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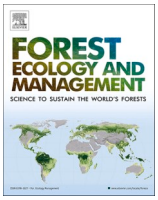

# Perspectives – Academic career in ecology: Effect of gender, caregiving labor, and the working environment

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ABSTRACT

True meritocracy is only fair when a leveled playing field is guaranteed. Scientists with caregiving responsibilities, often women, carry a heavy burden of unpaid labour, and therefore suffer downfalls in performance. Centered on an online survey that circulated among Argentinean ecologists between March and June 2020, we explored some of the mechanisms that may be behind differential performance and perception of performance in scientific tasks between genders. Based on 437 responses, we found that caregiving relays more on women than men, and that women dedicate less uninterrupted time to paid work, and more to unpaid domestic labour, especially when working from home. Women seem to start their careers younger than, but promote to higher categories older than men. Women value their own work more poorly than men. Both female and male researchers seem to choose more male referents and advisers, especially among older generations. The interaction between family and work is perceived negatively by women in early career stages, yet women and men felt supported by their advisers with respect to family-related issues. After the COVID pandemic, home-office has become an acceptable work practice adopted in different work places. However, our results show that at least in some fields of science, this may be inequitably productive for men and women. Public policies must help relieve all scientists, but especially women, from heavy unpaid caregiving labour and facilitate leaving their home space to detach from tasks related to domestic issues during work hours. Greater peer recognition of women's research should increase their participation as advisers and referents, and improve perception of their own work and those of other women. Public policies should aim at a fairer and more equitable working environment for women.

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## 1. Introduction

The traditional view of science favors the idea that objectivity and valuation neutrality guarantee that researchers may advance in their careers and excel based on their own merit, without the influence of external factors. However, evidence shows that such so-called meritocracy reproduces the inequities installed in society, specifically those linked to gender stereotypes and the evaluation of scientific careers (Revelles-Benavente and González Ramos, 2017). Real meritocracy can occur only if all participants depart from the same start point and have the same opportunities to complete their tasks. If a scientist had to dedicate, even if partially, to another job besides doing science, their academic performance would likely suffer a downfall (Wolfinger et al., 2009). Involvement in a second job is much more common than we usually consider, as we have increasingly grown aware that responsibilities related to having a family should be considered labor, even if unpaid. The roots of this concept lay on the origins of capitalism as an economic and social structure, back around the XVI-XVII centuries (Federici, 2010). Such consideration is especially important if, as has been thoroughly argued and broadly recognized, most of that unpaid labor relies on women (Carrasco, 2009): we can deduce that full dedication to scientific tasks, and the opportunities that come with that, will be gender biased. The meritocratic nature of the system, in itself, may be questioned under a gender lens, as there is no meritocracy if opportunities differ among genders. (In the Methods section we clarify why we use the binary gender classification.)

The scientific and technology systems, as social institutions, are not exempt from gender inequities. Moreover, they reproduce and reinforce the pattern. Although the proportion of women in science has gradually increased since the 50s, gender gaps in productivity and impact on differential achievement in scientists' careers have also increased regularly since the 70's for all disciplines and in most countries (Huang et al., 2020). Multiple dimensions of gender inequities (O'Brien et al., 2019) are globally well-known, accounting for disparities in number of researchers and citations, positions, funding, awards, promotion, composition of editorial boards, and salary, among other aspects (Martin, 2012; Astegiano et al., 2019; James et al., 2019; de Kleijn et al., 2020; Segovia Salcedo, 2021).

Although the situation varies between different countries in the region, in Latin America there is often a strong presence of women in the scientific system, yet the gender gap persists (Valentova et al., 2017; UNESCO, 2019; Grosso et al., 2020, 2021). The Argentinian scientific system has often been cited as exemplary in gender equity among its researchers (de Kleijn et al., 2020), with 54% women in Argentina's main public science institution, the National Council for Scientific and Technical Research (hereafter CONICET for its acronym in Spanish) in 2022. These numbers set it much higher than the world average of 28% women as research and technological development employees (CONICET, 2022a). However, when we look into more detail, Argentinian women, like women in the scientific systems of other Latin-American countries (Kochen et al., 2001), seem to face barriers as they advance in their scientific careers, which prevent them from reaching the higher ranks. Statistics from 2022 (CONICET, 2022a) show that the high percentage of women in the Argentinian public scientific system mentioned above is mainly driven by gender distribution among Assistant Researchers, the lowest and most populous of five categories of researchers, where women represent 61%. Yet the proportion of women decreases to 26% among Superior Researchers, the fifth and highest category in the institution. Detailed studies on specific cohorts of researchers between 1994 and 2002 also show that, although women tended to increase in numbers in the later years in the upper categories, men promoted more or, at least, faster (Franchi et al., 2008). This pattern recovers the classical vertical segregation shown in most scientific institutions, where the gender gap is evident, and may be at least partially explained by a 'leaky pipeline' phenomenon (Wolfinger et al., 2009; Huang et al., 2020), where women abandon their careers more often than men.

If we have demonstrably gender inequities that systematically affect women's scientific careers, we are facing an issue of public interest, and a serious need to understand the mechanisms that cause it. If we are to understand the leaky pipeline phenomenon mentioned above, we must understand how the inequities in the scientific system affect women's performance and ability to promote and remain in the system. Inequities may be related to having high burdens of responsibilities outside work (e.g., caregiving) or to receiving less recognition than their male counterparts. Both may be potential mechanisms by which scientific women often express the "imposter syndrome" (Clance and Imes, 1978), where they doubt of their own capacities, think their success is due to some external cause (e.g., luck) and feel that they do not deserve their prestige, perceiving themselves like frauds or imposters. There is a much lower representation OF WOMEN in certain academies of science (Hilton, 2013) and women are less likely than men to occupy leadership roles (O'Brien et al., 2019). Moreover, there is evidence of inequities when it comes to authorship in positions representing leadership, percentage of representation in tenured jobs, citations, and the amount of funding received between female and male ecologists (Lortie et al., 2007, 2012; Martin, 2012). This lack of recognition towards women in the sciences may be an important mechanism behind the so-called imposter syndrome. Understanding how men and women value the performance of women scientists, will help visualize and take action on something that women have been pointing out for several years: the working environment is more hostile, even oppressive, for women than for men. Gender differences in science are evident worldwide (de Kleijn et al., 2020; Huang et al., 2020), and may be affected by our perception and valuation of our own work and that of others (Pell, 1996; Zubieta, 2007).

