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SOCIAL SCIENCES

Scientific production in biodiversity: the gender gap continues in Brazilian universities

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Abstract: Scientometrics enables us to comprehend the interests and trends in scientific knowledge production and dissemination. In this study, we evaluate the effects of gender, academic experience, location of residence, and graduate program score on the quantity of published articles, the number of citations and the H-index of researchers belonging to Brazilian graduate programs in Biodiversity. Variables related to the researchers were measured, and the relevance in explaining scientific production was examined using hierarchical models. In graduate programs, there were more men than females. The number of articles as first author and the H-index increase progressively through the researchers' career, while the number of citations increases at the beginning of their careers, stabilizing between 10 and 20 years, and increasing again after 30 years of career. We concluded that gender, academic experience, and graduate program score were the most important variables in explaining the scientific production of graduate programs in Biodiversity in Brazil.

Key words: Bibliometrics, ecology, females in science, scientometrics.

INTRODUCTION

Brazil has significantly increased its scientific production in the last two decades, ranking 13th in the world in 2018 (Clarivate Analytics 2018). One area of knowledge experiencing remarkable growth is biodiversity, which is expected since the country has approximately 20% of the total number of species worldwide (Myers et al. 2000). In addition, it has the highest percentage of tropical forests, a high number of endemic species, and the presence of two biomes considered biodiversity hotspots: the Atlantic Forest and the Cerrado (Overbeck et al. 2018). The country also provides various ecosystem services, contributing to the social and economic development of the region (Joly et al. 2019).

The interest of the Brazilian university system in environmental problems stimulated the development of graduate programs (GPs) focused on topics on Biodiversity and Ecology (Prates & Irving 2015). The GPs motivated a significant increase in the scientific production in the area, which obtained the highest number of articles and citations in South America in 2017/2018 (Clarivate Analytics 2018). This increase was driven by the scientific production of academics and their research teams (Vosgerau et al. 2017). Distinct factors can influence academic productivity, such as gender, age, access and participation in research networks, or access to funding. Scientometrics examines aspects of information and communication using quantitative and qualitative indicators to study scientific production (Santos & Kobashi 2009). This allows evaluate the performance or trends in knowledge production between researchers, groups, universities or nations (Oliveira & Lopes 2021). For example, the scientometric analysis may include gender, academic formation, or academic experience. Therefore, scientometrics can help to identify scientific ecosystems with economic deficits and gaps in scientific representation.

Scientific production is asymmetric in several aspects. One of the most cited and recurrent asymmetries is the gender gap: males produce about 70% of the total scientific articles. The causes of this gap are diverse, such as the decrease in the time invested in research by females due to motherhood and socially imposed gender roles, less financial support for research (Abramo et al. 2009, Borsuk et al. 2009, Larivière et al. 2013, Lopes & Lopes 2022, Prpiû 2002), or socio-historical causes due to the hegemonic structure of scientific production (Krause 2016). Although studies have shown the gender gap expressed in the number of researchers and project funding (Ferrari et al. 2018, Oliveira et al. 2021, Salerno et al. 2019, Zandonà 2022), little is known about the differences in scientific production between males and females in the Biodiversity and Ecology research (Mcmanus et al. 2020, Zandonà 2022).

In the last forty years, the number of females in academic positions in Biological Sciences in Brazil has increased (Perlin et al. 2017). However, they achieve less prestigious academic positions than males, which negatively influences academic opportunities and productivity (Duch et al. 2012, Larivière et al. 2013, Mauleón & Bordons 2006, Perlin et al. 2017, Sandström 2009). In addition to structural gaps, females face a higher rejection rate than males in the peer review process when submitting their manuscripts approved in indexed journals (Fox & Paine 2019). The lack of diversity and gender representation is enhanced when regional asymmetries are considered since most males with prestigious positions in universities is found in the metropolitan regions of the country (Ferrari et al. 2018). Another aspect pointed out as a critical factor in the generation of knowledge and scientific production is academic experience. The number of publications increase right after finishing doctoral studies, stabilizing in the middle of the academic career and subsequently decreasing towards the end of the research career (Bonaccorsi & Daraio 2003, Gonzalez-Brambila & Veloso 2007).

In this study, we evaluate the effects of gender, academic experience, location of residence, and graduate program score on the quantity of published articles, the number of citations and the H-index of researchers belonging to Brazilian graduate programs in Biodiversity. Although the growth of scientific production on Brazilian biodiversity is recognized, few studies explore the importance and role of graduate programs in Biodiversity on this increase in scientific production (CAPES 2017a, Diniz-Filho et al. 2016). Additionally, little is known about possible asymmetries related to gender or geographic regions and their influence on the generation of scientific knowledge in Biodiversity and Ecology (Oliveira et al. 2021, Zandonà 2022). The reduction of regional or gender asymmetries contributes to the development of science, economic growth, and the increase in innovative solutions for decision-making about socio-environmental problems (Jacobi et al. 2015, Sarseke 2018). In this way, this study offers an overview of scientific production in a highly relevant area of knowledge for Brazil, which could help decision-making concerning the promotion of national research and the reduction of disparities in science.

MATERIALS AND METHODS

Sampling design

We collect personal and scientific production data of academics from GPs in Biodiversity, with a focus on Ecology, from public and private institutions in Brazil, available on the Sucupira platform (2019). This platform provides the guidelines to the evaluation of GPs in the Brazilian system. In Brazil, there are currently 111 GPs in Biodiversity with a focus on Ecology.

