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# Scientific impact of Chilean-based animal behavioralists is positively associated with co-authorships from developed countries, high impact factor journals, but not with gender

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## Abstract

**Background** Previous bibliometric studies in scientific researchers from developed countries generally support that sharing efforts during research enhances productivity and impact and suggest these effects may be important for researchers from less developed countries exhibiting more exiguous science budgets. We examined whether researchers in the field of animal behavior in an economically less developed country compensate for this burden by collaborating with researchers from developed countries, and whether this effect is gender specific.

**Methods** We quantified collaborations of 30 Chilean-based focal animal behavioralists with peers from developed countries based on co-authorships within 664 animal behavior papers. We examined whether the mean number, or mean proportion of such co-authorships was positively associated with productivity (number of research papers) and impact (*h*-index, citations per research paper) when gender, author role (i.e., first or corresponding author), and other covariates were considered. We complemented these analyses with a survey to focal researchers to estimate the perceived relevance of collaborations with peers from developed countries.

**Results** The *h*-index, but not the number of animal behavior papers published by focal researchers, increased with the mean number (but not with the mean proportion) of international co-authors from developed countries, an effect not gender-specific, but that supported the perceived importance of collaborations with peers from developed countries. The number of papers and the individual impact of focal researchers increased with academic age. The number of citations of individual papers increased with journal impact factor, year since publication, but not with the role (first or corresponding author) played by collaborators from developed countries.

**Conclusions** Our bibliometric and survey-based approach supported that establishing collaborations with researchers from developed countries and publishing in high impact factor journals are correlated with the career-long impact of Chilean-based animal behavioralists, and that this association is not contingent on gender, or influenced by the role (first or corresponding author) played by collaborators.

**Keywords** Behavioral ecology, International collaborations, *h*-index, Gender, Academic age, Journal impact factor, First authorship, Corresponding role

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## Introduction

Increasing evidence indicates that the establishment of collaboration networks enhances the productivity and impact of academic researchers [1–4]. For instance, the progression of the academic career of researchers in the field of animal behavior and its interface with evolutionary biology is enhanced by the size of their network of collaborators [5]. These positive consequences likely root in a diversity of factors emerging from collaborations, such as access to different expertise, funding, or exchange of ideas [2, 6, 7]. As a result, collaboration networks have increased globally in research communities [8–10].

Highly relevant, the context of collaborations based on the country of affiliation of co-authors seems to modulate emerging benefits [11]. International co-authorships have been associated with the highest positive effects on the impact of publications (based on citations) compared with domestic (or national) co-authorships in the research communities of economically developed countries such as Finland [12], Hungary [13–15], Germany [16, 17], United Kingdom [14, 18], the United States [14], or across countries [19]. Similarly, an examination of different academic disciplines within the Polish research community indicates that productivity, i.e., research papers published, is positively associated with international research collaboration [20]. Thus, although some studies suggest no effects [21], most available evidence generally is supportive of positive effects of international collaborations on main research outputs.

Despite available studies [11], relatively less is known about how international collaboration based on co-authorships enhances the scientific output and career progression of researchers from relatively less developed countries, such as those from the Latin American region. The consolidation and advancement of the scientific and academic career seem to be more challenging in this region due to a shortage of collaborators and a lack of adequate infrastructure driven by a reduced financial budget [22–24]. Latin American countries allocate a relatively small proportion of their gross domestic budget to Research and Development compared with the average (2.71%) of the currently 37 member countries of the OECD. Thus, estimates for Colombia (0.29), Mexico (0.30), Chile (0.34), and Argentina (0.52) are all well below the average (2.71%) of the currently 37 member countries of the OECD (<https://www.oecd.org/> accessed 24–07-2023). The observation that measures of gross expenditure in Research and Development or Domestic Product in Latin America correlates positively with the impact of scientific publications [25] suggests that researchers from this region face major constraints to scientific

development. However, researchers of these less developed countries may compensate for these constraints by establishing collaborations with peers from developed countries [e.g., [26]. Evidence based on the Brazilian research community is preliminarily consistent with this hypothesis. Research articles with international co-authorships attain a higher level of citation impact than papers with domestic authors exclusively [27], and the nine most cited Brazilian scientists collaborate with researchers affiliated with developed and English-speaking countries [28].