The field of Ecology has a tradition on studies in gender inequities (Lortie et al., 2007, 2012; O'Brien and Hapgood, 2012; West et al., 2013; Fox et al., 2018, 2019; Astegiano et al., 2019; Salerno et al., 2019; Whelan and Schimel, 2019; Huang et al., 2020; Frances et al., 2020; Campbell and Simberloff, 2022). Perhaps this is not coincidental, as this field has a combination of field, lab and office work, that make it hard to juggle family-related responsibilities and work. Such combination is not exclusive of Ecology, however, and therefore results are applicable to a wide range of science disciplines. We chose to focus our study on this field, and contribute to previous studies that help understand gender dynamics in science, and emphasize the need to address gender imbalances and promote inclusivity within the research community. Moreover, we chose Argentinean ecologists as our study case, as they are representative of the wider reality of Latin America (Kochen et al. 2001) where, as mentioned above, although participation of women in science is very active, gender imbalances persist within patriarchal societies (López-Aguirre, 2019, Beigel et al. 2023). Also, leaving aside the characteristic structural inequalities that affect Latin American countries with respect to most European or North American countries (e.g., disparities in technology and digital access, limited resources for academic institutions, communication limitations due to the use of English as the academic language; Beigel et al. 2023), our study case also represents other academic situations worldwide, including those of many developed countries (van den Besselaar and Sandström, 2017, de Kleijn et al. 2020).

Through a self-perception survey answered by Argentinian ecologists, we collected data to answer the following specific questions: 1. How is unpaid caregiving/domestic labor distributed between female and male ecologists? 2. Are ecologist's dedication and performance related to scientific activities, affected by unpaid caregiving/domestic labor, gender, or both? 3. Are career paths of women scientists different from those of male scientists? 4. How do researchers value their own work performance, and that of others (i.e., choice of referents and Ph.D. advisers), and does that differ between genders? 5. How do researchers perceive the interaction between having family-related responsibilities and a successful career? 6. Do PhD students feel supported by their

advisors when dealing with family-related issues? And, how is this perception related to student and advisor genders, and unpaid caregiving/domestic labor? By addressing these questions, we hope to contribute to the development of effective public policies to counteract present-day inequities.

## 2. Materials and methods

We composed an online survey with 60 questions (Supporting Information) that was widely distributed amongst Argentinian ecologists between March and June 2020, using professional and social networks to reach as many Argentinian ecologists as possible. Because the lockdown due to the COVID-19 pandemic started shortly after we started distributing the survey in the country, 25% of the answers were received before the lock-down, and 75% after the lockdown started in Argentina (March 20, 2020). Participation in the survey was voluntary and anonymous, and respondents were aware of the use of the data for research purposes as this was specified in the text preceding the survey (Supporting Information). All methods were carried out in accordance with relevant guidelines and regulations of our Institution, and approved by the Committee of Ethics in Research of the National University of Tucuman and CONICET (CEI, UNT-CONICET).

We obtained 437 responses from ecologists working at different institutions throughout Argentina, mostly public, and predominantly from CONICET. As mentioned, CONICET is the main public agency aimed at research and technology in Argentina. Throughout Argentina, it has more than 12,000 researchers and 12,000 doctoral and postdoctoral fellows. Researchers are distributed amongst 310 research CONICET institutes, public and private universities, as well as other research institutions, across the 24 jurisdictions throughout the whole country. To ensure that our sample was representative of the population of Argentinian ecologists, we estimated the potential population size of ecologists working in Argentina by recording the number of past and present-day members of the Argentine Association of Ecology (AsAE), which was 1126 ecologists. Although this measure may underestimate the total population, as not all ecologists are (or have been) members of AsAE, we consider it to be the closest possible estimation. Considering this information, we estimated that our sample represents around 39% of the total population of Argentinian ecologists. Although we could not determine the proportion of ecologists dedicated to any specific topic (e.g. forest ecology), we expect similar patterns across sub disciplines of Ecology. In fact, most of our results might apply to any discipline where male and female scientists, with families and/or caregiving duties, alternate between home office and work in an institution, and are subject to hierarchical working situations. Among the 437 participants in the survey, 282 were women (65%), 152 were men (35%), and 3 respondents (< 1%) identified themselves as “Other gender”. Therefore, given the low numerical representativeness of this last category, we restricted statistical analyses and conclusions to women and men. The total number of respondents that belonged to CONICET was 346, of which 234 (68%) were women and 112 (32%) were men, including doctoral and postdoctoral fellows, and researchers in all categories. This approximated the gender proportions observed in the population of CONICET researchers (CONICET, 2022b).

For data analysis, in some cases we restricted the responses to researchers from CONICET in order to homogenize the universe of respondents (e.g., when we needed to quantify productivity, which is measured differently in different institutions). Also, in some cases, we grouped scientists in three categories: 1. PhD and Postdoctoral Fellows (PPF); 2. Assistant and Associate Researchers in CONICET, considered as early career researchers (ECR); and 3. Independent and Principal Researchers in CONICET, considered as senior researchers (SR). We left out the highest category, Superior Researchers, because we received only two answers from people in that category. Statistical analyses were done using R Statistical Software (R Core Team, 2018) and Infostat (Di Rienzo et al., 2012). For each analysis we clarify which restrictions were applied to the dataset used.

To answer the first question, about the distribution of caregiving/domestic responsibilities between female and male scientists, we focused on researchers that answered that they did have that kind of unpaid labor, specifically caregiving. Assuming that caregiving, mostly involving children, could potentially be divided between two parents, we compared the number of female and male researchers that chose among three options: 1. they took charge of more than 50% of their caregiving responsibilities, 2. they took charge of half of their caregiving responsibilities, and 3. they took charge of less than 50% of their caregiving responsibilities. We analyzed these data with a Chi-squared test.

To answer the second question, related to the possibility of fully dedicating to scientific work in relation to unpaid caregiving/domestic labor and gender, we quantified: 1. the total number of uninterrupted working hours and 2. the amount of time dedicated to unpaid caregiving/domestic labor during working hours, as proxies to fully dedicating and concentrating on scientific work tasks, when working from home and from the office. Home-office has been a common practice among Argentinian scientists from CONICET, historically (pers. obs). Moreover, after the COVID pandemic, home-office has become a common work practice adopted in different institutions (Adekoya et al. 2022, Smite et al. 2023). Therefore, we think that the results found here will be useful for institutions beyond our study case. As a proxy to academic performance, we also quantified the number of first-author papers published in indexed journals, as reported by respondents (the validity of using such a measure to quantify productivity is discussed in the Discussion section). We are aware that the last and corresponding author positions are also indicators of protagonist academic performance, especially for senior authors. However, we decided to focus only on the first position because there is still no clear consensus on what those positions should represent (Tscharntke et al. 2007). Although this has been changing in the past years, this is still especially true in Ecology (Duffy, 2017) and low-income countries (Rees et al. 2019) such as Argentina. We compared this proxy between respondents (a) with different levels of unpaid caregiving labor and (b) of different genders. When analyzing unpaid caregiving labor in relation to academic performance, we analyzed separately the answers for the three categories of researchers described above (PPF, ECR, and SR), because the expected number of publications, distribution of unpaid caregiving work and gender composition are very different among those categories. The number of uninterrupted hours dedicated to work was analyzed with a t-test and an ANOVA, while the number of publications was analyzed with an ANOVA. The amount of time dedicated to unpaid domestic labor while working from the office or from home, was analyzed with a Chi squared test, as we looked at the number of researchers that chose each of the three following options: 1. no time at all, 2. less than one hour, and 3. one hour or more. For this particular analysis, levels of caregiving responsibilities were characterized as: 1. people that reported not to have any caregiving responsibilities; 2. people that had such responsibilities but assumed less than half of those responsibilities; and 3. people with caregiving responsibilities that assumed half or more than half of caregiving duties.

