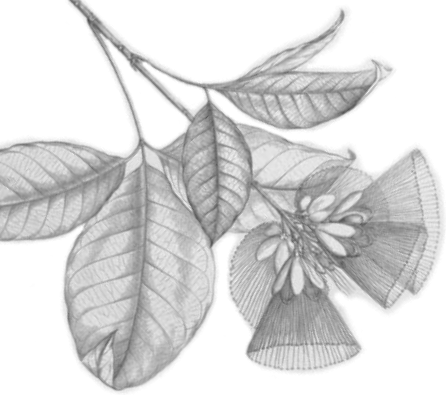

Comparison of the Regional and Global Production of Scientific Papers: A Perspective from Freshwater Fish Studies in Goiás State, Central Brazil

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ABSTRACT

Scientific production is often explored at broader scales but understanding whether regional trends follow global ones is an important issue for science and public policies. Using freshwater fish papers' production in the Goiás State, Central Brazil, we tested two hypotheses: *i*) regional production of papers follows global tendencies; *ii*) regional production is driven by the number of authors, institutions, financial support and dissertations/thesis produced. From published papers we extracted the: year of publication, authors' institution, journal of publication, impact factor and financial support. To test both hypotheses we performed, respectively, a Pearson correlation between papers number and year, and a multiple linear regression considering papers number or impact factor as response variable and authors, institutions, financial support and dissertations/thesis as predictors variables. We observed a positive correlation between papers number and year, whereas financial support, institutions and dissertation/thesis were the main drivers for papers number and impact factor. Regional production of fish papers follows global patterns of production (financial support and institutions number as mains drivers). However, this production remains influenced by particularities such as: an inconstant production through time and the fact that many papers are still published in journals without an impact factor.

Keywords: Paraná Basin; Tocantins-Araguaia Basin; Temporal Trends; Financial Support.

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The scientific production of papers is increasing all over the world (King 2004; Parreira et al. 2017) leading to an intense debate among scientists on whether this increase is a matter of quality or quantity (Fischer, Ritchie, and Hanspach 2012; Loyola, Diniz-Filho, and Bini 2012). This upward trend is also followed not only by the Biological Sciences' knowledge area (Padial et al. 2010; Nabout et al. 2012) but also by Ecology and Genetic research fields, which include a significant increase in the number of multiauthored papers and collaborative networks (Parreira et al. 2017; Nabout et al. 2015). Nevertheless, these tendencies result from scientific production measured worldwide or at a country level, Brazil in this case (e. g., increase of scientific production of articles by De Almeida & Guimarães (2013); coauthorship networks by Mena-Chalco et al. (2014)); scientific production in the Biological Science area (biochemistry, physiology and pharmacology; Roos et al. (2014)) that does not necessarily reflect regional or local trends.

The scope of freshwater studies has gradually shifted from regional to broader scales given the advances, needs and particularities of different research fields, such as: earth sciences, climate policies, watershed management and conservation (Alcamo et al. 2008). In Brazil, it is observed an increase in the number of scientific papers related to freshwater fishes in the last two decades (Castro 1999; Dias et al. 2016), including those of the Goiás State (Carvalho and Tejerina-Garro 2019). Still, Brazil faces a high socioeconomic and structural asymmetry among its regions (North, Northeast, Central-West, Southeast, and South), two factors recognized as important drivers of the scientific production (Parreira et al. 2017; Nabout et al. 2015; Dias et al. 2016). Additionally, it is recognized that the increase of Brazilian scientific papers production was potentialized by periodic evaluations of graduate programs conducted by the Coordination for postgraduate personnel improvement (CAPES) since 1976 (Marenco 2015; Fernandes and Manchini 2019). Thus, the Brazilian scientific papers number's increase results not only from the linear relationship with the number of graduated PhDs (de Almeida and Guimarães 2013; de Meis, Arruda, and Guimarães 2007), but also from the influence of federal and state funding (Marenco 2015) and the co-publications with researchers of international institutions (Glänzel, Leta, and Thijs 2006). On the other hand, the lower impact of some Brazilian scientific papers is associated to low researchers' English proficiency (Vasconcelos, Sorenson, and Leta 2009) and to a scientific production centered on quantity instead of quality (Roos et al. 2014). In this context, comprehending regional trends of scientific production is an essential step to fulfill existing gaps and improve science's quality.

