

Scientific production of researchers with doctorate in Brazil and abroad: gender differences in the area of Ecology

Produção científica de pesquisadores com doutorado no Brasil e no exterior: diferenças entre gêneros na área de Ecologia

Producción científica de investigadores con doctorado en Brasil y en el exterior: diferencias de género en el ámbito de la Ecología

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Abstract

This study compared the patterns of scientific productivity of researchers in the area of ecology, from both genders, and evaluated the influence of doctoral education in Brazil and abroad, in terms of the number of articles published in Brazilian and international journals during different career phases. The curriculum vitae of 105 researchers whom obtained their doctorate between 1990 and 2004 were analyzed. Women published fewer articles than men, and those who achieved their doctoral degree abroad published even fewer articles than those who studied in Brazil. Among men, those who achieved their doctoral degree abroad published more articles than those who studied in Brazil, except while they were doing their doctorate and during the first five years of their careers.

Keywords: Scientific Production. Gender. Doctorate Abroad. Ecology.

Resumo

O objetivo deste estudo foi comparar a produtividade científica dos pesquisadores brasileiros da área de ecologia, de ambos os sexos, que realizaram o doutorado no Brasil e no exterior, em termos do número de artigos em periódicos brasileiros e internacionais em diferentes fases da carreira. Foram analisados os currículos de 105 pesquisadores que concluíram o doutorado entre 1990 e 2004. As mulheres publicaram menos artigos que os homens e as que realizaram o doutorado no exterior publicaram ainda menos do que as que realizaram o doutorado no Brasil. Os homens que realizaram o doutorado no exterior publicaram mais do que aqueles que realizaram o doutorado no Brasil, exceto no período durante o doutorado e nos primeiros cinco anos da carreira.

Palavras-chave: Produção Científica. Gênero. Doutorado no Exterior. Ecologia.

Resumen

El objetivo de este estudio fue comparar la productividad científica de los investigadores brasileños del área de ecología de ambos géneros que hicieron el doctorado en Brasil y en el exterior en términos del número de artículos en periódicos científicos brasileños e internacionales en diferentes fases de la carrera. Se analizaron los currículos oficiales online de 105 investigadores que concluyeron el doctorado entre 1990 y 2004. Las mujeres publicaron menos artículos que los hombres y las que hicieron el doctorado en el exterior publicaron menos que las que hicieron el doctorado en Brasil. Entre los hombres, los que hicieron el doctorado en el exterior publicaron más que los que hicieron el doctorado en Brasil excepto durante el doctorado y en los primeros años de la carrera.

Palabras clave: Producción Científica. Género. Doctorado en el Exterior. Ecología.

Introduction

Current models for evaluating scientific activities across all disciplines of knowledge take into account different productivity indicators, with the publication of articles in scientific journals being the most important (FERREIRA, 2010). The production of articles is paramount to the academic success of individual researchers, since the quantity and quality of these publications are critical to performance evaluations, promotions, and obtaining research funding (BORREGO et al., 2010). In addition, these publications have consequences for the greater national scientific community as countries compete for positions among international rankings of scientific productivity. However, regardless of the position among these rankings, the problem of gender inequality in science is pervasive among many countries (OLINTO, 2011). Women are less productive than men in the sciences, both among countries with a long scientific tradition as well as those whose consolidation of knowledge is more recent, such as Brazil. These consistent differences between genders represent an enigma whose cause remains unclear. This enigma has been coined as a “productivity puzzle” by Cole and Zuckerman (1984). Identifying each piece of the puzzle is essential to achieve a greater balance in the contribution of women to science (BRONSTEIN et al., 1993).

Differences between genders in the production of scientific articles have been well explored in the literature (VELHO; LEÓN, 1998; LEWINSON, 2001; SYMONDS et al., 2006; BORREGO et al., 2010). The majority of studies demonstrate that women tend to publish less than men. Among ecologists and evolutionary biologists, women have significantly lower scientific productivity than men across their entire career, despite female publications having higher quality (SYMONDS et al., 2006). Data from Brazil indicate that among researchers with greater scientific productivity, men accounted for 86% of the production while women accounted for 14% (LETA; BATISTA, 2010). However, when scientists within a lower range of productivity (< 50 articles) were compared, no differences were found between genders. Among Spanish Ph.Ds., articles authored by women were published in higher impact

journals and were more often cited than articles authored by men (BORREGO et al., 2010). However, men accounted for 92.8% of the most highly cited researchers in environmental science and ecology (PARKER et al., 2010). Similar results from two decades earlier demonstrated that women were absent among top researchers in number of articles and impact of citations (PRIMACK; O'LEARY, 1989). Despite how widespread is the gender gap in science, a definitive explanation for it has not been found.