For the selection of the GPs, we used a stratified random sample considering the five regions of Brazil (North, Northeast, Center-west, Southeast, and South) and the GP score (hereafter referred to as score) given by "*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (*CAPES* – Ministry of Education). In Brazil, GPs are evaluated every four years according to the academics' scientific production and human resources training. Scores range from one to seven. Higher scores mean a higher overall quality of the program. The programs in operation have scores between three and seven. The scores and region of the GPs were obtained from the Sucupira platform (2019). We used the variable region as a criterion to not underestimate or overestimate the number of GPs sampled per region. For each region of Brazil, we sampled one GP per score ranging three to seven. Except for the south and center-west, the rest of the regions did not present programs with a score of seven. In these cases, we assigned a program with a score of six. When there were no GPs with a score of six or seven in a region, we assigned a program with a score of five.

For the GPs, we evaluated the score and region where develops its activities. For academics, we identified their sex and academic experience based on information in their online curricula available in the César Lattes Platform (Platform César Lattes 2022). The academic experience was estimated as the difference between the year of data collection (2019) and the researcher's doctoral completion year. We compiled the researcher's name and contrasted it with a list of proper names in Brazil (Diccionário de Nomes Próprios 2022). It was possible to assign sex to 97.9% of the academic cases (male or female). The remaining cases were disregarded from the sample. There is no information on gender in the curricula. Therefore, we consider that the sex of the researchers corresponds to their gender (males = men; females = women), admitting the possible biases associated with cases of gender recognition (Torgrimson & Minson 2005).

We compiled the scientific production of the professors from the Scopus database (2022) in the period between 2003 and 2018. The analysis started in 2003, since between that year and 2014 there was an increase in the number, and an expansion in the distribution of federal universities and other federal education and research institutions in Brazil (Casqueiro et al. 2020). The increase in the number of universities at the national level and, therefore, in the number of graduate programs, allowed us to obtain a more diverse sample, with a higher number of programs in general, and by score, distributed throughout the country. Additionally, data collection extended until 2018, as all analyses were performed in 2019. For each academic, we measured the number of articles in which they appeared as the first author from 2003-2018, the average number of citations, and the H-index. Researches show that in Ecology the first author is the researcher who contributes the most to the article, being directly involved in most of the preparation, data analysis, and writing of the article (Weltzin et al. 2006, Wren et al. 2007). In that sense, we evaluate the first author of the articles because in the Biodiversity field they represent the person who did most of the work. Furthermore, the quantitative parameter "articles as first author" is used for the evaluation of graduate programs in the field of Biodiversity in Brazil (CAPES 2017a), justifying its importance for understanding researchers' scientific production. The average number of citations was calculated as the sum of the number of citations registered over the number of articles registered. The H-index expresses the weighting between the number of publications and citations received by an author throughout his academic career (Bornmann et al. 2007). The process of searching and retrieving data from the César Lattes Platform Lattes and Scopus was conducted manually for each researcher. All registered publications were full articles with International Standard Serial Number (ISSN).

Statistical analysis

We identified the variables with the greatest power to explain the quantity and impact of scientific production using multinomial regressions with a hierarchical partition test using the package *hier.part* (Nally 1996) in R (R Development Core Team 2018). We built three models that included the predictor variables: academic experience, gender, score, and the region in Brazil where the GP was based. The models were differentiated only by the response variable analyzed. Model I evaluated the effect of the explanatory variables on the H-index, model II evaluated the effect on the average number of citations per author, and model III evaluated the effect on the number of articles produced per author. The hierarchical partition test was used to identify the variables with a greater explanatory capacity in the magnitude of the response variables. However, as a methodological limitation, hierarchical models do not allow us to identify the direction or magnitude of the relationships between the explanatory variable and the response variable. Therefore, it is necessary to explore these relationships based on the nature of the variables analyzed. The joint and alone contribution of each variable were verified (Nally 1996). The Z- values were obtained (indicate statistical significance) using a data randomization process; when Z- values > 1.65 were considered significant because they were located in the upper range of the confidence interval of 0.95.

We evaluated the presence of possible multicollinearity between the explanatory variables of each model using the Variance Inflation Factor (VIF) analysis with the package *car* in R (R Development Core Team 2018). VIF values > 3 indicate multicollinearity. The VIF analysis showed the absence of collinear variables in our study. Due to the existence and behavior of outliers, a Quasi-Poisson distribution was assumed for the variables.

RESULTS

We evaluated 581 curricula from academics available in the César Lattes Platform. From these, 491 (84.5%) corresponded to full professors, 88 (15.2%) assistant professors, and two (0.3%) visiting professors. From the total number of academics evaluates, 211 (36%) were females and 370 (64%) were males. A total of 28.932 articles were examined (Table I). The relative number of articles weighted by the number of GP for each score varied widely, with 720 articles for a GP score of three and 1,780 for a GP score of seven. Similarly, the average number of citations was correlated to the GP score, ranging from 13.2 for programs with a score of three to 25.3 for those with a score of seven.

Despite the GPs score or the GP region, the proportion of female academics was lower for all GPs studied. GP that scored four had the highest average number of female researchers per program with 43%. GP that scored seven had the highest average number of males

Table I. Data of scientific production collected from the 25 GPs in biodiversity categorized by their graduate program score. The relative number of articles: number of articles weighted by the number of GP for each score.

GP score	Number of GP	Relative number of articles	Average number of citations	Total number of researchers	Proportion of females (%)
Three	5	720	13,2	96	34
Four	5	1040	14,9	120	43
Five	6	1108	14,3	127	33
Six	7	1418	19,7	183	37
Seven	2	1780	25,3	55	31
Total	25	1157	17	581	36

per program (69%). Similarly, the center-west region had the highest average number of male researchers (72%), while the southeast region had the highest average number of female researchers (41%).