The first main aim of our study was to examine the role of international collaborations with researchers affiliated with institutions in developed countries in scooping productivity and impact of researchers residing in less developed countries. To do so, and based on our academic interest, we conducted a bibliometric search on the Chilean research community whose focus of study includes animal behavior (or behavioral ecology, ethology). Peer-reviewed publications in the mainstream journal “Animal Behaviour” increased steadily from the late sixties through the early 2000s, a trend mainly driven by researchers based in North America and Western Europe compared with researchers from less developed regions such as Latin America [29]. While the number of research papers produced on animal behavior by Latin-American [22] and Chilean-based researchers mirrored these trends [30, 31], research in this field seems relatively less developed in Chile. Specifically, the field of animal behavior remains less visible compared with ecology. Fewer animal behavioralists are internationally recognized or achieving high impact [32, 33], and graduate and undergraduate teaching courses in animal behavior are rare [34].

It is well known that gender is an important factor driving productivity and impact of researchers in science [35, 36]. Thus, we further examined whether establishing international collaborations for Chilean animal behavioralists enhances the careers of women and men scholars differently. The establishment of international collaborations in developed countries are affected by the researcher’s gender [2, 37]. For instance, women researchers tend to establish fewer international collaborations than men in Italy [38], but this is different in Norway when the field of research is considered [39]. In contrast, women researchers in animal behavior (or behavioral ecology) are slower and less likely to become principal investigators, have fewer collaborators, and publish fewer papers than men peers [5]. Therefore, our second aim was to determine how the putative effects of international collaborations may be different in woman and man animal behavioralists.

## Methods

We examined women and men researchers who developed all or a proportion of their scientific careers in Chile regardless of their citizenship, where they attained their PhD (i.e., “Chilean-based researchers”), and whose research questions addressed mechanisms, development, function, and/or evolution of behavioral traits. We accomplished this aim through the following steps. First, we considered an exhaustive review of 2110 journal articles published from 1940 through 2019 built to examine the diversity of research topics addressed in animal behavior on Chilean native species [31]. We retrieved these publications from Web of Science (WoS, managed by Clarivate) by means of using combinations of keywords (“Chile”, “chile#”, scientific name of taxa, “behavior”, “social behavior”, “mating”, “communication”, “hormone”, “reproduction”, “competition”) both in Spanish and English. Second, we used the previous information to extract a listing of Chilean based researchers who stated animal behavior and related topics as part of their research interests and skills. To do so, we consulted profiles potentially held by each researcher in their institutional, Google Scholar (GS), and Research Gate (RG) sites to verify the main disciplines and skills declared. Based on this information, we built a list of 30 (11 women and 19 men) Chilean-based focal researchers. Of these,  $n=11$  used animal behavior, behavior, or behavioral ecology terms as descriptors of their main disciplines, and  $n=9$  used these terms as declared skills. To that, we added researchers who used relatively more specific descriptors for main disciplines such as Animal Communication, Behavioral Endocrinology, and Neuroethology ( $n=4$ ), Animal Well-being ( $n=1$ ), Entomology ( $n=1$ ), Ecology and/or Evolution ( $n=3$ ), and Marine Biology ( $n=1$ ). The complete listing of Chilean-based animal behaviorists examined is provided in Electronic Supplementary Material #1.

Third, we searched in GS and WoS during January 2022 to retrieve all peer-reviewed research and review papers published by each focal scientist within the field of Animal Behavior irrespective of species examined. Thus, books, book chapters, dissertations, or other non-peer-reviewed reports were not included. We used the main objectives declared in each paper to classify them as being in the field of Animal Behavior or in other areas. We included a research paper as an animal behavior publication whenever aims declared by the authors fitted mechanisms (e.g., when addressing genetics, molecular, physiological aspects of behavior), development, function, or evolution of behavior, regardless of whether these were descriptive, correlational (including comparative), or experimental. We characterized each of these publications based on the following attributes: article age (years since publication through 2021), the 2021–2022 journal

impact factor based on WoS, and the number of citations reported by WoS and GS, which is a common measure of research impact (yet not perfect; see [40, 41]). Additionally, we extracted the number of international authors with affiliations to a selected list of developed countries (Australia, Canada, Japan, New Zealand, United States, and the following European countries: Austria, Belgium, Denmark, France, Finland, Germany, Greece, Iceland, The Netherlands, Italy, Norway, Portugal, Spain, Sweden, Switzerland, the Republic of Ireland, and the United Kingdom) at the time of publication, representing a proxy of research collaboration [42]. Whenever a co-author had more than one country of affiliation, we considered her(his) first stated affiliation. Additionally, we included the potential effect of motivation of collaborators by means of recording whether the corresponding author role or the first author position was held by a Chilean-based (domestic) author or by an international author affiliated to an institution in a developed or a less developed country.