Some alternative explanations for the differences between men and women in science are related to factors strongly correlated with scientific productivity. These include overall motivation, the quality of the academic education received, the quality of the work environment, the amount of time dedicated to research, and the field of knowledge (BLACKBURN et al., 1978). Other authors suggest that the differences between scientists from both genders in physics, chemistry, biology, and the social sciences may be associated with social constructs of gender within academia, such as the socialization for gender roles, levels of investment in women education, and the cultural traditions of the country (VELHO; LEÓN, 1998). Psychological factors such as feelings of inadequacy, anxiety related to job evaluation, perfectionism, and low self-esteem are suggested as being responsible for the lower representation of women among professors within United States universities (BRONSTEIN et al., 1993). The longer time spent by women as compared to men engaging in activities associated with the family, such as the maintenance of the household and the care of young children has been linked to greater difficulty in achieving professional stability in the neurosciences (BARINAGA, 1992) and are suggested as causative factors of lower female productivity in science (D'AMICO et al., 2011).

In Brazil, women have outnumbered men in earning doctoral degrees since 2004 (CGEE, 2010). However, despite their greater representation among doctorate recipients in a diversity of fields, especially in Biology where women accounted for 61% of doctoral degrees earned between 1996–2008 (CGEE, 2010), many indicators still demonstrate an unfavorable gender disparity for women in the sciences.

For instance, the scientific production of Brazilian women is still lower than that of men (VELHO; LEÓN, 1998) and the majority of women with a doctoral degree work as high school teachers (CGEE, 2010). In addition, the opportunities for promotion and recognition in academia are fewer for women as compared to men, a phenomenon also present in the United States and the United Kingdom (ACKER, 1992). If the same level of gender equality found in the training of doctorates is achieved in scientific production in Brazil, it would represent a major advancement in the indicators of science, technology, and innovation, which are increasingly associated with development indicators (OECD, 2005).

In the field of ecology, the entry of new researchers into the labor market and the scientific productivity has increased since the first graduate courses were offered in Brazil in 1976 (MARTINS; LIMA, 2000). The importance of this field of knowledge is reflected on the 2007 ranking divulged during the 59th Annual Meeting of the Brazilian Society for Scientific Progress (SBPC), when the field of Ecology was identified as one of the fastest growing disciplines in the comparison between the periods of 2001-2003 and 2004-2006. More than 2.000 articles were published in the areas of ecology and environmental science during the 2008-2010 period in Brazil, representing approximately 3% of the total number of articles published in the country (SCARANO; OLIVEIRA, 2005). The development of the discipline is driven by the heightened interest in ecological themes, as well as the policies of developmental agencies such as Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), and Fundações de Amparo a Pesquisa (FAPs) that encourage and support the training of young Brazilian doctoral students in ecology at distinguished universities mostly in the United States and Europe (SCARANO; OLIVEIRA, 2005).

In Brazil, public policies that encourage the training of researchers abroad have changed the standard of professional qualifications. Scholarships financed with public resources provide greater participation for Brazilian researchers in training, projects, and networks in the international scientific community. This, in turn, contributes to the

advancement of academic research and competitiveness of Brazil in science and technology (CARVALHO, 2002). Training of Brazilian doctoral students abroad is a key element of Brazil's inclusion into the international community of science and technology resulting not only from the direct learning of formal knowledge but also through the passive internalization of implicit knowledge from foreign institutions (VELHO, 2001). Upon returning to the country of origin, researchers trained abroad are expected to have increased performance in terms of productivity. This performance boost is associated with integration into new foreign scientific networks and the maintenance of links within these networks, what will enhance cooperation between researchers across borders (JIN et al., 2007).