All predictor variables significantly influenced the H-index model (Z-value>1.65; Table II). Academic experience was the predictor variable with the greatest magnitude of explanation (56.4%). The H-index increased as the academics advanced in their research careers though time. Specifically, throughout their entire academic experience males have a higher H-index than females (Fig. 1a). Gender explained 6.2% of the variation, with males having an average H-index of 13.4 (SD = 9.94) and females having an average H-index of 10.97 (SD = 6.03) (Fig. 1b). The GP score explained 23.6% of the variation in the H-index since its increase is associated with an increase in the GP score, with programs that scored three having the lowest average H-index (mean = 8.56; SD = 5.98) and programs that scored seven having the highest (mean = 18.52; SD = 10.08) (Fig. 1c). Finally, GP region was responsible for explaining 13.8% of the variation observed, with the center-west (mean= 14.22; SD= 9.77) and Southeast (mean = 13.95) regions obtaining the highest H-index values (Fig. 1d).

The significant predictors factors for the average number of citations per author model were academic experience (Z-value = 6.94) and GP score (Z-value = 5.83) (Table II). Academic experience explained 26.1% of the variation in the average number of citations. The number of citations by author increased in the first ten years after the completion of doctorate studies, reaching an asymptote between 10 and 20 years, and increasing again when academics reached 30 years of academic experience (Fig. 2a). The GP score was the most significant predictive variable (Table II) since an increase in the GP score was associated with an increase in the average number of citations. The GPs that scored three had the lowest number of citations (mean = 13.2; SD = 13.1), whereas the programs that scored seven had the highest average number (mean = 25.27; SD = 18.3) (Fig. 2b).

Academic experience had the most significant predictive variable (62.3%; Z-value = 50.29) in the model for the number of articles, although gender (12.9%; Z-value = 10.57) and GP score (10.8%; Z-value = 3.15) were also significant (Table II). The number of articles published gradually increases until academics reached approximately 30 years of work experience, and then reached an asymptote (Fig. 3a). However, males publish a greater number of articles

Table II. Results of the hierarchical partition analysis, including the percentage of total explanation (%) of the predictors variables (gender, academic experience, GP score, and GP region) in relation to the response variables (H-index, average number of citations, and number of articles) in the tested models (I, II, and III). * Denotes variables having significant Z-score values (Z>1.65).

	Predictors variables			
-	**Gender**	**Academic experience**	**GP Score**	**GP Region**
H-Index	6,2*	56,4*	23,6*	13,8*
Average number of citations	0,2	26,1*	43,2*	30,6
Number of articles	12,9*	62,3*	10,8*	13,7

than females throughout their entire careers as professors and/or researchers. Concerning gender, males (mean = 55.28; SD = 49.7) published 1.4 times as many articles as females (mean = 40.32; SD = 28.3) (Fig. 3b). Finally, it was found that the number of articles increased gradually with the GP score (Fig. 3), with an average of 37 articles in GPs with a score of three, increasing to an average of 65 in GPs with a score of seven.

DISCUSSION

Our study evidenced a lower presence of females compared to males in academic positions in Biodiversity and Ecology in Brazil (Table I). A similar pattern was reported in Exact and Natural Sciences careers, where there was a high percentage of males (Abramo et al. 2009, Perlin et al. 2017). Females also had lower number of publications and H index than males, but these differences were of low magnitude (Fig. 1b; Fig. 3a). Nevertheless, the number of citations did not differ between genders. It is important to highlight that our study did not analyze the influence of variables such as the presence of self-citations or the nationality of the researchers on the number of citations. We are aware that our choices may have influenced our results. In this sense, it is known that North American and European researchers produce more cited articles than Latin American researchers (Romero 2020). Regarding self-citations, it has been reported that, when considering them, males have a greater number of citations than females. However, by excluding self-citations, there are no gender differences (Astegiano et al. 2019). Gender inequality in the number of articles published does not necessarily reflect gender differences in scientific impact. Our results agree with studies in Ecology and Evolution that show that although males are more productive than females, there are no gender differences in the number of citations or H-index (Bornmann et al. 2007, Ledin et al. 2007, Symonds et al. 2006). Our results may indicate that publications led by females may have a greater scientific impact than those led by males.

Historically, many graduates from programs in the natural sciences are not incorporated into academic positions as professors, affecting their scientific production, development, and permanence in the research career (Addessi et al. 2012, Goulden et al. 2011, Zandonà 2022). The decrease in the presence of females in universities may be the result of a structural process called the scissors effect, characterized by a decrease in the number of females advancing in the academic career (Arêas et al. 2020). Our results show the presence of this effect, since as the graduate program score