In this study, we investigated the production of scientific papers related to freshwater fish at the Goiás State, Central Brazil, in the last 30 years given that the number of fish studies in South

America started to grow over 1990's (Castro 1999). We choose the Goiás State, because: i) it includes the headwaters of two important hydrographic river basins (Tocantins-Araguaia and Paraná River, Tejerina-Garro (2008)); ii) it encompasses an expressive freshwater fish diversity in the upper Paraná section (214 species/morphospecies, Tejerina-Garro, Carvalho, & Teresa (2017)) and Tocantins-Araguaia River basin (273 species/morphospecies, Braudes-Araújo, Tejerina-Garro, & Carvalho (2019)); and iii) investments on different fields of knowledge often consider geopolitical boundaries, which may directly affect trends of scientific production.

In this way, first, we tested whether the scientific production in this region increases through time and follows global tendencies for the scientific production in the Biological Sciences knowledge area. Second, we determined which factors influence on the number of scientific papers and their impact factor along the years. Our main hypotheses are: i) the regional production of freshwater fish papers does not increases through time and unfollows global tendencies for Biological Sciences knowledge area; ii) the regional production of freshwater fish papers and its impact factor are both driven by the number of authors, institutions, financial support related to papers, and the number of dissertations/thesis produced by regional institutions.

MATERIAL AND METHODS

To search for published papers on freshwater fish over the last 30 years, we used the *Google Scholar* (https://scholar.google.com.br), which offers reliable Internet research results as Web of Sciences and Scopus (Delgado-López-Cózar and Repiso-Caballero 2013; Harzing and Alakangas 2016) and the following keywords in both English and Portuguese languages: (fish* AND Goiás state), (fish* AND Goiás AND Araguaia), (fish* AND Brasilia), (fish* AND Distrito Federal), (fish* AND Goiás AND Paraná), (fish* AND Goiás AND Tocantins), (freshwater fish* AND Goiás). Despite it is not considered part of the Goiás State, we included the Distrito Federal in our research because this district is geographically located inside Goiás State region.

In addition, we used the *Lattes* platform from Brazilian National Council for Scientific and Technological Development (CNPq) (http://lattes.cnpq.br/) to check published papers from the authors' *Curriculum Vitae* found in the *Google Scholar* research aiming to render more robust our database.

Scientific papers included in the final database fulfilled the following requirements: i) the objectives were related to freshwater fish and had an available on-line file in the Portable Document Format (PDF) in order to guarantee the access to the information related to each study; ii) the fish data

was collected inside the geopolitical boundaries of the Goiás State in order to guarantee that scientific papers represent the river basins located in this State.

From each paper, we extracted the following information: year of publication, main author and co-authors' name, main author and co-authors' institution, and any financial support mentioned in the acknowledge section. For author and co-authors, we registered their full name and institutions exactly as it was informed in the paper. For each paper, we also obtained the journal's Impact Factor (IF) consulting the Impact Factor List (2017/2018), accessed at the Scijournal.org (2018). Additionally, for each year we listed the number of master dissertations and PhD thesis produced by Goiás State institutions accessing the Catalog of Thesis (https://catalogodeteses.capes.gov.br) from CAPES. The keywords used (Federal District, Goiás AND Fish) were in both English and Portuguese languages. The selected institutions were all located inside geopolitical boundaries of the Goiás State (including Federal District). The dissertations and thesis considered were only those related to freshwater fish.