Among factors strongly linked to scientific production, the publication of articles at the beginning of a researcher's career is a good indicator of productivity throughout the career (LIGHTFIELD, 1971; COLE; COLE, 1973). A positive correlation between early productivity and high productivity during the career was found in a study conducted among 10 countries (TEODORESCU, 2000). For a researcher with low initial productivity, accumulated experience did not guarantee better productivity later in the career suggesting that high productivity in the beginning of a career is a good predictor of high productivity later, for both genders (BORREGO et al., 2010).

The objective of this study is to compare the patterns of scientific productivity of researchers in the area of ecology, from both genders, and evaluate the influence of doctoral training in Brazil or abroad, during different career phases. Achieving this objective may improve our understanding of mechanisms that drive differences in scientific productivity between men and women. The careers of researchers included in the study were analyzed among five phases, and productivity was quantified in terms of number of publications in Brazilian and international journals. For the purposes of this study, publications in international journals were considered of higher impact, as the impact factors of international journals are generally higher than Brazilian journals in the field of ecology.

Method

Data for this study was gathered from June 18th to 26th, 2012, at CNPq (<http://lattes.cnpq.br/>) *curriculum vitae* database (CV Lattes), applying the following search filters: Subject: Ecology; Base: doctoral degree; Academic level: doctoral degree; Academic field: Biological Sciences; Focal Field: Ecology; Professional Activity: Nature of the activity – all; current activity – yes; Country: Brazil. This search generated a list of approximately 3,770 CVs. Then, I narrowed the sample to 832 CVs in which the relative frequency of the search terms was at least 72%. This tool was available at Lattes Platform during the time the search took place. Finally, I selected CVs from researchers who finished their doctorate between 1990-2004, reducing the final sample to 137 CVs. All researchers that completed their doctorate abroad (50) were included in the sample (32 men – 64% and 18 women – 36%). In order to achieve a balanced sample, 55 CVs of researchers that completed their doctorate in Brazil were selected randomly from a total of 87 CVs (28 men – 51% and 27 women – 49%). The remaining 32 CVs were not included in the analyses.

For each CV, the following information was analyzed: gender, location (Brazil or abroad) of the university that granted doctoral degree, beginning and end date of doctoral training and number of publications in Brazilian and international journals. Brazilian journals were defined as those published by Brazilian institutions, irrespective of language and international journals, those published in other countries. The careers phases were as follow: (1) before beginning of doctoral training; (2) during doctoral training; (3) from the first to the fifth year after earning doctoral degree; (4) from the sixth to the tenth year after earning doctoral degree; (5) and from the eleventh to the fifteenth year after earning doctoral degree. Four distinct groups were created: (1) women with a doctoral degree in Brazil; (2) women with a doctoral degree abroad; (3) men with a doctoral degree in Brazil; and (4) men with a doctoral degree abroad. Taking into account the year of degree conclusion (1990-2004), sample sizes for longer career phases naturally decrease (Table 1).

Table 1. Number of CVs of men and women analyzed across location of doctoral degree training and career phases

Gender	Location of doctoral degree training	Career phases				
		Before doctoral degree	During doctoral degree	First to fifth year after doctoral degree	Sixth to tenth year after doctoral degree	Eleventh to fifteenth year after doctoral degree
Men	Brazil	28	28	28	20	6
	Abroad	32	32	32	28	14
Women	Brazil	27	27	27	21	8
	Abroad	18	18	18	14	8
Total		105	105	105	83	36

Two-way Analysis of Variance (ANOVA) was used to test for differences among the number of publications between genders, between the location of doctoral degree training (Brazil vs. abroad), and the interactions between these two factors. The same type of statistics was used to test for differences in the number of articles published in Brazilian and international journals between each one of the five career phases, the total number of published articles, and the cumulative number of published articles until the fifteenth year after doctoral degree conclusion. In cases where distributions were not normal, data was transformed (\log_{10}) before testing. Significance level of $p < 0.05$ was used.