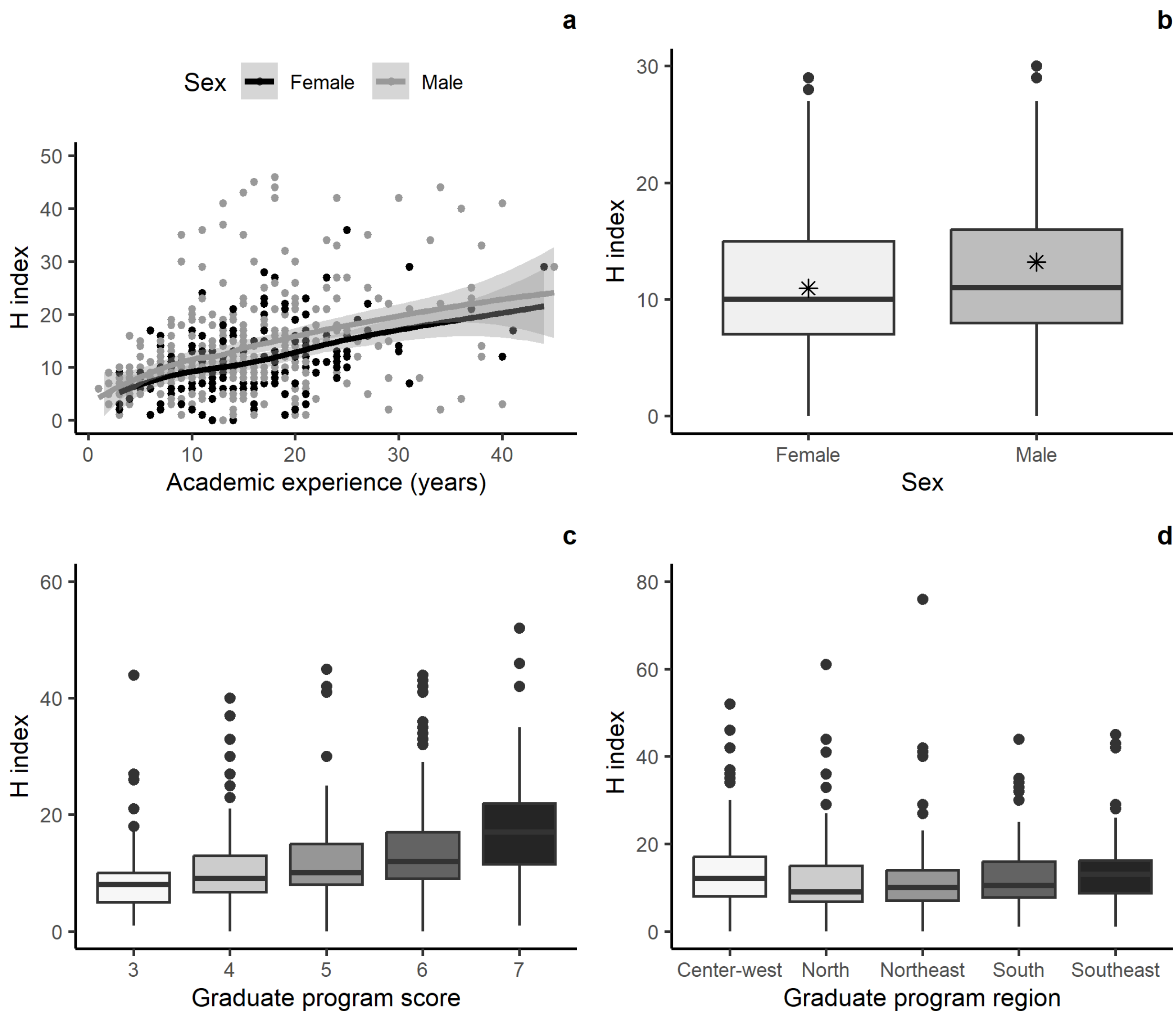

Figure 1. Relationships between significant predictive variables and the H-index in the explanatory model I. Variation of the H-index according to academic experience (a), between men and females (b), between GPs scores (c), and the five GPs regions (d).

increases, the proportion of females decreases notably. As is known, there is a gender gap in the areas of science, technology, engineering, and mathematics (STEM), where males publish on average up to 27% more than females (Huang et al. 2020, Shen 2013, Zippel 2017). This disparity of scientific production is probably due to differences in the duration of the academic career between males and females, where males remain longer in universities, resulting in a greater number of publications than females (Huang et al. 2020). Factors such as maternity and home routine can promote a decrease in the scientific production of females, explaining this shorter duration of their academic career. (Carpes et al. 2022). Thus, as admission of professors to higher score graduate programs requires a high scientific production as an evaluation criterion, it is likely that the greater number of articles produced by males favors their entry into these academic prestige positions.

The proportion of females was lower in all regions and GPs studied (Table I). The accumulation of attributes due to the existence

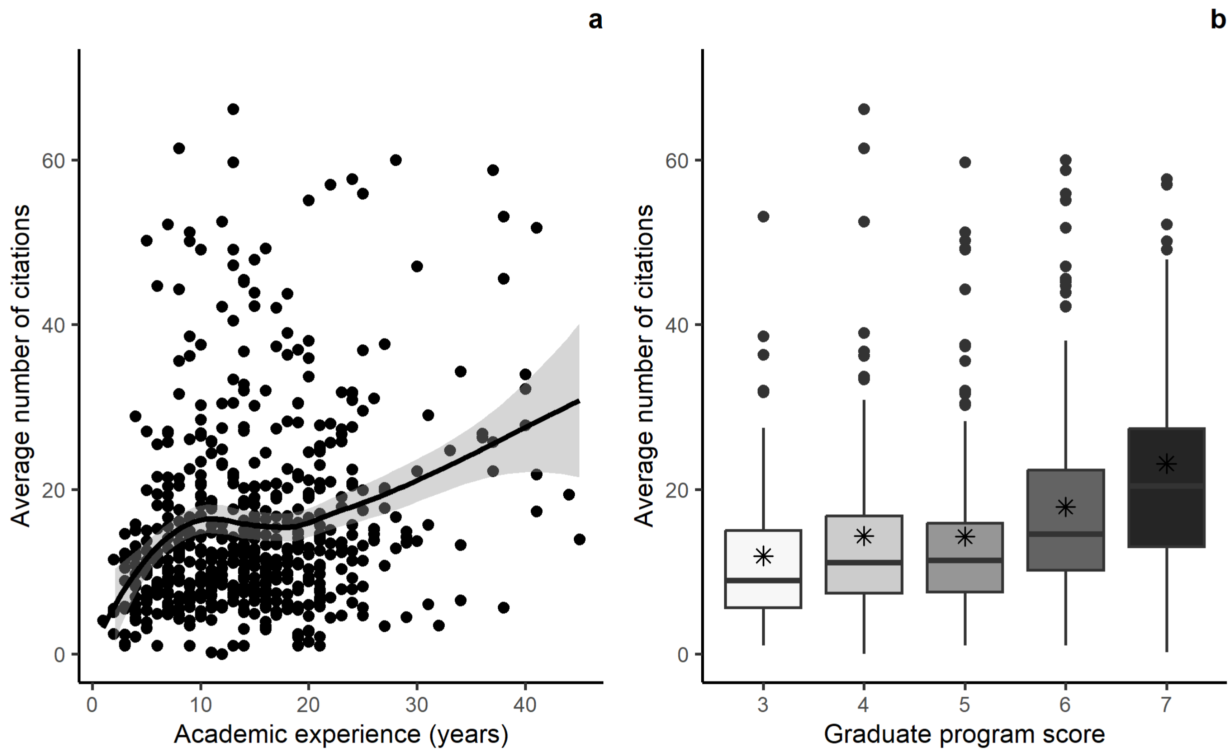

Figure 2. Relationships between significant predictive variables and the average number of citations per author in the explanatory model II. Variation in the average number of citations based on academic experience (a) and GP score (b).