Data collected was organized in three different data matrices. The first matrix was composed by the year and the proportion of number of papers (%NP) for each year; it was used to test temporal trends of papers production with a Pearson's correlation following the protocol described by Nabout et al. (2012), that is, years were ordered from 0 (the first year when a paper was published, 1989 in this case) to 29 (the last year when a paper was published, 2018). We expected that trends of the regional scientific production follow global ones. The second matrix was composed by the number of papers produced in each year (NP), the number of papers with co-participation among institutions per year (COP), the number of papers with co-authorship per year (COA), the number of papers with financial support per year (NPFS) and the number of master dissertations and PhD thesis produced per year by regional institutions (Thesis). This matrix was used to perform a multiple linear regression model considering NP as the response variable and COP, COA, FIN and Thesis as the predictor variables. The third matrix was composed by the impact factor of the journal where the paper was published (IF), the number of institutions related to each paper (NI), the number of authors related to each paper (NA) and the number of financial supports given for each study (NFIN). This third matrix was used to test the drivers of the impact factor of regional scientific production with a multiple linear regression model considering IF as response variable and NI, NA, NFIN as predictor variables. In this case, we considered papers published in journals without impact factor as zero (0).

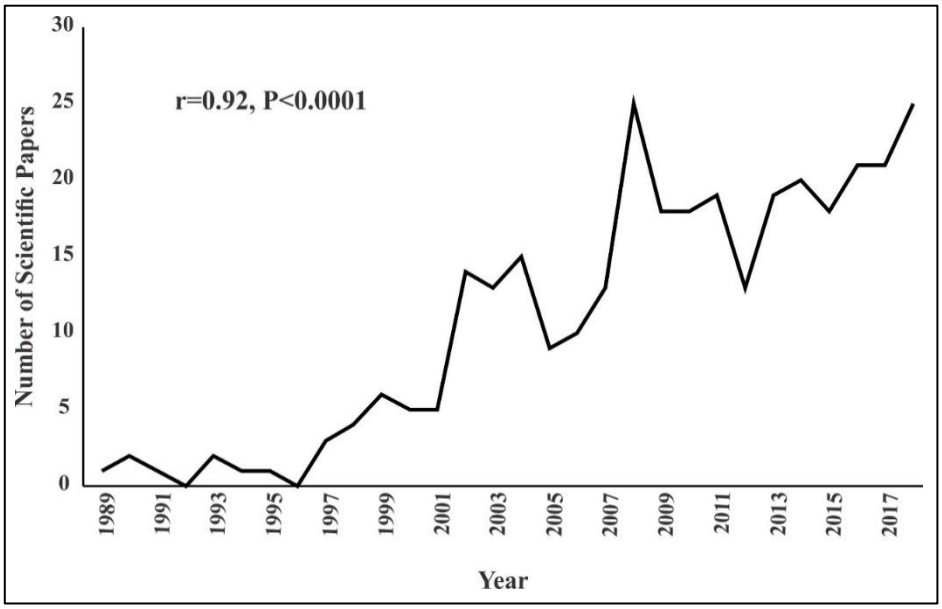
Previously the development of each multiple linear regression models, we tested the multicollinearity among variables. For this, we used the variance inflation factor (VIF) and considered values of VIF>10 as indicating strong multicollinearity (Woolnough, Downing, and Newton 2009;

Ghani and Ahmad 2010). All analyses performed were conducted in the R software environment (The R Development Core Team 2018). We used the package *fmsb* to calculate VIF (Nakazawa 2018) and the package *Vegan* for multiple linear regression models (Oksanen et al. 2018).

RESULTS

Our search revealed a total of 322 scientific papers related to freshwater fishes within the limits of the Goiás State in the last 30 years (227 or 70.5% of these papers were published in journals with impact factor). The Pearson's correlation indicated that the number of scientific papers increased over the years ($r=0.92$, $P < 0.0001$), but this growth was inconstant through time, that is, the scientific production of fish papers had a faster growth after the year of 2000 with three distinct periods of growth: 2001-2004, 2007-2011, 2014-2018 (Figure 1).

Figure 1. Number of scientific papers published per year on freshwater fish fauna of the Goiás State, Central-West region, Brazil. Statistics refer to the result of Pearson's correlation (r) between proportion of papers number and years, and the statistical significance of the test (p).



Source: The Authors.