Results

The results of publications analyses in Brazilian journals are presented in Fig. 1 and Table 2. Analysis of publications in Brazilian journals before the beginning of the doctoral degree demonstrate that women publish significantly less than men ($F_{1,101} = 5.78, p = 0.018$). The location of doctoral degree training significantly influenced the number of publications during the doctoral degree. Researchers that obtained their doctoral degree in Brazil were more productive than those who graduated abroad ($F_{1,101} = 8.95, p = 0.003$). In the first five years of their career, men published more than women ($F_{1,101} = 4.96, p = 0.028$), and

researchers who graduated in Brazil were more productive than those who graduated abroad ($F_{1,101} = 4.59, p = 0.034$). Women who graduated abroad were the least productive among the four groups during the doctoral degree training and throughout their entire career. Men published more articles than women, on average, between the sixth and the tenth years ($F_{1,78} = 11.52, p = 0.001$) and between the eleventh and fifteenth years ($F_{1,32} = 5.96, p = 0.020$).

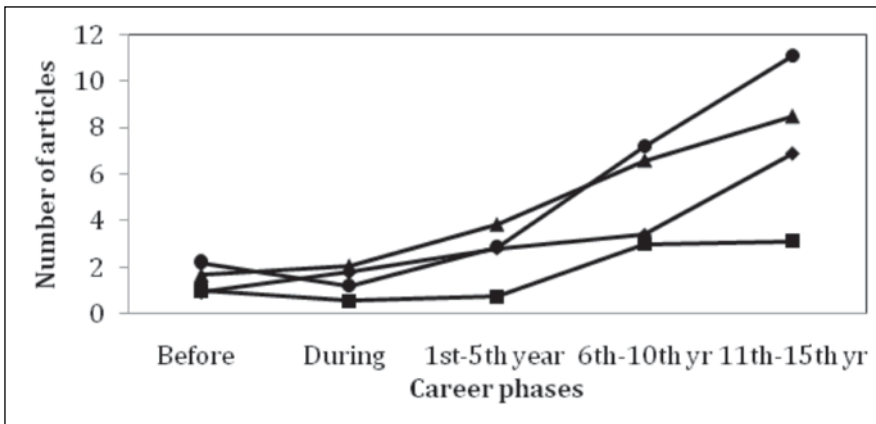


Figure 1. Average number of articles published by ecology researchers in Brazilian journals by gender and location of doctoral degree training across career phases (circles = men abroad; triangles = men in Brazil; squares = women abroad; diamonds = women in Brazil)

Table 2. Significance tests results of ANOVAs comparing publication in Brazilian and international journals across career phases by men and women ecologists by location of doctoral degree training (Brazil vs. abroad). Significant values ($p < 0.05$) are in bold

Journal	Career phases	General model	Gender	Location	Gender* Location
Brazilian	Before start of doctoral degree	0.070	0.018	0.455	0.571
	During doctoral degree	0.024	0.171	0.003	0.595
	1 st -5 th yrs after doctoral degree	0.043	0.028	0.034	0.441
	6 th -10 th yrs after doctoral degree	0.008	0.001	0.846	0.584
	11 th -15 th yrs after doctoral degree	0.044	0.020	0.571	0.222

Journal	Career phases	General model	Gender	Location	Gender* Location
International	Before start of doctoral degree	0.010	0.002	0.398	0.691
	During doctoral degree	0.006	0.011	0.077	0.206
	1 st -5 th yrs after doctoral degree	0.122	0.140	0.155	0.403
	6 th -10 th yrs after doctoral degree	0.013	0.248	0.081	0.039
	11 th -15 th yrs after doctoral degree	0.011	0.266	0.063	0.034
Total	Before start of doctoral degree	0.006	0.001	0.344	0.556
	During doctoral degree	0.050	0.009	0.753	0.221
	1 st -5 th yrs after doctoral degree	0.118	0.023	0.691	0.315
	6 th -10 th yrs after doctoral degree	0.004	0.006	0.197	0.130
	11 th -15 th yrs after doctoral degree	0.002	0.007	0.753	0.022
Cumulative	Until start of doctoral degree	0.006	0.001	0.344	0.556
	Until end of doctoral degree	0.001	0.001	0.668	0.050
	Until 5 th yr after doctoral degree	0.004	0.002	0.481	0.098
	Until 10 th yr after doctoral degree	0.002	0.003	0.409	0.047
	Until 15 th yr after doctoral degree	0.004	0.018	0.576	0.022