of baseline disparities (Bol et al. 2018), called Matthew effect, may explain the higher number of articles published by males in our study. Such indicators of scientific production give males professional advantages, such as better opportunities of achieving financial support for research projects or advancing faster in the research careers (Astegiano et al. 2019, Perc 2014, Rørstad & Aksnes 2015). Furthermore, our findings may also reflect the Matilda effect wich explains that females usually receive fewer credits than males and their work is less recognized (Rossiter 1993). The sociology of science has shown the existence of structural causes in gender disparity, with multiple cases where females are more productive than their males colleagues, but still have received fewer prizes and credits for their discoveries (Knobloch-Westerwic et al. 2013, Lincoln et al. 2012).

The long-term persistence of advantages for males in their work, and consequent disadvantages and lower recognition for females could promote gender disparity. Several actions can be taken to help reduce the gender gap in science. For example, institutions can award prizes and grants for research teams led by females as well as include females in leadership and decision-making positions. Also, it is important to establish clear hiring criteria that ensure equal opportunities between males and females, as well as to consider maternity as an evaluation factor (Carpes et al. 2022, Donoso et al. 2011). The implementation of these actions will be able to collaborate with the participation and permanence of females in science.

In Ecology, the male perspective has been prioritized. This may be a result of lower financial support to females research projects, and the smaller number of females in high

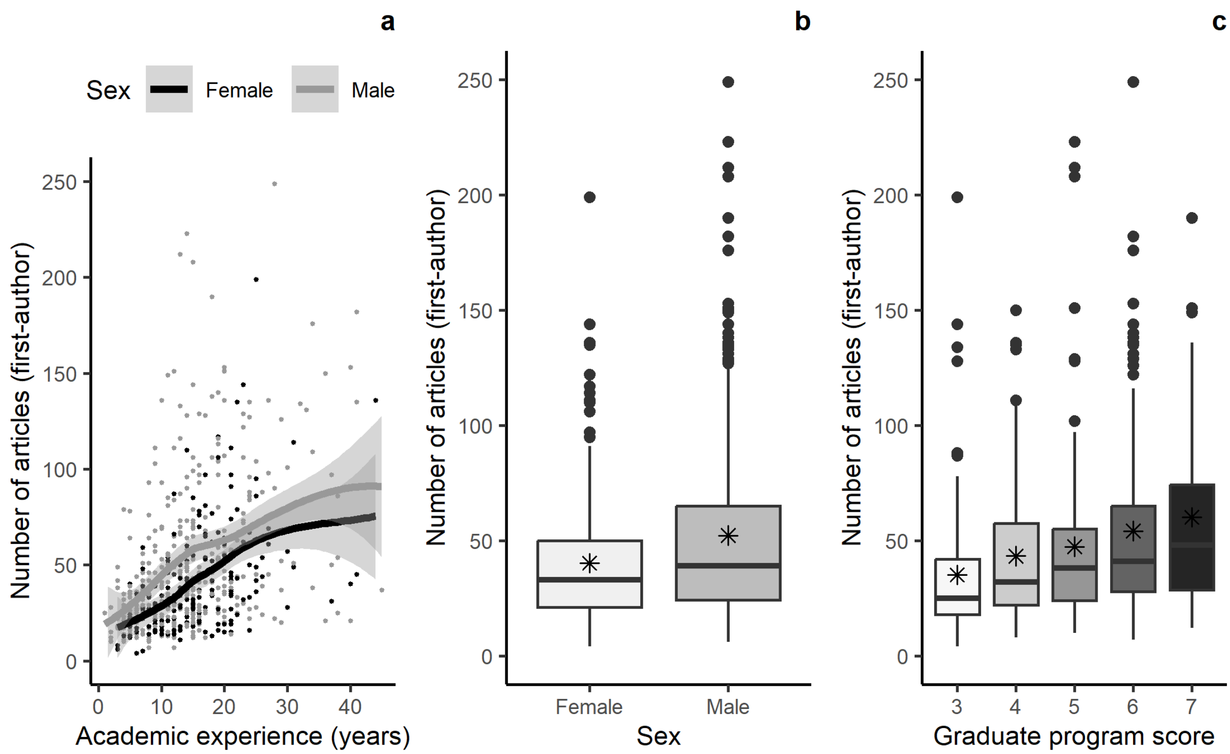

Figure 3. Relationships between significant predictive variables and the number of articles as first-author in the explanatory model III. Variation in the number of articles based on academic experience (a), gender (b), and GP score (c).

academic positions, when compared to males (Outram 1987, Zandonà 2022). However, females's contribution has been relevant in many areas of science, such as behavioural ecology (Lupon et al. 2021). Also, they have stood out in other areas, making interdisciplinary contributions from environmental sociology and conservation theory (Puleo 2017). These areas of study, with a strong presence of females, have promoted new perspectives. One of them is Ecofeminism, a theoretical framework that synthesizes the need to mediate in society to inhibit gender biases (Cova 2005). The contributions of females in science provide a diversity of innovative scientific questions than males generally do not address in science.