We used the count of peer-reviewed research papers retrieved from GS and WoS to quantify the productivity of each focal researcher. Regarding impact, we retrieved the  $h$ -index reported by WoS (during January 2023) based on the total number of citations since the first publication in the field of animal behavior by each focal researcher. The  $h$ -index quantifies the number of  $h$  research papers cited at least  $h$  times [43]. Before doing so, we verified the existence of alternative GS and WoS research profiles of a researcher (e.g., Ebensperger LA, Ebensperger L), and if so, we fused them. We characterized each focal researcher based on the following attributes: gender (woman or man, based on first names and our direct knowledge of each) and academic age (years between the first and the last publication in animal behavior up to 2022). We used the count of international co-authors per research paper to compute the mean number and the mean proportion of international co-authors from developed countries for each focal researcher [e.g., [44]]. We opted not to use Ioannidis [45]’s measure for collaboration after verifying that the total number of publications produced was  $<30$  in 24 out of the 30 researchers examined.

## Survey to Chilean-based animal behaviorists

We conducted a survey with seven questions to quantify the perceived relevance given by the focal researchers to collaborations with peers from developed countries in advancing their research careers (Electronic Supplementary Material #2). Consulted benefits included enhanced success during funding applications, publication of research articles in international high impact journals, or in keeping an active research career. During mid-late

January 2022, we e-mailed an invitation to answer the survey to each of 10 women and 16 men focal researchers (i.e., after self-excluding two of us [AL, LAE], FV whose contact e-mail did not work, and JI-R who passed away during June 2021). Colleague researchers accepting the invitation were provided with an online link to answer anonymously the survey in the platform <https://www.surveio.com>, which was available during two months after receiving the invitation.

### Main predictions and statistical analysis

We predicted that productivity (prediction 1a) and impact (prediction 1b) of Chilean-based focal researchers increases with increasing number (or proportion) of co-authors from developed countries. We addressed these predictions by means of linear modeling. Specifically, we examined how the mean number (or mean proportion) of international co-authors from developed countries, academic age, and gender of focal researchers explained variation in the number of research articles published (prediction 1a: models 1 and 2 in Table S1 of Electronic Supplementary Material #3). For prediction 1b, we examined how the mean number (or mean proportion) of international co-authors from developed countries, academic age and gender of focal researchers explained variation in the *h*-index of focal researchers (models 3 and 4 in Table S1 of Electronic Supplementary Material #3). During these analyses, we needed to log-transform the number of research articles published and the *h*-index of focal researchers to achieve linearity. We verified that model assumptions were met, including Normality and homogeneity of residuals. These verifications revealed two men researchers with extremely high *h*-index and total number of publication values that were influential to model fit. Because these two researchers did not state Animal Behavior within their primary research interests, we excluded them from analyses of predictions 1a and 1b.

We further predicted that the impact of individual research paper based on the number of citations received reported on WoS (prediction 2a) and GS (prediction 2b) increases with increasing proportion of co-authors from developed countries. We addressed these predictions using generalized mixed effect models (models 5 and 6 in Table S1 of Electronic Supplementary Material #3, respectively) with a Negative Binomial error distribution and a log-link function to examine the number of citations per article. Thus, we examined how the number of citations per research paper was explained by the proportion of international co-authors, and other potential contributing factors, including gender of focal researcher, journal impact factor, publication age, and a proportion of international co-authors by gender of focal researcher factor interaction. We included the focal researcher

ID name as a random factor to account for statistical dependency among research papers within focal researchers.

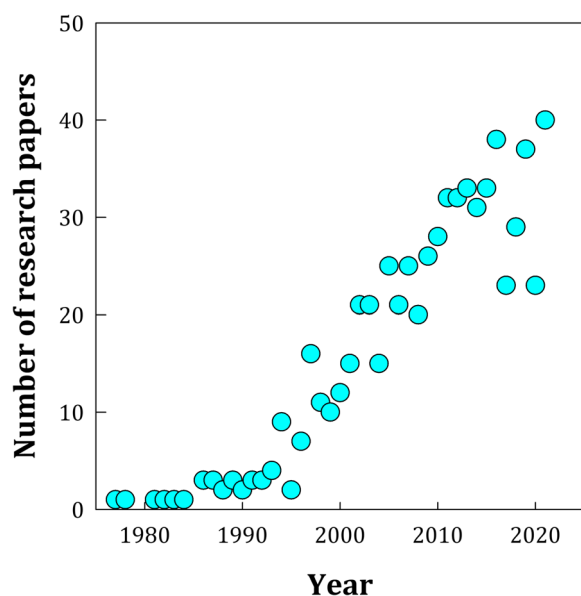
Finally, we predicted that research papers including co-authors from developed countries attain more citations whenever motivation of such co-authors increases (prediction 2c). Thus, we determined how the number of citations per research paper (based on WoS) was influenced by the role played by international co-authors during publication, either when being the first author (model 7 in Table S1 of Electronic Supplementary Material #3) and/or when holding the corresponding author role (model 8 in Table S1 of Electronic Supplementary Material #3).

