for structuring communities, population and nutrient dynamics), *growth, ecosystem, toxicity* and *effect* (abiotic factors in communities, competition, top-down and bottom-up, local and regional for community structuring). Finally, group C, which contains the most recent years (2008 to 2015), was more influenced by the words *analysis* (statistical analysis applied to zooplankton, genetic analysis), *climate* (climate change), *diversity* (of species), *environmental* (environmental factors/variables), *ecology, changes* (affecting zooplankton community), *eutrophication.*

Discussion

The global scientific production is growing over time and it is reflected by the increasing number of all studies published yearly in a database, as we detected when we correlated the years with the total articles published annually in Thomson ISI Web of Science database. This is an indicative that researchers and studies are increasing over time, as well as the scientific and technological progress, considering that the number of publications is one of the most used measures to quantify the science progress and evolution (Verbeek *et al*., 2002). The emergence of new technologies, the easiness of disseminating knowledge globally, the human population increase and greater investments in training scientists are possible mechanisms that may explain this increase in global scientific production (King, 2004). However, the decrease in the total number of publications visualized in 2015 may be explained by the fact that when we searched in the database (in May, 2016), the articles published in the previous year were not yet totally available in the database. When we performed the same search in August 2016, we obtained 2,346,920 publications, a higher number than previously found in 2014.

We also detected that the zooplankton literature is dominated by copepods that, in this study, had approximately three times as many articles as cladocerans and rotifers and 23 times more articles than testate amoebae. Such divergence may be related to some important copepod characteristics, such as: (i) its wide geographical distribution and abundance (Schminke, 2007), being cosmopolitan and inhabiting almost all aquatic ecosystems (Ferdous and Muktadir, 2009; Jagadeesan and Jyothibabu, 2016); (ii) their importance in the aquatic food chains, being used as supplementary feed for a large variety of fish larvae (Sipaúba-Tavares and Pereira, 2008; Camus and Zeng, 2009) and (iii) its largest size as a zooplankton group, facilitating its sampling, preservation and identification (Richardson, 2008).

On the other hand, despite having presented significant increase in number of articles published over the years, testate amoebae were the less studied zooplankton group. This issue may be related to the difficulty in identifying these organisms. Some common species can be easily identified, but there is an urgent need for a taxonomic review and a synthesis of existing data (Mitchell *et al*., 2008). Species identification may not be carried out safely by most ecologists due to intraspecific morphological differences that are not described, the lack of adequate identification criteria, the difficulties in accessing the original descriptions or simply because there is no synthesized source where species are clearly described (Foissner, 2006; Mitchell *et al*., 2008).

According to the correlation between years and total zooplankton studies (or its groups) before removing the effect of total publications in the database, we detected the same increasing trend of total science. However, when we removed the effect of total publications, the number of articles on zooplankton, cladocerans and rotifers did not fit a linear pattern over the years. Nevertheless, publications on total zooplankton significantly fitted the quadratic model ($R^2 = 0.42$, $P = 0.002$). It happened because the number of zooplanktons studies showed an increase in some years by the period from 1998 to 2005. The number of zooplankton studies is mainly influenced by copepod studies, followed by cladoceran and rotifer studies. Analyzing the data, we visualized that this peak in zooplankton publications was probably attributable to copepod studies. Despite the high number of publications, copepods presented a decrease of publications over the years, leading to highlight possible factors that may determine the low scientific interest, such as the low investment growth in research on this subject or the existence of few specialized taxonomists (Torstrom *et al*., 2014). On the other hand, the testate amoebae had the smallest number of published studies, but tended to increase its number over the years. This increase can be justified by the large gap in the studies, presenting greater opportunities for descriptive studies and tests of ecological theories. It is important to highlight that the increase in absolute numbers of papers (analysis before removing the effect of total publications) does not necessarily lose importance in relation to the relative numbers, but it is a complementary information of science monitoring about zooplankton community.

The United States is the leadership country in number of scientific articles published, including those related to several aspects in the life sciences area (King, 2004) such as biodiesel (Ferreira *et al.*, 2014), population ecology (Lima-Ribeiro *et al.*, 2007) and phytoplankton (Carneiro *et al.*, 2008). Several articles also corroborate the USA as a leadership in Research and Development (R&D) (*e.g.* Shelton and Holdridge, 2004; Jappe, 2007; Shelton and Foland, 2009; Ferreira *et al.*, 2014; Livingston *et al.*, 2016). The main reason for the USA leadership may be a reflection of investment in research funding, infrastructure and education, not only by public institutions, but also by private companies and non-governmental organizations (Jappe, 2007; Shelton e Holdridge, 2004; Shelton e Foland, 2009; Ferreira *et al.*, 2014; Basu *et al.*, 2018). Also, the United States accounts for 40% of the total spending on scientific research and development in the world, employs 70% of the Nobel Prize winners and is home to 75% of the top 40 universities in the world (Galama and Hosek, 2008). In contrast, less developed countries and, consequently, less human development index (HDI) are the ones that have fewer publications (Livingston *et al.*, 2016).

The PCA performed with the keywords/title words pointed to a pattern of four groups similar to those formed by the cluster analysis, also following the temporal scale and suggesting tendencies related to the words used the most in each period. The words that most influenced A and B groups (1991 to 2000) showed trend of studies on zooplankton more focused on species description, lifestyles, niches occupied in the food web and limited interaction with other species, being more related to feeding (qualitative analysis, Appendix A). Publications on species description are fundamental, as species provide a more practical metric for distinguishing habitats and tracking progress in biodiversity exploration. Thus, once species are described, different studies can be performed (Costello *et al*., 2013).