The academic experience is critical in understanding the number and impact of publications, indicating a peak in scientific productivity with the advance in the academic career. For both females and males, the production and impact of articles increased in a non-linear manner with academic experience (Fig. 1a; Fig. 2a; Fig. 3a). This relation has already been documented (Rørstad & Aksnes 2015), where young researchers increase their scientific output as their cooperation networks develop and become professors, when they achieve a peak in their scientific output (Bonaccorsi & Daraio 2003). However, between genders, females achieve lower levels of productivity and intellectual recognition at the same ages that males due to the problems they experience throughout their academic careers, which impair their stability, growth, and productivity (Holman et al. 2018).

The GPs score provided an excellent predictive capability of scientific production, with a progressive increase in number of publications from program score three to score seven (Fig. 1c; Fig. 2b; Fig. 3c). The GPs are assessed every four years, and their scores are based on many indicators related to productivity, social impact, internationalization, and program development. The evaluation criteria primarily consider the scientific output of researchers in general, among professors and students (CAPES 2017b). Thus, the increase in the average number of publications, citations, and H-index per researcher is linked to an increase in the GP score, which is used to measure academic excellence and internationalization. The score is a key factor for the allocation of government funds, number of scholarships, laboratory equipment, and infrastructure, all of which directly influence the potential for scientific production (Furtado & Santos 2016, CAPES 2017b).

Regional socioeconomic and educational disparities are well recognized, and they have resulted in divergences in the development of universities and research centers (De Almeida & Guimarães 2017). For example, it is in the most of Brazil's biodiverse regions that there are fewer human resources in universities (Avellar 2015). Despite this well-known asymmetry, our findings demonstrate that the GPs region is only one of the variables that significantly influenced the variation in the H. Here, we find that the programs located in the southeast region were among the ones with the highest average H-indices in the country (Fig. 3d). The first graduate courses in Ecology were created in São Paulo (e.g., Universidade Federal de São Carlos, Universidade Estadual de Campinas, Universidade de São Paulo), which contributed to its greater number of GPs and the presence of universities with high scientific production at the national level (Zorzetto et al. 2006). In addition, the largest number of graduate courses in the Southeast area is related to the promotion of science through important research agencies, such as the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) or the Serrapilheira Institute (Oliveira & Lopes 2021). Regional asymmetries become visible when recognizing that the North of the country has only 3% of human resources in the academic field and the lowest per capita income at the national level, probably impacting the lowest number of GPs in this region (MEC 2013, IBGE 2019). The asymmetry is also regulatory and fiscal because state institutions do not prioritize resources for the promotion of science and innovation.

Science promotion must be a permanent guideline in societal development and must include gender policies that promote parity between viewpoints, sectors, and areas of research interest (Ordorika 2015). It is an opportunity to learn about new issues and other perspectives on our relationship with nature. Although there has been a growth in the number of graduate programs and research in the field of biodiversity and ecology over the last 15 years (CAPES 2017a), the knowledge about scientific production and the disparities between researchers has not yet been studied. This is important for promoting new perspectives about biodiversity by bringing together academic institutions and actors from many sectors, such as decision-makers, regional research centers, and local communities (Rosa et al. 2021).

In conclusion, we verified that there is a gender disparity in the graduate programs in Biodiversity in Brazil. In these GPs there are a greater number of male researchers than female and males have more articles published and a higher H-index than females, but their numbers of citations is comparable. Despite this gender disparity, females have been associated with solving environmental problems, coming up with innovative ideas, and ensuring more successful conservation practices (Maas et al. 2019). Nonetheless, their authority in biodiversity and environmental policy decision-making remains limited because females's knowledge, needs and priorities in relation to biodiversity are overlooked (CBD, unpublished data, Jacobi et al. 2015). Finally, it is crucial to consider that science is cumulative and diverse by nature, so the real inclusion of females will allow for greater scientific progress and development. For example, mixed-gender teams produce more novel and highly cited papers than same-gender teams (Yang et al. 2022). A gender balance in science can promote new approaches and scientific discoveries with greater inclusion and diversity in scientific communities.

REFERENCES

ABRAMO G, D'ANGELO CA & CAPRASECCA A. 2009. Gender differences in research productivity: A bibliometric analysis of the Italian academic system. Scientometrics 79: 517-539.

ADDESSI E, BORGI M & PALAGI E. 2012. Is Primatology an Equal-Opportunity Discipline? PLoS ONE 7: 1-6.

ARÊAS R, ABREU A, SANTANA A, BARBOSA M & NOBRE C. 2020. Gender and the scissors graph of Brazilian science: from equality to invisibility. OSF Preprints. https://doi.org/10.31219/osf.io/m6eb4. (accessed 4 August 2022).

ASTEGIANO J, SEBASTIÁN-GONZÁLEZ E, CASTANHO C. 2019. Unravelling the gender productivity gap in science: A meta-analytical review. Roy Soc Open Sci 6.

AVELLAR S. 2015. Migração interna de mestres e doutores no Brasil: algumas considerações. Rev Bras Pos 11.

BOL T, DE VAAN M & VAN DE RIJT A. 2018. The Matthew effect in science funding. P Natl Acad Sci Usa 115: 4887-4890.

BONACCORSI A & DARAIO C. 2003. Age effects in scientific productivity: The case of the Italian National Research Council (CNR). Scientometrics 58: 49-90.

BORNMANN L, MUTZ R & DANIEL H. 2007. Gender differences in grant peer review: A meta-analysis. J Informetr 1: 226-238.

BORSUK R, BUDDEN A, LEIMU R, AARSSEN L & LORTIE C. 2009. The Influence of Author Gender, National Language and Number of Authors on Citation Rate in Ecology. Open J Ecology 2: 25-28.

CAPES. 2017a. Relatório da Avaliação Biodiversidade. https://capes.gov.br/images/stories/download/avaliacao/relatorios-finais-quadrienal-2017/20122017-BIODIVERSIDADE-quadrienal.pdf. (accessed 20 November 2019).