When publications in international journals were analyzed (Fig. 2 and Table 2), even though the group of men who graduated with their doctoral degree abroad shows clear separation from the other groups, this difference was only significant during two phases: before completion of the doctoral degree ($F_{1,101} = 10.16, p = 0.002$) and during the doctoral degree ($F_{1,101} = 6.64, p = 0.011$). There was no significant difference between men and women, or between location of doctoral degree training in the phases that correspond to the first five years of their careers or the following six to ten years of their careers. There was a significant interaction between gender and location of doctoral degree training ($F_{1,32} = 4.91, p = 0.034$) between the eleventh and the fifteenth years of their career, showing that women who graduated

in Brazil had lower productivity only when compared to men who graduated abroad.

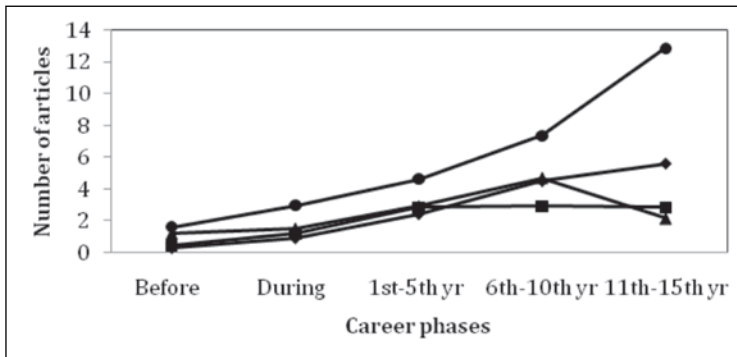


Figure 2. Average number of articles published by ecology researchers in international journals by gender and location of doctoral degree training across career phases (circles = men abroad; triangles = men in Brazil; squares = women abroad; diamonds = women in Brazil)

When publication in Brazilian and international journals were analyzed together (Fig. 3 and Table 2), the differences between men and women were significant for all phases (before the start of their doctoral degree [$F_{1,101} = 10.9, p = 0.001$], during their doctoral degree [$F_{1,101} = 7.05, p = 0.009$], from the first to the fifth year after they finished their doctoral degree [$F_{1,101} = 5.35, p = 0.023$], from the sixth to the tenth year after they finished their doctoral degree [$F_{1,78} = 7.98, p = 0.006$], and from the eleventh to the fifteenth year after they finished their doctoral degree [$F_{1,32} = 8.16, p = 0.007$]). The interaction between gender and location of doctoral degree training was significant ($F_{1,32} = 5.78, p = 0.022$) in the last phase due to the higher average number of publications of men who were trained abroad compared to the other three groups.

When the cumulative number of publications within the first 15 years of the career was analyzed (Fig. 4 and Table 2), the differences between men and women were significant across all career phases (before the start of their doctoral degree [$F_{1,101} = 10.90, p = 0.001$], until the end of their doctoral degree [$F_{1,101} = 13.72, p < 0.001$], until the fifth year after they finished their doctoral degree [$F_{1,101} = 10.16, p = 0.002$], until the tenth year after they finished their doctoral degree [$F_{1,81} = 9.42, p = 0.003$], and until the fifteenth year after they finished their doctoral degree [$F_{1,32} = 6.22, p = 0.018$]). The interaction between gender and

location of doctoral degree training was significant for the cumulative data set ($F_{1,101} = 3.94, p = 0.050$), as well as in the last two phases analyzed (until the tenth year after they finished their doctoral degree [$F_{1,81} = 4.08, p = 0.047$] and until the fifteenth year after they finished their doctoral degree [$F_{1,32} = 5.78, p = 0.022$]). These results were due to the higher number of publications of men that studied abroad in relation to the other three groups.