To answer the third question, whether career paths of female scientists differ from those of males, we looked at the average age at which researchers entered the different academic categories at CONICET, separated by level of caregiving responsibilities and gender. When needed, we analyzed these data using Kruskal-Wallis tests.

To answer the first part of the fourth question, how researchers value their own academic performance, and how that is related to gender, we asked the respondents to value their academic performance, classifying themselves as being below, equal, or above average relative to their colleagues. To test whether the probability of classifying themselves in one of the three categories was different for women and men, given similar academic performance (i.e., number of papers), we applied multi-nominal logistic regression using *multinom*() function in nnet package (Venables and Ripley, 2002) in R Statistical Software (R Core

Team, 2018). In order to homogenize the standards of productivity to which researchers are subject, for this analysis we included only researchers from CONICET. To answer the second part of the fourth question, how researchers value the academic performance of others, and how that is related to gender, we asked respondents to: 1. name three referents in their field of study, which we later sexed mostly by looking up their institutional web pages, and 2. tell us the gender of their Ph.D. adviser. For item 1, we asked for names, without making any reference to the gender of the referent to avoid inducing bias in responses (the survey, as distributed amongst researchers, can be seen in Supporting Information). For items 1 and 2, we compared the number of female and male advisers and referents between female and male respondents using Chi-squared tests.

To answer the fifth question, about the perception of the interaction between having a family and a successful career, we compared how many female and male respondents answered whether their family situations, as they had defined it in previous questions, facilitated, negatively affected, or had no effect at all in their academic performance. Conversely, we also asked whether they found an effect of their career on their family plans. For both questions we analyzed the data using Chi squared tests.

To answer the sixth question, about the level of support from the PhD advisers in relation to gender both of the student and of the advisor, we compared answers from female and male respondents, who could choose from a scale from 1 (I got no support at all from my adviser) to 5 (he/she was very supportive). We also looked at the incidence of having a female or male adviser in the answer, and of having different levels of caregiving responsibilities. We analyzed answers using Chi-squared tests.

## 3. Results

To make sure that our results were not a special case due to the pandemic lock-out (1/3 of the responses were written before the pandemic, and 2/3 after it had already started), we ran some analyses comparing data before and after the pandemic and found no significant results. We do not report those results here, as the topic of the paper is not the effect of the pandemic. We decided, therefore, to pool all data together.

Regarding our first question, on the distribution of unpaid caregiving work between genders, we found that, among researchers that reported having caregiving responsibilities (124 women and 62 men), a larger percentage of women (55%) than of men (5%) reported carrying more than half of caregiving duties. A smaller percentage of women (2%) than men (27%) reported carrying less than half of shared caregiving duties (X squared = 58.705, $df = 2$, $P < 0.001$) (Fig. 1).

For our second question, we used uninterrupted working hours per day as a proxy to dedication to scientific work. Overall, when we compared the mean number of uninterrupted hours worked by men (mean = 5.77 h, $N$ =108) and women (mean = 5.68 h, $N$ = 234) with unpaid caregiving work, regardless of level of burden, we found no significant difference ($t = -0.29$, $df = 340$, $P = 0.77$). When we looked at the effect of having caregiving work, regardless of gender, researchers without unpaid caregiving work, reported working an average of 6.2 uninterrupted hours. Researchers that had unpaid caregiving work but took charge of less than 50% of the burden reported working, on average, 5.7 uninterrupted hours, while those that took charge of 50% or more of unpaid caregiving reported working, uninterruptedly, the least number of hours, 5.25 h ($F = 5.7$, $df = 2$, $P = 0.004$). When considering both gender and levels of caregiving work, women and men without caregiving duties reported the longest period of uninterrupted work time, which was significantly greater than that reported by men and women who took on half, or more than half, of their shared caregiving responsibilities ($F = 2.31$, $df = 5$, $P = 0.044$). Women and men that took charge of less than half of their shared responsibilities, showed an intermediate position and did not differ significantly between them and

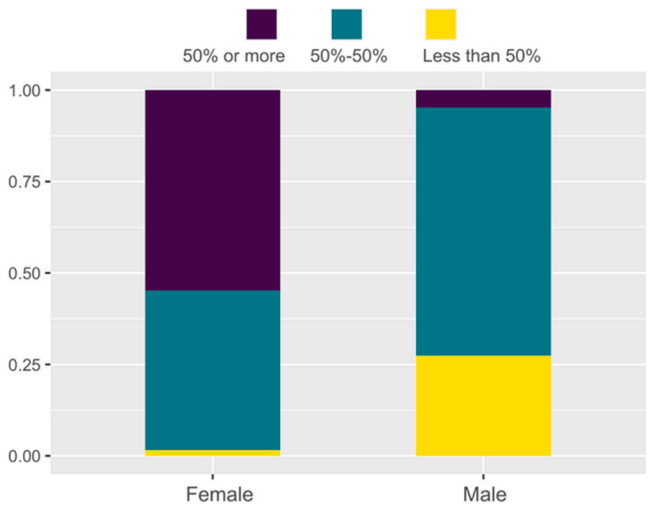


**Fig. 1. :** Percentage of female and male survey respondents with unpaid caregiving labor among Argentinian ecologists, who reported to share those responsibilities evenly with their partner (purple), take charge of more than 50% of the responsibilities of caregiving (green), or take charge of less than 50% of their corresponding responsibilities (yellow). Female respondents take charge of over 50% of caregiving responsibilities much more frequently than their male counterparts, while men respond more frequently that they take charge of less than 50% of the shared responsibility.

from the other combinations of gender and caregiving responsibilities. For the other proxy used (Fig. 2), the amount of time dedicated to tasks other than work, we saw that, while doing home office, researchers with higher caregiving duties tend to occupy more than one hour of work time on unpaid domestic work, while researchers with less or no caregiving duties tend to occupy less than one hour to no time at all, more often than expected by chance (Chi-squared = 18.04, $df = 4$, $P = 0.0012$) (Table 1). While working from the office, there is no statistical difference in the time invested in unpaid domestic work among researchers with different caregiving duties (Chi-squared = 7.52, $df = 4$, $P = 0.111$), nor between men and women (Chi-squared = 11.68, $df = 10$, $P = 0.31$) (for frequencies and deviations from expected under independence, see Table 2). When working from home, however, women with a heavy load of caregiving duties dedicate more time to unpaid domestic work during paid work hours than any other gender-caregiving category (Chi squared = 24.7, $df = 8$, $P = 0.0017$). Women with no caregiving responsibilities at all reported dedicating the lowest amount of time to unpaid domestic work (Table 3).