CAPES. 2017b. Relatório da Avaliação Quadrienal. https://www.capes.gov.br/36-noticias/8691-capes-divulga-resultado-final-da-avaliacao-quadrienal-2017. (accessed 20 November 2019).

CARPES P, STANISCUASKI F, OLIVEIRA L & SOLETTI R. 2022. Parentalidade e carreira científica: o impacto não é o mesmo para todos. Epidemiol Serv Saude, 31.

CASQUEIRO M, IRFFI G & SILVA C. 2020. A expansão das Universidades Federais e os seus efeitos de curto prazo sobre os Indicadores Municipais. RAIES 25: 155-177.

CLARIVATE ANALYTICS. 2018. Research in Brazil: a report for CAPES by Clarivate Analytics. https://propp.ufms.br/diretorias/research-in-brazil-report-for-capes-by-clarivate-analytics/. (accessed 4 August 2022).

COVA N. 2005. El Ecofeminismo Latinoamericano, Las Mujeres y la Naturaleza como Símbolos. Cifra Nueva: Univ de los Andes-Trujillo.

DE ALMEIDA E & GUIMARÃES J. 2017. A pós-graduação e a evolução da produção científica brasileira. Senac: São Paulo.

DICCIONÁRIO DE NOMES PRÓPRIOS. 2022. https://www.dicionariodenomesproprios.com.br/. (accessed 3 July 2022).

DINIZ-FILHO J, FIORAVANTI M, BINI L & RANGEL T. 2016. Drivers of academic performance in a Brazilian university under a government-restructuring program. J Informetr 10: 151-161.

DONOSO T, FIGUERA P & MORENO M. 2011. Gender barriers in the professional development of females university graduates. Rev de Educ 355: 187-212.

DUCH J, ZENG X, SALES-PARDO M, RADICCHI F, OTIS S, WOODRUFF T & NUNES AMARAL L. 2012. The Possible Role of Resource Requirements and Academic Career-Choice Risk on Gender Differences in Publication Rate and Impact. PLoS ONE 7: e51332.

FERRARI N, MARTELL R, OKIDO D, ROMANZINI G, MAGNAN V, BARBOSA M & BRITO C. 2018. Geographic and gender diversity in the Brazilian Academy of Sciences. An Acad Bras Cienc 90: 2543-2552.

FOX C & PAINE C. 2019. Gender differences in peer review outcomes and manuscript impact at six journals of ecology and evolution. Ecol Evol 9: 3599-3619.

FURTADO A & SANTOS J. 2016. A área Ciências Biológicas III da CAPES e a pós-graduação na Amazônia: desafios atuais e perspectivas futuras. Rev Pan-Amaz Saude 7: 9-11.

GONZALEZ-BRAMBILA C & VELOSO F. 2007. The determinants of research output and impact: A study of Mexican researchers. Res Policy 36: 1035-1051.

GOULDEN M, MASON M & FRASCH K. 2011. Keeping Females in the Science Pipeline. Ann Am Acad Pol Soc Sci 638: 141-162.

HOLMAN L, STUART-FOX D & HAUSER C. 2018. The gender gap in science: How long until females are equally represented? PLoS Biol 16: 1-20

HUANG J, GATES A, SINATRA R & BARABÁSI A. 2020. Historical comparison of gender inequality in scientific careers across countries and disciplines. PNAS 117(9): 4609-4616

IBGE. 2019. Produto Interno Bruto. 2019. https://www.ibge.gov.br/explica/pib.php. (accessed 26 November 2019).

JACOBI P, EMPINOTTI V & TOLEDO R. 2015. Gênero e meio ambiente. Ambient Soc 18.

JOLY C ET AL. 2019. Brazilian assessment on biodiversity and ecosystem services: Summary for policy makers. Bio Neotrop 19.

KNOBLOCH-WESTERWICK S, GLYNN C & HUGE M. 2013. The Matilda effect in science communication: an experiment on gender bias in publication quality perceptions and collaboration interest. Sci Commun 35(5): 603-625.

KRAUSE M. 2016. 'Western hegemony'in the social sciences: Fields and model systems. Sociol Rev 64: 194-211.

LARIVIÈRE V, NI C, GINGRAS Y, CRONIN B & SUGIMOTO C. 2013. Global gender disparities in science. Nat 504: 211-213.

LEDIN A, BORNMANN L, GANNON & WALLON G. 2007. A persistent problem: Traditional gender roles hold back female scientists. EMBO Rep 8(11): 982-987.

LINCOLN A, PINCUS S, KOSTER J & LEBOY P. 2012. The Matilda Effect in science: Awards and prizes in the US, 1990s and 2000s. Soc Stud Sci 42(2): 307-320.

LOPES R & LOPES A. 2022. Lacunas de gênero entre as grandes áreas do conhecimento na ciência baiana: uma abordagem das diferenças nas escolhas competitivas. Cad Cien Soc A, p. 77-99.

LUPON A, RODRÍGUEZ-LOZANO P, BARTRONS M, ANADON-ROSELL A, BATALLA M, BERNAL S & PASTOR A. 2021. Towards females-inclusive ecology: Representation, behavior, and perception of females at an international conference. PLoS ONE 16.

MAAS B, TOOMEY A & LOYOLA R. 2019. Exploring and expanding the spaces between research and implementation in conservation science. Biol Conserv 240.

MAULEÓN E & BORDONS M. 2006. Productivity, impact and publication habits by gender in the area of Materials Science. Scientometrics 66: 199-218.

MCMANUS C, BAETA NEVES A & MARANHÃO A. 2020. Brazilian publication profiles: Where and how Brazilian authors publish. An Acad Bras Cienc 92: 1-22.

MEC. 2013. Análise sobre a Expansão das Universidades Federais de 2003 a 2012. https://www.portal.mec.gov.br›docman›janeiro-2013-pdf. (accessed 24 November 2019).