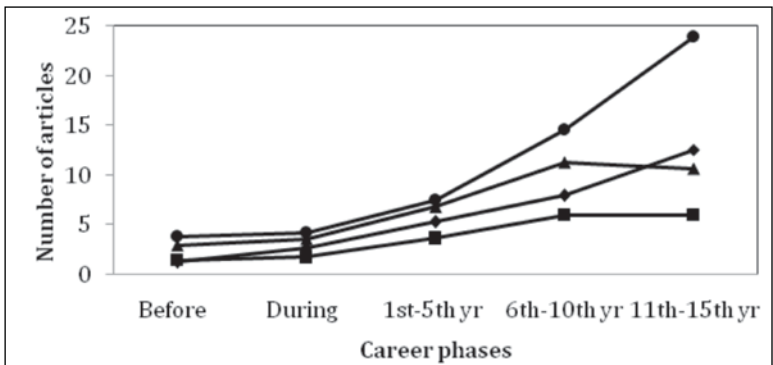


Figure 3. Average number of articles published by ecology researchers in Brazilian and international journals (combined) by gender and location of doctoral degree training across career phases (circles = men abroad; triangles = men in Brazil; squares = women abroad; diamonds = women in Brazil)

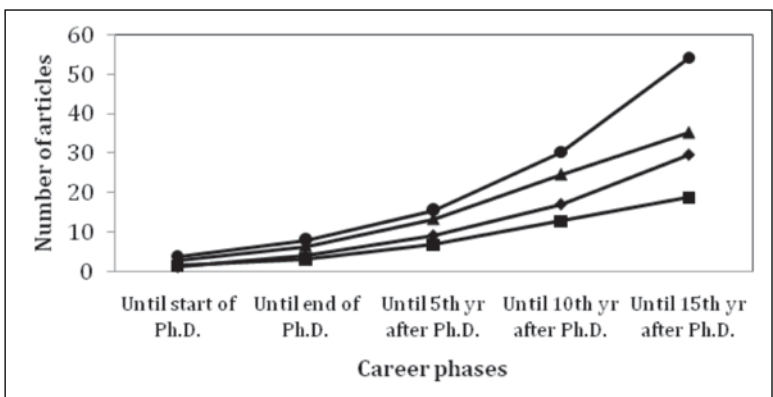


Figure 4. Total (cumulative) number of articles published by ecology researchers in Brazilian and international journals (cumulative) by gender and location of doctoral degree training across career phases (circles = men abroad; triangles = men in Brazil; squares = women abroad; diamonds = women in Brazil)

Discussion

The results found in this study showing that women tend to publish less than their male counterparts are consistent with others on the participation of women in the sciences (VELHO; LEÓN, 1998; LETA; BATISTA, 2010; PARKER et al., 2010). Lower scientific productivity of women throughout their careers was found in the field of ecology by Symonds et al. (2006) and is likely to be found also in other fields of knowledge, according to these authors. The main reason presented in the literature for the lower productivity of women is the amount of time devoted to family obligations (PARKER et al., 2010) and the more intense desire to find "...work-life balance, integrating science and personal life. Women seem to resent barriers and segregation that exist in academic life..." (VELHO; LEÓN, 1998, p. 343). In the field of Ecology, difficulties identified by women researchers related to a career in science include lack of professional mobility, absence of female role models, lack of job security, power imbalances in the work place, and discrimination (PRIMACK; O'LEARY, 1989). However, the most common factor identified by women in various fields, as the main reason for lower scientific productivity, is the time dedicated to family (BARINAGA, 1992; OLINTO, 2011), especially the care of young children (D'AMICO et al., 2011).

The proportion of men to women among university faculty is also used as an explanation for the differences in productivity between genders. According to a study conducted by the Biology Institute of the University of Campinas (UNICAMP), there is an inverse relation between female scientific productivity and representation among faculties. In fields where women are a minority, their productivity tends to increase to the same level as that of men. In contrast, in fields in which there is a predominance of women in faculty bodies, their productivity is lower than that of men. The explanation for this pattern is that when women represent a majority, they tend to impose their work rhythm instead of reaching out to achieve male productivity styles, which allows them to achieve a better work-life balance (VELHO; LEÓN, 1998). The argument of an inverse relation between female representation among university faculty and productivity could partially explain the results found in the present study, although there is no data to confirm it. Further studies

comparing female representation among faculty and the relative productivity of individual female researchers could shed light on this question.