When considering number of publications as first author in peer-reviewed journals as a proxy of performance, we found that for PhD and Postdoctoral Fellows (PPF) the number of publications is not independent of the burden of unpaid caregiving work ($F = 8.04$, $df = 2$, $P = 0.0005$). Fellows with the highest burden show less publications than those with a lower burden (mean = 2.93 vs. 5.14, respectively). Unexpectedly, fellows with no unpaid caregiving work at all show the lowest number of publications (mean = 1.63) (Table 4). For Early Career Researchers (ECR) and Senior Researchers (SR), we found that performance was independent of the amount of unpaid caregiving work (ECR: $F = 0.78$, $df = 2$, $P = 0.4615$, Table 5; SR: $F = 1.24$, $df = 2$, $P = 0.2971$, Table 6). When we consider gender, there are significant differences in the mean number of publications between women (1.71) and men (3.4) only for PPF ($t = -2.2$, $df = 33$, $P = 0.04$). Women and men in the ECR and SR categories, show a similar trend to PPF although not significant (ECR: mean = 8.67 total papers for women, 9.95 for men, $t = -1.01$, $df = 58$, $P = 0.32$; SR: mean = 23.17 for women, 33.52 for men, $t = -1.53$, $df = 44$, $P = 0.13$). When we take into account the different levels of caregiving duties and gender, we found an effect for PhD and Postdoctoral Fellows ($F = 5.18$, $df = 4$, $P = 0.0007$). Men that take charge of


**Fig. 2. :** Divided into three caregiving categories, we looked at the amount of time that male and female researchers had to dedicate to domestic duties during their work day while working (A) from home and (B) from the office. Caregiving categories were as follows: took charge of 50% or more (50% or more) or of less than 50% (less than 50%) of their shared caregiving responsibilities, or had no caregiving responsibilities (no caregiving). The survey offered three categories of time dedicated to domestic work: one hour or more (>= 1 hour), less than one hour (< 1), no time at all (none). Only when working from home we saw that women spend more time in unpaid domestic work than men do. This difference does not exist when working from the office.

**Table 1**
Number of lost hours during home office as a function of level of unpaid general domestic labor. Absolute frequencies and deviations from what is expected under independence (in parenthesis). In columns: Level of dedication to unpaid caregiving labor.

| Work hours lost at home | Unpaid caregiving labor | | |
|---|---|---|---|
| | 50% or more | Less than 50% | None |
| One hour or more | 130 (10.85) | 12 (0.88) | 109 (-11.73) |
| Less than one hour | 15 (-13.01) | 2 (-0.61) | 42 (13.62) |
| Nothing | 5 (2.15) | 0 (-0.27) | 1 (-1.89) |

Pearson's chi-squared = 18.04; $df = 4$; $P = 0.0012$

**Table 2**
Number of lost hours while working from the office as a function of unpaid caregiving labor. Absolute frequencies and deviations from what is expected under independence (in parenthesis). In columns: Level of unpaid caregiving labor.

| Work hours lost at office | Unpaid caregiving labor | | |
|---|---|---|---|
| | 50% or more | Less than 50% | None |
| One hour or more | 63 (4.62) | 10 (3.28) | 48 (-7.9) |
| Less than one hour | 75 (-3.16) | 9 (0) | 78 (3.16) |
| Nothing | 27 (-1.46) | 0 (-3.28) | 32 (4.74) |

Pearson's chi-squared = 7.52; $df = 4$; $P = 0.1108$

less than 50% of caregiving responsibilities published the most (5.14), followed closely by men that evenly share the responsibilities (4.40), and by women that take charge of 50% or more of caregiving responsibilities (2.61). Also unexpectedly, the lowest numbers of papers are reported by men and women without unpaid caregiving work (2.44 and 1.44, respectively). We did not find such differences amongst researchers (ECR: $F = 0.79$, $df = 5$, $P = 0.556$; SR: $F = 1.27$, $df = 4$, $P = 0.296$).

For our third question, we found that the age at which researchers start the different categories in CONICET is not a function of the level of unpaid caregiving work (Fig. 3A). We considered there was no need to analyze these data statistically as they show no pattern in relation to level of caregiving responsibility. However, the age at which researchers start the different categories in CONICET is associated with gender (Fig. 3B). Women start as PPF younger than men do ($H = 4.562$, $df = 1$, $P = 0.033$) while we found no significant differences for the other categories (ECR: $H = 0.166$, $df = 1$, $P = 0.684$; SR: $H = 0.00007$, $df = 1$, $P = 0.993$). Statistical analyses were performed using the three categories described earlier (PPF, ECR, and SR) to have enough data in each category and to minimize the number of pairwise comparisons. However, in Fig. 3B we graphed all CONICET categories to visualize the data more clearly, and we see that for the first three categories of CONICET, women tend to start earlier than men, and the trend seems to revert in the last three categories.

Results related to our fourth question, regarding self-perception of capacity to carry on their own career, show that 70% of respondents categorized themselves as average in comparison with their colleagues. The number of publications explained self-perception of academic

**Table 3**
Number of lost hours during home office, as a function of gender and unpaid caregiving labor. Absolute frequencies and deviations from what is expected under independence (in parenthesis). In columns: Gender and level of unpaid caregiving labor.

| Work hours lost at home | Gender and unpaid caregiving labor | | | | |
|---|---|---|---|---|---|
| | Women 50% or more | Women None | Men 50% or more | Men Less than 50% | Men None |
| One hour or more | 95 | 75 | 35 | 12 | 34 |
| | (7.63) | (-8.4) | (3.23) | (0.88) | (-3.33) |
| Less than one hour | 13 | 30 | 2 | 2 | 12 |
| | (-7.54) | (10.4) | (-5.47) | (-0.61) | (3.22) |
| Nothing | 2 | 0 | 3 | 0 | 1 |
| | (-0.09) | (-1.99) | (2.24) | (-0.27) | (0.11) |

Pearson's chi-squared = 24.7; $df = 8$; $P = 0.0017$

**Table 4**
LSD Fisher tests for numbers of published papers as a function of unpaid caregiving labor (UCL) for PhD and Postdoctoral Fellows (alfa = 0.05, *LSD* = 1.79487, error: 6.5261, *df*: 127). Means with a common letter are not significantly different (p > 0.05). *LSD*: least significant difference; *SE*: standard error.

| UCL | Mean | *N* | *SE* | Group |
|---|---|---|---|---|
| None | 1.63 | 95 | 0.26 | A |
| 50% or more | 2.93 | 28 | 0.48 | B |
| Less than 50% | 5.14 | 7 | 0.97 | C |

**Table 5**
LSD Fisher tests for numbers of published papers as a function of unpaid caregiving labor (UCL) for Early Career Researchers (alfa = 0.05, *LSD* = 4.12187, error: 36.0261, *df*: 143). Means with a common letter are not significantly different (p > 0.05). *LSD*: least significant difference; *SE*: standard error.

| UCL | Mean | *N* | *SE* | Group |
|---|---|---|---|---|
| None | 6.29 | 7 | 2.27 | A |
| 50% or more | 9.11 | 35 | 1.01 | A |
| Less than 50% | 9.2 | 104 | 0.59 | A |

performance for male and female researchers (Table 7). When analyzed by gender, the probability that a woman researcher classified her capacity as below average, or average, was higher than that for men with equal productivity (Fig. 4A and B, Table 7). Instead, the probability that a male researcher classified himself above average was higher than that for women (Fig. 4C). The model predicts that the probability of an individual with 50 publications to self-evaluate as "lower than their peers" would be 6.3% for women but 4.4% for men. Self-classifying as "average" would be 69% being a woman and 61.4% being a man, and as "higher than their peers" would be 24.7% and 34.2% respectively.