The words that most influenced the D group (2001 to 2007) also pointed out a tendency of species description, with studies more focused on feeding habits and growth patterns of zooplankton species, and presented by words like feeding, growth, production. However, there is also a trend towards more ecological and broad aspects, such as nutrient cycle – mainly carbon, ecosystem, interspecific competition and “effects” in zooplankton community. It is worth to mention that, in this period, the global concern about the environment had increases due to the deleterious effects caused by the global warming, human land use and unplanned occupation and other forms of ecosystem degradation (Solomon *et al*., 2009). In addition, global warming is intrinsically linked to the carbon cycle because of the greenhouse gases in the atmosphere that had increased greatly due mainly to anthropogenic causes since the industrial revolution (Anikuttan *et al*., 2016). Thus, in this period, several articles brought the effects of climate change on zooplankton and its relation to the carbon cycle. Also in this period, toxicological and ecotoxicological zooplankton studies were highlighted, especially those including cladocerans.

Finally, taking into account the words most related to C group (2008 to 2015), it was possible to verify a significant number of articles focused on environmental issues and, consequently, on preservation and sustainability. An example is the great concern arising from the consequences of climate change and the increase in the trophic state of water on zooplankton community and also the food web associated with it. In addition, it was easily verified in the articles of this period the urgency for biodiversity conservation and the decrease in human impact on the environment (Brooke and Otter, 2016).

Conclusion

Zooplankton community studies are important for a better understanding of ecological processes in local and ecosystem scale. In this sense, the relative stability of the number of published studies on cladocerans and rotifers and also the relative decline in copepod publications may indicate that national policies of research promotion, including funding agencies, should provide specific strategies to form new taxonomists and also to allocate resources in studies on zooplankton community. Some important recommendations for studies on zooplankton community would be, besides broad ecological aspects (*e.g.* feeding habits and nutrient cycling), also genetic analyzes and mainly environmental preservation, prioritizing the relation of the zooplankton community with the water eutrophication process, impacts of climate change and some aspects related to the dynamics of species diversity.

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Appendix

Appendix A. Qualitative analysis of some abstracts that contain the word "*zooplankton*" or one of its groups ("*cladocera*", "*copepod*", "*rotifer*" or "*testate amoebae*"). In the first column (from left to right) is the group generated in the cluster analysis; the second column refers to the period correspondent to each group; the third column contains some words that better describe each group, according to the PCA; the fourth column contains the subject of the words found by analyzing some abstracts and, finally, the fifth column contains the reference of the abstracts analyzed.

Group	Years	Words influenced	Related to	References
A	1995	*Behavior*	Predation	Meester *et al.* (1995); Purcell and Cowan-Jr (1995); Stirling (1995); Svensson (1995)
			Daily vertical migration in the water column	McKelvey and Forward (1995)
			Modes of locomotion/swimming	Mackenzie and Kiorboe (1995); Melchin and Demont (1995); Van Duren and Videler (1995)
			Metabolism	Hassett and Blades-Eckelbarger (1995)
B	1991 to 2000	*Rate*	Population growth	Irigoien *et al.* (2000); King and Greenwood (1992); Pollingher (1991); Shuter and Ing (1997)
			Productivity in the aquatic ecosystem	Miller *et al.* (1991)
			Feeding	Atkinson *et al.* (1996); Nixdorf and Arndt (1993); Tóth (1992)
			Respiration and excretion	Pagano and Saint-Jean (1994)
			Carbon cycle	Miquel *et al.* (1994)
		Grazing	Preferences and eating habits	Gifford (1993); Hansson (2000); Nejstgaard and Solberg (1996); Noges (1992)
D	2001 to 2007	*Carbon*	Carbon cycle	Beisner *et al.* (2003); Hays *et al.* (2001); Legendre and Rivkin (2002)
		Dynamics	Local and regional for structuring communities	Bunioto and Arcifa (2007); McIntyre *et al.* (2006)
			Population dynamics	Castilho-Noll and Arcifa (2007); Hamzah *et al.* (2007)
			Nutrient dynamics	Lopez-Flores *et al.* (2006)
		Effect	Abiotic factors in communities	Ghosal and Kaviraj (2002); Koski *et al.* (2003); Mackas *et al.* (2001); Muren *et al.* (2005)
			Competition	Hall (2004); Traunspurger *et al.* (2006)
			Top-down and bottom-up	Mehner *et al.* (2001)
			Local and regional for community structuring	Kim *et al.* (2001); Van Der Gucht *et al.* (2007)
C	2008 to 2015	*Analysis*	Statistical analysis applied to zooplankton	Obertegger *et al.* (2010); Zhaoli (2008)
			Genetic analysis	Frisch *et al.* (2013)
		Climate	Climate change	Sipkay *et al.* (2008); Moss *et al.* (2011); Wooldridge and Deyzel (2012)
		Diversity	Of species	Almeida *et al.* (2012); George *et al.* (2014)
		Environmental	Environmental factors/variables	Dai *et al.* (2014); Meleg *et al.* (2012); Sellami *et al.* (2009)
		Ecology	Ecology patterns	Lenz *et al.* (2012); Mieczan (2009); Pellowe-Wagstaff and Simonis (2014); Wintzer *et al.* (2013)
		Changes	In zooplankton community	Ayon and Swartzman (2008); Bi *et al.* (2014); Galir and Palijan (2012)
		Eutrophication	Trophic state	Imoobe and Adeyinka (2009); Moss *et al.* (2011); Mukherjee *et al.* (2010)

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