An alternative explanation that has been suggested is that lower female productivity levels are a consequence of the quantitative criteria used to compare men and women. The use of metric systems corrected for the effect of quality would seem to favor women, since they tend to publish fewer articles with higher impact (SYMONDS et al., 2006; BORREGO et al., 2010). In this study, publication in international journals was considered an indicator of impact and it was found that in the last phase of career considered, women that obtained their doctoral degree in Brazil published more articles in international journals than men within the same career group. However, due to the reduced number of CVs in this phase (Table 1), conclusions about the relationship between quantity and quality should be taken as preliminary. Larger numbers of researchers' CVs of both genders in this phase of their career is necessary to explore this issue further.

Scientific productivity at the beginning of a career is a good predictor of productivity along the career (CRESWELL, 1985). For authors such as Cole and Cole (1973), researchers that are less productive in the beginning of the career are not expected to be highly productive later. Thus, the initial phase of the career, specifically the first five years, may establish a pattern of productivity throughout the career (LIGHTFIELD, 1971). In relation to the impact, there would also be a relationship between the phase of the career in which the articles are published and the number of citations. Some studies show that the most cited studies tend to be published in the initial phase of a researcher's career, regardless of time since publication (FALAGAS et al., 2008). The initial phases of a woman's scientific career usually coincides with important life events, such as pregnancy, breast-feeding, and care of young children. This should not be ignored and should be taken into consideration in comparisons of scientific productivity between genders. More research on the different aspects of female experiences in the context of their scientific careers could contribute to the adaptation of the metrics used in the evaluation of productivity. These could include correction factors

for lower productivity for women with young children and give incentives for scientific production later in the career.

This study suggests that women that obtained their doctoral degree abroad had the lowest productivity of all groups among all career phases, including women that obtained their doctoral degree in Brazil. I did not find other studies that compared scientific productivity of men and women who earned their doctoral degree within their countries of origin or abroad. The interest in understanding the reasons for women's lower scientific productivity is justified in face of their representation in doctoral programs in Brazil and abroad.

Some studies suggest that the high investment of Brazilian agencies to support graduate students abroad is not reflected in higher scientific productivity (MENEQUINI 1991). Scientific productivity of researchers in a subfield of the Biological Sciences who graduated between 1994 and 2009 show that those with doctoral training in Brazil were 56% more productive than those trained abroad (JESUS et al., 2011). For Biochemistry researchers, the country of doctoral training did not influence the number or the impact factor of published articles during or after graduation (MEIS & LONGO, 1990). The results found in the present study contradict those described in the literature, since scientific productivity of men trained abroad was higher than the production of all other groups (men trained in Brazil and women trained in Brazil and abroad), except for the number of publications in Brazilian journals during the first five years of their careers. However, the results found in relation to female productivity are consistent with the literature. A potentially unique contribution of this research is the indication that comparisons between researchers trained in Brazil and abroad in terms of scientific production, must account for gender differences. Results indicate that the cost of training a researcher abroad is not offset by a return in scientific productivity, which may be biased by the female portion of the samples. More research is needed to clarify this issue. Future studies should focus on comparing the scientific production of researchers across genders, location of doctoral degree training, and discipline. In addition, comparisons of doctoral program quality between Brazilian and foreign universities where students were trained may help understand the reasons for differences in productivity between groups.

Final considerations

The comparison between patterns of productivity throughout the careers of men and women that accounted for the location of doctoral degree training confirmed the existence of inequality in scientific productivity between genders. These differences can be even more pronounced among researchers who studied abroad. Considering the variability of publication standards in all studied groups, larger samples should be used in future research in order to confirm the patterns found here. Studies that integrate other factors such as location of training and alternative metrics (which account for both quantity and quality of publications) to analyze the performance of researchers could shed light on the underlying reasons for differences between genders.

More attention to women's specific demands during doctoral training and in the initial phases of their career (a period that usually coincides with caring for young children) could bring significant improvement in the contribution of women to science and translate equality in academic training into equality in terms of scientific production. Furthermore, studies conducted in different cultural, social, and academic contexts could bring contributions to support funding agencies and graduate programs in the development of effective policies that will result in incentive strategies to increase women's scientific production. Clarifying the reasons for lower female productivity, a contemporary phenomenon that was identified almost three decades ago, could be essential to mitigating the problem of gender inequality in science.

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