When we analyzed the choice of academic referents in their field of studies, of a total of 1202 referents named by respondents, 81% were men and a 19% were women (Chi-squared = 37.122, $df = 1$, $P < 0.0001$). Of the referents chosen by female respondents (807), 24% were women, and this percentage was even lower for male respondents (8%) (Fig. 5A). Similarly, male advisers were a lot more common than female advisers (Fig. 5B). When data were partitioned in different categories of researchers, the largest proportion of female advisers was found among current Doctoral and Postdoctoral Fellows, and the lowest among late career researchers (Chi-squared = 11.729, $df = 2$, $P = 0.003$) (Fig. 5B).

**Table 6**
LSD Fisher tests for numbers of published papers as a function of unpaid caregiving labor (UCL) for Senior Researchers (alfa = 0.05, *LSD* = 22.88491, error: 679.9750, *df*: 49). Means with a common letter are not significantly different (p > 0.05). *LSD*: least significant difference; *SE*: standard error.

| UCL | Mean | *N* | *SE* | Group |
|---|---|---|---|---|
| None | 23.31 | 26 | 5.11 | A |
| 50% or more | 32 | 5 | 11.66 | A |
| Less than 50% | 35.19 | 21 | 5.69 | A |

Adviser gender is independent of advisee gender (PPF: Chi-squared = 0, $df = 1$, $P = 1$; ECR: Chi-squared = 1.314, $df = 1$, $P = 0.252$; SR: Chi-squared = 0, $df = 1$, $P = 1$; Fig. 5B).

For our fifth question, 67% of respondents indicated that family-related issues are perceived as negatively affecting academic performance. This was not significantly different between female and male researchers (family affects performance: women = 113 (69%), men = 46 (57%); family does not affect performance: women = 51 (31%), men = 35 (43%); Chi-squared = 2.98, $df = 1$, $P = 0.084$). However, when we partitioned data in different categories of researchers, results deviated from expectations by chance at the stage of ECR, where female researchers more frequently respond that their career is being affected by family-related issues (Chi-squared = 5.32, $df = 1$, $P = 0.02$; Fig. 6A). Results for PPF and SR are not significant (PPF: Chi-squared = 0.86, $df = 1$, $P = 0.35$; SR: Chi-squared = 0.04, $df = 1$, $P = 0.30$). When we analyzed the reciprocal effect of career on family plans, again, results are significant for ECR, where most researchers, especially female, answered that their career had a negative effect on their family plans (Chi-squared = 5.95, $df = 1$, $P = 0.01$; Fig. 6B). Instead, PPF and SR showed no significant results (PPF: Chi-squared = 3.35, $df = 1$, $P = 0.07$; SR: Chi-squared = 0.58, $df = 1$, $P = 0.44$).

Regarding our sixth question, 233 people responded that they felt their advisers were supportive (67%), 70 felt their advisers had a neutral attitude (20%), and 37 said they were unsupportive (13%). We found no effect of gender, neither of the respondent (Chi-squared = 0.53404, $df = 2$, $P = 0.7657$) nor of the adviser (Chi-squared = 1.074, $df = 2$, $P = 0.5845$); and no effect of the level of caregiving duties (Chi-squared = 3.3353, $df$ = NA, $P = 0.5172$).

## 4. Discussion

As an intellectual activity, doing science demands several hours of uninterrupted concentration for quality scientific production. We show that caregiving, and other types of unpaid domestic work, affect the possibility to dedicate fully and exclusively to work during a workday. If we were to quantify a scientist's scientific productivity, we should consider only the time that they can dedicate exclusively and freely to scientific research (something like "achievement relative to opportunities" –ARO- from the University of South Wales (Johnston, 2020)). Otherwise, there is no fair measure of that scientist's merits. We show that it is not just a gender problem, in general, nor it is a problem of presence/absence of caregiving responsibility: it is the level of dedication to such unpaid labor that reflects on the ability to fully dedicate quality (i.e., uninterrupted) time to remunerated scientific work. Although men and women with a high load of caregiving labor are equally affected in their capacity to work uninterruptedly, the community of female scientists will be, on average, more heavily affected than men because caregiving relies more heavily on women. Therefore, the distribution of unpaid family-related labor is not a "personal issue", as it drives the general pattern of gender disparities (Barrancos, 2011; Grosso et al., 2021). As long as women are the main caregivers, this issue belongs to the public domain, as it results in a gender bias and becomes an

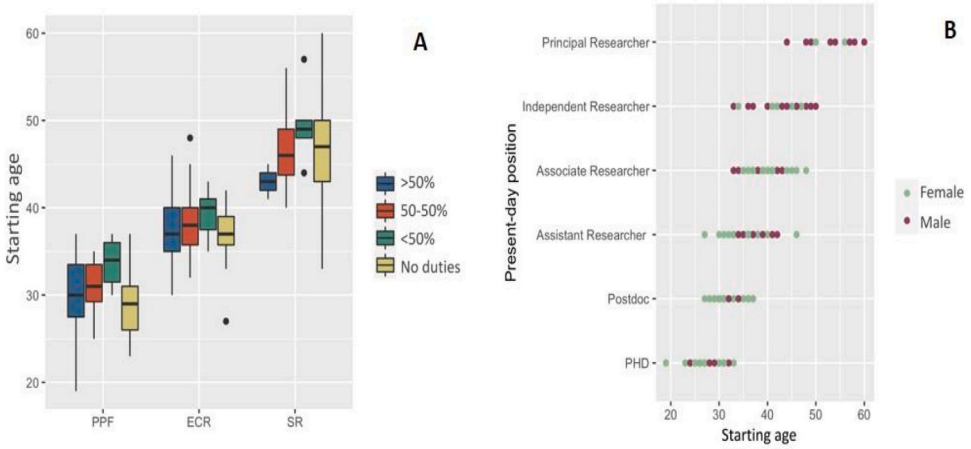


**Fig. 3.** Age at which Argentinian ecologists entered the CONICET category that they hold at present, according to level of unpaid caregiving work (A) or gender (B). A. PPF: PhD and Postdoctoral Fellows, ECR: Early Career Researchers, SR: Senior Researchers. Levels of unpaid caregiving work are as follows: researchers that take charge of more than 50% of the caregiving responsibilities in relation to their partners (blue); those who equitably share caregiving responsibilities (red); those who take charge of less than 50% of their corresponding responsibilities (green), and those with no unpaid caregiving work (yellow). B. Each dot represents one person that answered the survey. In green are women respondents, in purple male respondents.

**Table 7**
Multinomial logistic regression model results regarding self-perception of academic performance expressed as odd ratios (CI 95%). $N = 357$. Base category is "below average" self-perception of academic performance. $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

| Predictor | Category "as average" | Category "higher than average" |
|---|---|---|
| *N* publications | 1.06* (1.0–1.1) | 1.11***(1.04–1.1) |
| Female | 3.83*** (2.3–6.1) | 0.39*** (0.2–0.74) |
| Male | 4.9***(2.2–10.8) | 0.69 (0.26–1.8) |

obstacle for the advancement of women in science.