The multicollinearity analyses indicated that COA was highly correlated to other variables (VIF>10), thus this variable was removed from the data matrix. After its removal, all other variables presented a VIF<5. The first multiple linear regression model indicated that NP is positively affected by COP, NPFS and Thesis (87 in total, $R^2adj=0.98$, $P<0.0001$), i.e., the growth in the number of papers published is highly affected by an increase in the number of co-participations among institutions, financial support and dissertation/thesis. NFS was the main driver of the regional production (R^2 adj=0.65, $P<0.0001$) followed by COP (R^2 adj=0.52, $P<0.0001$) and Thesis (R^2 adj=0.35, $P<0.001$).

The second multiple linear regression model indicated that IF is positively affected by NI and NFIN (R^2 adj=0.10, P<0.0001), i.e., the impact factor of regional production is affected by an increase in the number of institutions related to papers and financial support given. NFIN was the main driver of the impact factor (R^2 adj=0.22, P<0.0001) followed by NI (R^2 adj=0.08, P<0.0001).

DISCUSSION

We observed that the regional production of papers related to freshwater fish has a similar trend of global scientific production, that is there is an increase in the number of papers published over the last three decades (Padial et al. 2010; Nabout et al. 2012). This trend is in accordance with our first hypothesis. Moreover, scientific production was published in journals with impact factor which may indicate an increase on paper's quality and comprehensiveness of the regional production (Padial et al. 2010). Scientists training, stimulation of collaboration and the development of new technologies (e.g., bioinformatics, mutagenesis and transgenics) to deal with problems at different levels and scales are possible strong drivers of this increase (Parreira et al. 2017). Additionally, in the case of the Brazilian freshwater fish science, the last decades faced a relative increase in the number of studies in streams (Castro 1999; Dias et al. 2016), which are abundant in headwaters regions. Despite that, in this study the regional production of scientific papers on freshwater fish presents some particularities: an irregular scientific production through time (three distinct periods in this case) and the publication of papers in journals without impact factor (29.5% in this case), both strictly related to developing countries accordingly Loyola, Diniz-Filho, & Bini (2012). The former particularity can be associated to an inconstant availability of financial supports for scientific research, whereas the latter can be related to the researcher's English proficiency that was demonstrated influencing on the choice of a national (whose articles are predominantly in Portuguese) or international (English language) journal (Vasconcelos, Sorenson, and Leta 2009). Additionally, the high percentage of scientific papers published in journals with impact factor (70.5%) is in concordance with findings for the Biological Sciences area, in which it is recognized that there is a predominance of international publications using English language (de Souza and Ferreira 2013).

According to Pan, Kaski, & Fortunato (2012) and Parreira et al. (2017), the financial situation of a country and the availability of funds for scientific research affect directly both the number of publications and citations. We found that financial support influence positively on the number of papers published and the impact factor of publications, indicating that oscillation of the scientific regional production on freshwater fish may reflect research investments. This trend reinforces the idea that asymmetries in the number of studies along the years are a consequence of financial support

availability. Despite that, it is important to notice that the influence of the financial support is higher on the number of scientific papers than on the impact factor ones, as already observed for broader scales (Rigby 2013). This fact indicates that more investments are generating more publications but not necessarily in journals with high impact factor. However, we advise that before considering that investments have a low influence on papers factor impact, it should be interesting to ponder other ways to measure the impact of a publication than impact factor, such as paper's citations, as previously discussed by Padial et al. (2010) and Parreira et al. (2017).