MYERS N, MITTERMEIER R, MITTERMEIER C, DA FONSECA G & KENT J. 2000. Biodiversity hotspots for conservation priorities. Nat 403.

NALLY R. 1996. Hierarchical partitioning as an interpretative tool in multivariate inference. Austr Jour Ecol 21: 224-228.

OLIVEIRA A & LOPES W. 2021. Trends in scientific publication on ethnozoology: Brazil's highlight in international science. Rev Ibero-Am Cien Ambient 12: 691-698.

OLIVEIRA L, REICHERT F, ZANDONÀ E, SOLETTI R & STANISÇUASKI F. 2021. The 100,000 most influential scientists rank: The underrepresentation of Brazilian females in academia. An Acad Bras Cien 93: e20201952.

ORDORIKA I. 2015. Equidad de género en la Educación Superior. Rev Educ Sup 44: 7-17.

OUTRAM D. 1987. The most difficult career: Females's history in science. Int J Sci Educ 9: 409-416.

OVERBECK GE ET AL. 2018. Global Biodiversity Threatened by Science Budget Cuts in Brazil. BioScience 68.

PERC M. 2014. The Matthew effect in empirical data. J R Soc Interfase 11.

PERLIN M, SANTOS A, IMASATO T, BORENSTEIN D & DA SILVA S. 2017. The Brazilian scientific output published in journals: A study based on a large CV database. J Informetr 11: 18-31.

PLATFORM CÉSAR LATTES. 2022. https://lattes.cnpq.br/. (accessed 20 July 2022).

PRATES M & IRVING A. 2015. Conservação da biodiversidade e políticas públicas para as áreas protegidas no Brasil: desafios e tendências da origem da CDB às metas de Aichi. Rev Bras Pol Publ 5: 27-57.

PRPIÛ K. 2002. Gender and productivity differentials in science. Scientometrics 55: 27-58.

PULEO A. 2017. Perspectivas ecofeministas de la ciencia y el conocimiento La crítica al sesgo andro-antropocéntrico. Daimon 72: 41-54.

R DEVELOPMENT CORE TEAM. 2018. R: a language and environment for statistical computing. R Foundation for Statistical Computing. http://www.R-project.org. (accessed 20 October 2019).

ROMERO J. 2020. Plantas invasoras na américa latina: avanços, direções e desafios. Univ Fed de São Carlos: Brasil.

RØRSTAD K & AKSNES D. 2015. Publication rate expressed by age, gender and academic position - A large-scale analysis of Norwegian academic staff. J Informetr 9: 317-333.

ROSA C ET AL. 2021. The program for biodiversity research in Brazil: The role of regional networks for biodiversity knowledge, dissemination, and conservation. An Acad Bras Cien 93: e20201604.

ROSSITER M. 1993. The Matthew Matilda effect in science. Soc Stud Sci 23(2): 325-341.

SALERNO P, PÁEZ-VACAS M, GUAYASAMIN J & STYNOSKI J. 2019. Male principal investigators (almost) don’t publish with females in ecology and zoology. PLoS ONE 14.

SANDSTRÖM U. 2009. Combining curriculum vitae and bibliometric analysis: Mobility, gender and research performance. Res Eval 18: 135-142.

SANTOS R & KOBASHI N. 2009. Bibliometria, cientometria, infometria: conceitos e aplicações.

SARSEKE G. 2018. Under-Representation of Females in Science: From Educational, Feminist and Scientific Views. J Females High Educ 11: 89-101.

SCOPUS ELSEVIER. 2022. https://www.scopus.com/search/form.uri?display=basic#basic. (accessed 20 July 2022).

SHEN H. 2013. Inequality quantified: Mind the gender gap. Nature News 495: 22-24.

SUCUPIRA PLATFORM. Programas de pós-graduação. 2019. https://sucupira.capes.gov.br/sucupira/. (accessed 1 December 2019).

SYMONDS M, GEMMELL N, BRAISHER T, GORRINGE K & ELGAR M. 2006. Gender differences in publication output: towards an unbiased metric of research performance. PLoS ONE 1: 127.

TORGRIMSON B & MINSON C. 2005. Sex and gender: what is the difference? J Appl Physiol 99: 785-787.

VOSGERAU D, ORLANDO E & MEYER P. 2017. Produtivismo acadêmico e suas repercussões no desenvolvimento profissional de professores universitários. Educ Soc 38: 231-247.

WELTZIN J, BELOTE R, WILLIAMS L, KELLER K & ENGEL E. 2006. Authorship in ecology: attribution, accountability, and responsibility. Front Ecol Environ 4: 435-441.

WREN J, KOZAK K, JOHNSON K, DEAKYNE S, SCHILLING L & DELLAVALLE R. 2007. The write position: A survey of perceived contributions to papers based on byline position and number of authors. EMBO Rep 8(11): 988-991.

YANG Y, TIAN T, WOODRUFF T, JONES B & UZZI B. 2022. Gender-diverse teams produce more novel and higher-impact scientific ideas. Proc Natl Acad Sci 119(36).

ZANDONÀ E. 2022. Female ecologists are falling from the academic ladder: A call for action. Perspect Ecol Conserv: 1-6.

ZIPPEL K. 2017. Women in Global Science: Advancing Academic Careers Through International Collaboration, Stanford: Stanford University Press, 224 p.

ZORZETTO R ET AL. 2006. The scientific production in health and biological sciences of the top 20 Brazilian universities. Braz J Med Biol Res 39.

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Federico Garrido-de León, Ana Alice Eleuterio and Michel V. Garey conceived of the study, participated in the sampling and data analysis/interpretation. Federico Garrido wrote a preliminary version of the manuscript. Jair Romero collaborated with the writing and review of the manuscript. All the authors discussed the results and wrote a final version of the manuscript.