We found that women working from home are more distracted from scientific work by unpaid domestic labor than their male counterparts, yet while working from the office such a difference does not exist. This is especially relevant in the aftermath of the COVID-19 pandemic, and the idea that home-office is here to stay (Adekoya et al. 2022, Smite et al. 2023). However, our results show that at least in some fields of science, home-office may be inequitably productive for men and women. Public policies must help relieve all scientists, but especially women, from heavy unpaid caregiving labour and facilitate leaving their home space to detach from tasks related to domestic issues during work hours. Working from home may seem convenient, but it makes women's work tasks more difficult. Moreover, this agrees with studies showing that the lockdown during the 2020 and 2021 pandemic most probably took a greater toll on female than on male scientists (Cardel et al., 2020; King and Frederickson, 2021; Ruomeng et al., 2021). This will necessarily have consequences on the productivity of female scientists at present and, at least, in the mid-term, since the scientific work done (or not done) during the COVID19 pandemic will impact publications for at least two years after the pandemic was completely over and we were back to regular office work. This remains to be tested, as we have found no studies on the mid-term effects of the pandemic in differential productivity between men and women, or between having caregiving responsibilities or not. Hence, we urge authorities, academic leaders, funders, and scientific colleagues, to contemplate this fact when evaluating the performance of researchers with unpaid caregiving labor, especially women (Hassall et al. 2020). Even journal editors could add to the cause and make sure that the reviewers' and their own judgment of the manuscript under review is not gender-biased. In this sense, we also urge authorities to ensure an appropriate workplace environment for all academics, especially women, who need welcoming workplaces where they can detach from home-related tasks.

Despite the higher burden of caregiving labor on women, and the resulting limitation for uninterrupted work time, in general this did not reflect on differential productivity between genders. This suggests that women somehow overcompensate, and may be more productive than men on a per hour basis. However, among doctoral and postdoctoral fellows, those with the highest burden are less productive than those with a lower burden. Yet the lowest number of publications was reported by fellows without caregiving duties. This last observation may be an artifact caused by fellows that are just starting their research career and do not have caregiving duties, nor they have been in academia long enough to have many papers published. But this may also be a case of overcompensation and greater efficiency of people that do need to dedicate time to caregiving (Morgan et al., 2021). Given that caregiving requires a greater monetary investment, researchers with individuals under their care might feel more preoccupied with both maintaining their job and striving for promotions in their careers to increase their earnings. Overcompensation likely means extra energy allocated to paid work, adding up to the regular tasks of scientists. This results in extra-long journeys, as evidenced by a study by Mason and Goulden (2004), where academic women aged between 30 and 50 years old, with children, reported engaging in 101 h-long-weeks with reference to professional and domestic work. Contrastingly, men faculty with children reported an average of 88 hours per week, and men and women faculty without children, 78 hours. This may have consequences in the life quality of women with children in science. Following this reasoning, one might expect that mothers find academic jobs too strenuous and tend to drop out from academia more often than men or non-parent colleagues. Finer measures of scientific productivity reflecting quality of scientific research, not just quantity, may help us identify potential problems faced by scientists with family-related unpaid labor.

We acknowledge that using the number of first-authored papers in indexed journals as a proxy for scientific productivity has been widely questioned, as it pretends to be objective and emphasizes a supposed meritocracy. It is, at least, an incomplete measure of true productivity. Despite the fact that we are aware of the limitations, we used it because it is universal for all science systems, comparable among studies, readily reportable, objectively quantifiable, and hence, useful for an overall indicator of everyday scientific work. This proxy is still widely used in science systems throughout the world, and a factor by which most scientists still look upon for self-evaluation. Therefore, for now, this is a useful measure of productivity to answer our research questions. Meanwhile, we will continue to strive for a better and fairer measure of our contribution to society through science that privileges quality over

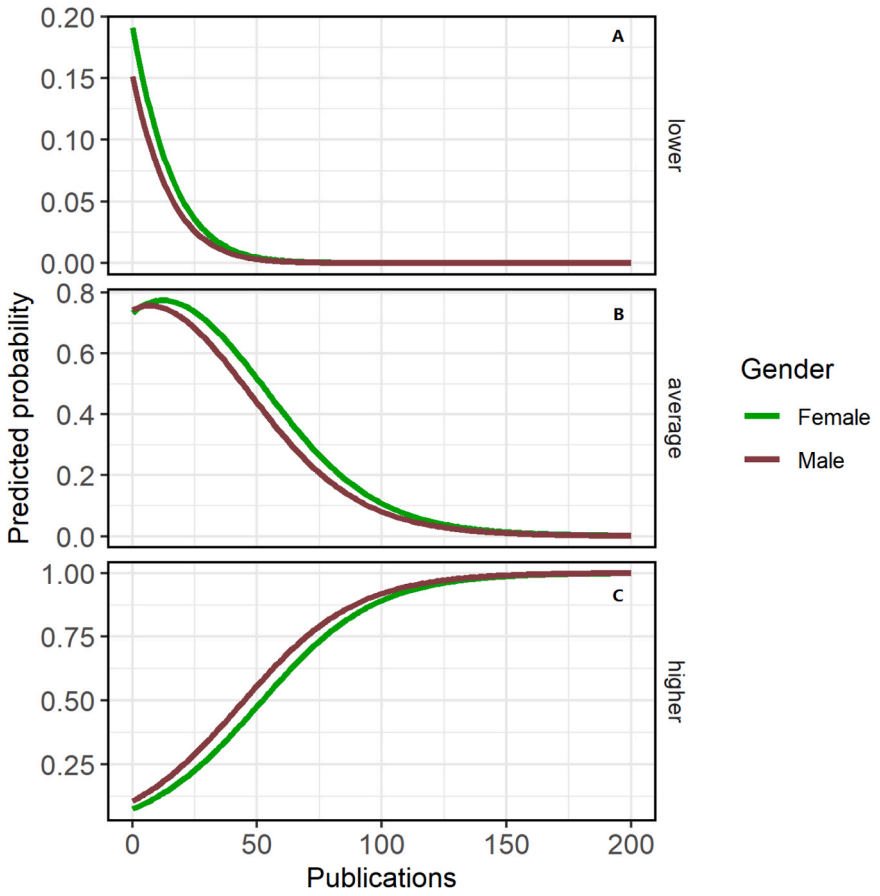


**Fig. 4.** Results of a multinomial test showing that the probability that a female researcher (green lines) classifies her own capacity to carry out her career as below average (A) or average (B) in relation to fellow researchers, is higher than for males (purple), given equal numbers of published papers. Conversely, the probability that a woman classifies her own capacity as higher than average (C) is lower than that for men given equal numbers of published papers.