In different fields of knowledge, collaboration among scientists has increased over the years (Nabout et al. 2012, 2015; Carneiro, Nabout, and Bini 2008; Whitfield 2008; Vermeulen, Parker, and Penders 2013) and this condition often reflects on the quantity, the quality and comprehensiveness of papers (Padial et al. 2010). Our findings indicate that the number of institutions participating in the development of paper seems to affect positively the number of papers published, i.e., more collaboration among institutions will stimulate the regional production of scientific papers. Considering freshwater fish papers, this evidence indicates that collaboration is an important factor driving regional production of scientific papers, as well as observed for broader scales (de Souza and Ferreira 2013; Huang 2015) and by field of knowledge (Mena-Chalco et al. 2014). According to Nabout et al. (2015), collaboration among authors helps scientists to deal with complex questions through the development of multifaceted approaches, to share research costs, and to form research groups that gather professionals from different areas and countries. Considering the paucity of funds for scientific researches in developing countries (Loyola, Diniz-Filho, and Bini 2012), collaboration among institutions is important even at a regional scale. Although the collaboration among institutions also affects positively the impact factor, its magnitude is very small, and we consider it as non-representative.

Even though final products of graduate programs, mainly thesis, are correlated to the qualified production of a doctoral program (Marenco 2015), among all variables tested as possible drivers of scientific production, the number of master dissertations and PhD thesis had the smallest effect on the number of scientific papers. This trend is possibly associated to the fact that several master dissertations do not necessarily are published as scientific papers as with the PhD graduates (de Meis, Arruda, and Guimarães 2007), moreover many graduate students (from master's degree programs) do not continue to carry out research activities.

In the last three decades, the number of scientific studies related to freshwater fishes increased in Brazil (Castro 1999; Dias et al. 2016). Our findings demonstrate that regional production of fish

papers, represented here by scientific production from Goiás State, has increased during this period and followed global tendencies observed for biological Sciences (Padial et al. 2010; Nabout et al. 2015). Moreover, our study indicates that regional production of fish papers is mainly driven by financial support and collaboration (among different institutions), as it was observed for broader spatial scales (Nabout et al. 2015; Huang 2015). However, regional production of fish papers at Goiás State is inconstant through time and many papers are still published in journal without impact factor, which are both particularities related to developing countries. In this context, investing in collaboration among scientists and institutions, as well as in the increase of financial support for scientific research, keystone strategies to overcome these obstacles and to improve not only the quantity but also the quality of papers.

CONCLUSIONS

We demonstrated that the regional production of scientific freshwater fish papers, here represented by the scientific papers related to the Goiás State, Central Brazil in the last 30 years, tends to follow observed patterns for global production described in the literature and it increases through time. However, this production seems to be still influenced for particularities of developing countries, such as: an inconstant production through time and the publication of papers in journals without an impact factor.

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Comparação da Produção Regional e Global de Artigos Científicos: Uma Perspectiva a partir dos Estudos sobre Peixes de Água Doce no Estado de Goiás, Brasil Central

RESUMO

A produção científica é geralmente explorada em escalas espaciais maiores, mas, compreender se estes padrões regionais seguem as tendências globais é um tópico importante para a ciência e as políticas públicas. Utilizando a produção científica de artigos sobre peixes de água doce no estado de Goiás, Brasil Central, testamos duas hipóteses: *i*) a produção regional de artigos segue as tendências globais; *ii*) a produção regional é influenciada pelo número de autores, instituições, suporte financeiro ligados aos estudos, de dissertações/teses produzidas. Dentre os artigos publicados, extraímos: ano de publicação, instituição dos autores, periódico de publicação, fator de impacto do periódico e suporte financeiro. Para testar ambas as hipóteses conduzimos, respectivamente, uma correlação de Pearson entre o

número de artigos e ano, e uma regressão linear múltipla considerando o número de artigos e fator de impacto como variáveis respostas e autores, instituições, número de financiamentos e dissertações/teses como preditoras. Observamos uma correlação positiva entre número de artigos e ano, enquanto suporte financeiro, instituições e dissertações/teses foram os principais fatores a influenciar o número de artigos e fator de impacto. A produção regional de artigos sobre peixes segue os padrões globais de produção (suporte financeiro e instituições como determinantes). Entretanto, esta produção permanece influenciada por particularidades: produção inconstante e o fato de muitos trabalhos serem publicados em revistas sem fator de impacto.

Palavras-Chave: Bacia do Rio Paraná; Bacia do Rio Tocantins-Araguaia; Tendências Temporais; Suporte Financeiro.

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