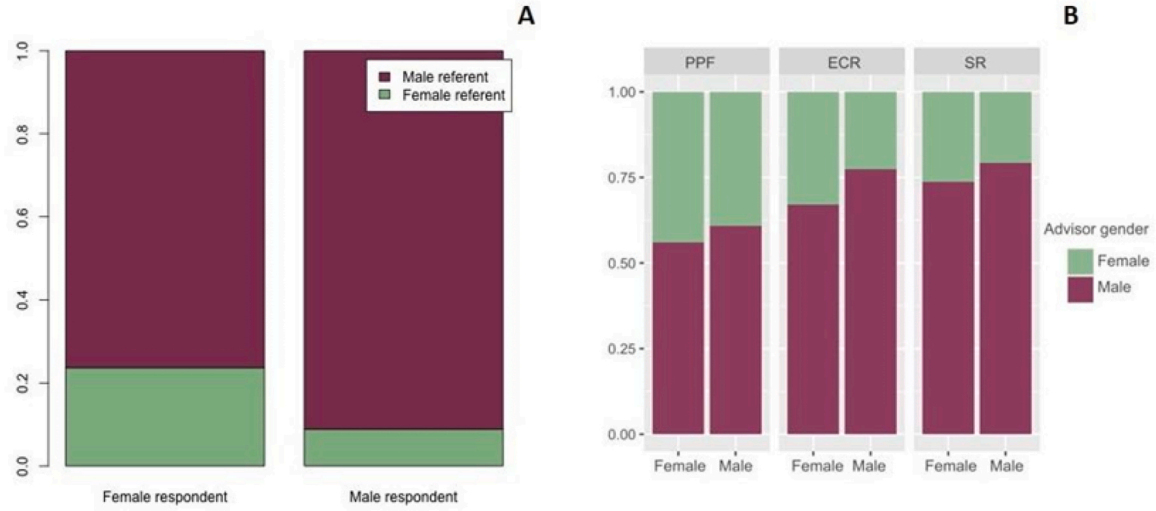


**Fig. 5.** Percentage of (A) female (green) and male (purple) referents in their field of study chosen by female (left) and male (right) respondents; and (B) female (green) and male (purple) advisers chosen by female and male respondents while doing their PhDs. Respondents at present were PhD and Postdoc fellows (PPF), Early Career Researchers (ECR), or Senior Researchers (SR).

quantity, and in turn, hopefully changes the way we judge our own performance.

Two other attention-worthy trends emerge from our results: the percentage of women researchers tends to decrease at higher categories in our study case, CONICET, and second, women tend to promote to higher categories at older ages than men. This pattern may result from two different mechanisms, which are not mutually exclusive: first, women may take longer than men to promote to higher categories and, second, women may quit their careers earlier than men. While a lower retirement age for women (60) than for men (65) in Argentina might

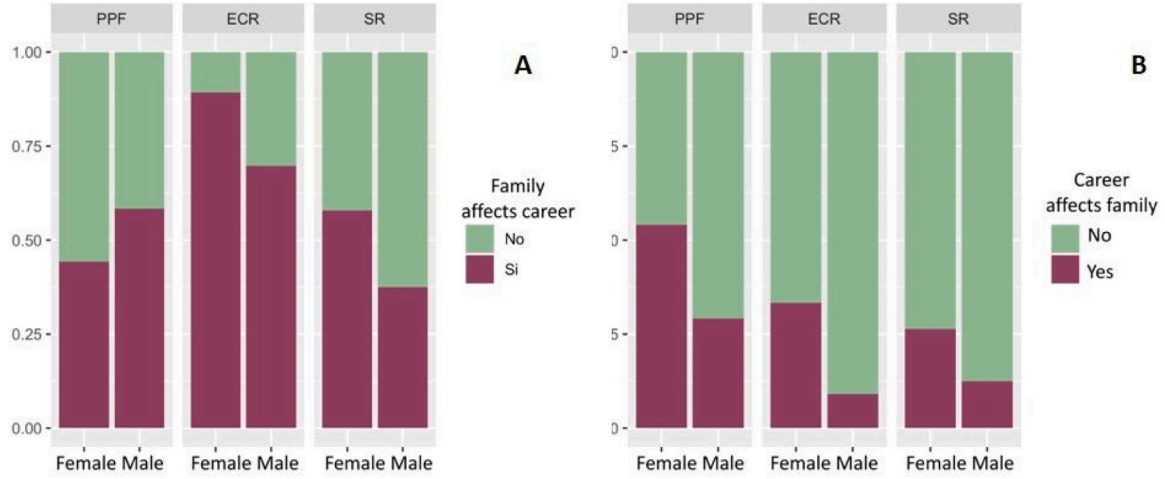


**Fig. 6.** Percentage of female and male respondents who perceive that their family plans affect their career (A), and that their career affects their plans to have a family (B).

partially explain that women do not reach higher positions as often as men do, this does not explain the pattern completely because this pattern is evident from the last two categories reported, which are reached, on average, much younger than retirement age. Both potential mechanisms are noteworthy given that we also see that women are generally not less productive than men. All these potential scenarios of career development, are unfavorable for women ecologists and, concomitantly, harmful for any scientific system. If women are retiring while in lower categories than men, they will do so with lower average retirement wages than men who, on average, reach higher positions in their careers. Moreover, if women quit early, we are facing a leaky-pipeline phenomenon. It is important to inquire further into the mechanism responsible for there being less women in the higher categories, so authorities can design policies to prevent it. In any case, either or all of the mentioned situations may occur, and it may have serious implications for the economic independence of women embarking in a scientific career.

Researchers that answered our survey, regardless of gender, do not seem to value women's academic work as highly as men's. Moreover, women seem to undervalue their own work performance in relation to men with similar performance metrics. This may reflect the imposter syndrome (Clance and Imes, 1978; Hawley, 2019) in Argentinian women ecologists, where women feel inadequate for their tasks, and unworthy of their achievements. In this frame, women may have to work harder to prove that they are capable and have equivalent expertise as men do. The expectation of excelling academic performance in a highly demanding environment on women may result in a low capacity to objectively judge the value of their own work. Having the extra burden of unpaid caregiving work, most likely worsens the situation. The absence of institutional recognition can have an impact on how women's competence and their contributions to science are perceived. This, in turn, affects how women view themselves and value their own work. In fact, bias against the competence of women and their contributions to science is likely the underlying systemic cause of imposter syndrome. Rather than solely framing the insecurities experienced by individuals from marginalized groups as an internal (personal) issue, it has been emphasized that future research needs to consider the significant role of the environment in triggering their perception of being imposters (Feenstra et al., 2020).

PhD fellows more often have male than female advisers, and researchers in general pointed more frequently to male referents than to female referents in their field of expertise. We can think of two potential reasons for this pattern. One is that researchers value the work and trajectory of male researchers more than that of female researchers, at least in the field of Ecology in Argentina, but likely more broadly. Another reason may be that there are just more men to choose from in advanced stages of the research career. We cannot rule out that possibility because we did not find a way to quantify the Universe of female versus male researchers to choose from. So, the mechanism behind this pattern might be a combination of historical availability and preference, as women respondents do tend to have slightly more women as advisors and as referents. It is encouraging that present-day doctoral and post-doctoral fellows chose proportionally more female advisors than did early-career and senior researchers when they did their PhDs. This, again, may be explained by two different scenarios: either today's students value women's academic performance more than early career and senior researchers did when they did their PhDs, or there are more women available to choose from. Both are encouraging as they may show a trend towards greater equity in the acknowledgement of the scientific trajectory of female and male ecologists.

It is expected and desirable that someone who chooses to form a traditional family can find an equilibrium with a successful career in science. But this does not seem equally achievable for men and for women. Women faculty have lower rates of marriage (Perna, 2001; Mason and Goulden, 2004), especially among higher-ranked researchers (Franchi et al., 2008), and tend to have fewer children or dependents in the household than men faculty. They also have children at older average ages than non-scientists, a difference that is greater than for male scientists (Morgan et al., 2021). Specifically, CONICET has an equal percentage of married women and men in the lower two categories of CONICET researchers, but only 40% of women in the third category (Independent Researcher) tend to be married, in comparison to 70% of men (Franchi et al., 2008). Although the mechanism that explains these data is not clear, authors report that interviews with female researchers suggest that they decided not to form a family in order to respond to their high work-related demands (Franchi et al., 2008). Although our results show that most researchers did not perceive conflict between family and career plans, female researchers seem to feel more strongly that their career is, indeed, affected by family, at the early stages of their scientific career. The reverse is also true: women at early stages of their career consider that their family plans are indeed affected by their career. This may be explained by the fact that women have a shorter window of opportunity for having children (assuming that family plans include having children) in relation to their biological possibilities. Also, it may be that men do not face the dilemma between having a family or a successful career because they do not suffer as much as women the difficulties of having a family and the associated unpaid labor that comes with it. Higher-ranked researchers did not report such concern,

which may be explained by three possible scenarios: 1. that younger researchers today are more aware that they have a right to have a prosperous career and to form a family, 2. that people in later stages of their career no longer remember the pressure back when they were forming a family, and/or 3. they were not as focused on the apparent dilemma as we are today.

It is relevant to say that in Argentina, as in many Latin American countries, maternity leave for researchers is only 100 days-long, which we all know is short compared to the length of time that a parent's life is affected (i.e., their capacity to return to full dedication to their paid job) after a child is born. Moreover, only women can take maternity leave, and will therefore suffer the effect of being absent from work for this time frame. In a fast-paced field as science, absence from the workplace due to maternity leave may lead to the exclusion of women from projects with application deadlines coinciding with their absence, or from field trips essential for collecting data for upcoming publications. Men in Latin America may not suffer such career penalties. This may explain, among other things, our results where women promote to higher categories in CONICET older than men do.

Finally, our finding that ecologists, regardless of gender, feel supported by their advisers when carrying family-related responsibilities is good news for Argentinian scientists and may help explain the higher women/male rates in the Argentine scientific system compared to other countries (de Kleijn et al., 2020). Yet we see a minority but important 30% of answers pointing to neutral or non-supportive advisers. An antagonistic, and even a neutral attitude to family-related matters from advisers, leads to a situation that we pointed out earlier: it results in the contrary effect of what is often claimed as meritocracy, because women with caregiving work do not part from the same start point as men in the same situation, or as anyone who does not have such extra labor. This is evidently a persistent issue that we should tackle to ensure the same rights and opportunities for people that do and do not have caregiving duties, be them female or male. It would be interesting to explore further whether identifying a negative interaction between caregiving and a successful career has to do with having a non-supportive adviser. This might be an important mechanism behind early drop-out by women in science. Public policies tending to support PhD students with unpaid family-related labor may help restrain these attitudes from advisers towards advisees and retain women in scientific careers.

Science institutions, be them public or private, should underpin researchers that have unpaid family-related labor, especially women, as they are the ones carrying most of the burden and, most probably, suffering the academic consequences. There should not be such a dilemma as having a family or a successful scientific career, especially when this dilemma is mostly faced by women. Evaluation processes in the sciences are not free of gender biases. Hence, to elaborate a new evaluation system, we cannot just propose a gender perspective to a system where gender inequities are an integral part (Acker, 1990). We also need to show better appreciation of the work of women scientists to create an appropriate environment for fulfillment of their potential. As mentioned by Pérez-Sedeño (2001), it is not just a matter of equity and justice: no society can afford to leave half of its population out of the development of the economy of knowledge. Furthermore, we need a more detailed study on the mid and long term effects of unpaid domestic labor in academic performance. The burden of caring for children or adults should be more explicitly and more justly recognized when evaluating a researcher's performance or when assessing the possibility of a career promotion. Equity will not come naturally; we need to continue to intervene in order to achieve a truly equitable work environment in the sciences (Cardel et al., 2020, Segovia Salcedo, 2021). This will only be achieved with public policies that take into account the differential requirements of scientists of different genders that are in charge of caregiving tasks related to social reproduction.

## 5. Conclusions

Our results show that Argentinian women ecologists are mostly in charge of unpaid domestic and caregiving labor, which, in general, seems to disrupt their advance in a scientific career. Therefore, it comes as no surprise that women consider having a family as an obstacle to their scientific careers, and their careers as disturbing family life, more so than their male counterparts. That may not be independent of the fact that scientists judge their own performance differently depending on their gender. Women underestimate themselves more than men do, which may be the result of historical bias and stereotypes. Scientists, regardless of their gender, also seem to assess women's academic trajectories worse than men's. The specific goal of the present paper is to make these results visible to our colleagues, as the patterns were quantified for Argentinian ecologists but are most likely applicable to various other scientific disciplines with heavy loads of field, lab, and office work. This must alert our colleagues about the obstacles that women in the sciences still face at present. We hope our results can, in turn, stimulate more revolutionary studies in the future: beyond visualizing the problem, we need to proactively work, as a community, towards a truly equitable system that incorporates these gender biases into the evaluation system, incorporating the great diversity of scientists that exists out there. At the very least, we must embrace the differential requirements of those that must attend caregiving tasks. Only then, will we engage in the true "domestic revolution", as named by Dora Barrancos (Barrancos, 2011), where we break with the social mandate of dividing the public sphere for men and the protection of the domestic sphere for women. That way, perhaps women will achieve complete citizenship (Barrancos, 2011) and we will be able to prevent people's personal choices, or situations, from becoming burdens to their scientific careers.

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## CRediT authorship contribution statement

**Marisa Alvarez:** Writing – review & editing, Formal analysis, Conceptualization. **Valeria Aschero:** Writing – review & editing, Methodology, Formal analysis. **Verónica Chillo:** Writing – review & editing, Investigation, Formal analysis. **María Gabriela Núñez-Montellano:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **María Piquer-Rodríguez:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Natalia Schroeder:** Writing – review & editing, Methodology, Formal analysis. **María Leonor Sandoval-Salinas:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lucía Zarbá:** Writing – review & editing, Methodology, Formal analysis. **Gabriela Fontanarrosa:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Edgardo Pero:** Writing – review & editing, Formal analysis. **Silvia Beatriz Lomascolo:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **María Daniela Rodríguez:** Writing – review & editing, Formal analysis. **Agustina Novillo:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **María Elisa Fanjul:** Writing – review & editing, Formal analysis. **María Fernanda Martínez-Gálvez:** Writing – review & editing, Formal analysis.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data Availability

Our data are available as Supplementary material for this manuscript.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.foreco.2024.121801.

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