All statistical analyses were performed in R 4.1.3 [46]. Response variables distributions were analyzed with *fitdistrplus* package 1.1–8 [47]. Generalized linear mixed models (GLMM) were fitted with the package *glmmTMB* 1.1.5 [48, 49] and we used the *DHARMA* package 0.4.6 [50] to confirm appropriate model fit and possible dispersion in residuals. We conducted model selection routines based on AICc values and AICc weights with the *MuMIn* 1.46.0 package [51, 52]. We verified variable inflation factor values in selected models with two or more continuous factors [53]. Finally, we reported pseudo marginal and pseudo conditional  $R^2$ -values as measures of goodness-fit for completeness [54].

### Results

The focal researchers who conducted animal behavior research in Chilean institutions published a total of 664 papers in the field of animal behavior between 1977 and 2021, and where the number of articles per year increased sharply from the mid-1990s (Fig. 1). These scientists published a mean (standard deviation; range) of 22.1 (21.5; 5–80) research articles in the field of Animal Behavior, which included 3.1 (2.4; 0–23) total co-authors per article. Of these co-authors, a mean number of 0.7 (1.7; 0–18) and a mean proportion of 0.1 (0.1; 0–0.5) were from developed countries. The academic age of these researchers averaged 19 (9.9) years and ranged from 8 to 42 years. The impact factor of researchers (*h*-index based on WoS) averaged 13.6 (12.1; 2–53) papers that were each cited at least 13 times. The impact factor of publications averaged 18.8 citations (21.8; 0–219 citations) based on WoS, and 27.0 citations (32.3; 0–331 citations) based on GS. The impact factor of journals (based on WoS) targeted by these researchers averaged 2.5 (1.2; 0.2–12.8).

In the context of hypothesis prediction 1a, the best model explaining variation in the log-transformed number of articles published by Chilean-based researchers included only a positive effect of academic age (sub-models 1.1 and 2.1 in Table S2 of Electronic Supplementary



**Fig. 1** Number of Animal Behavior research papers published per year since 1977 through 2021 by 30 focal researchers examined. A total of 664 papers were published

Material #3) (Table 1A, Fig. 2), and where the number of animal behavior papers of scholars increased in 0.02 log years for every 1% increase in academic age. Instead, neither the gender of focal researchers, the mean number nor the proportion of international co-authors from developed countries had an influence. Regarding prediction 1b, the best model explaining variation in the log-transformed *h*-index of focal researchers included positive effects of academic age and the mean number of international co-authors per article (sub-model 3.1 in Table S2 of Electronic Supplementary Material #3). Specifically, the *h*-index of scholars increased significantly in 0.03 log years for every 1% increase in academic age (Tables 1B and C, Fig. 3a), and in 0.43 log mean number of international co-authors per article for every 1% increase in the number of these co-authors (Table 1B, Fig. 3b), respectively. However, variation in the log-transformed *h*-index of focal researchers was not influenced by the mean proportion of co-authors from developed countries or by the gender of researchers (Table 1C; sub-model 4.1 in Table S2 of Electronic Supplementary Material #3). Based on two variants of models 1 and two variants of model 3 (Table S1 of Electronic Supplementary Material #3) we verified that the mean number of domestic or international co-authors from less developed countries did not influence the number of research publications or the *h*-index of focal researchers (not reported).

For hypothesis prediction 2a, the best model explaining variation in the number of citations per research article based on WoS included the journal impact factor

and article age (sub-model 5.1 in Table S2 of Electronic Supplementary Material #3), but no effects of gender, the proportion of international co-authors, or gender by proportion of international co-authors interaction. Specifically, the number of accumulated citations per article increased nonlinearly with the impact factor of the journal (Table 2, Fig. 4a), and with article age (Table 2, Fig. 4b). Similar findings were recorded when the number of citations per article was based on GS (prediction 2b) (sub-model 6.1 in Table S3, and Fig. S1a and S1b of Electronic Supplementary Material #3).

Regarding prediction 2c, a total of 245 research articles (out of the total = 664) had at least one international co-author. Of these, 92 included an author from a developed country as first author, 17 had an international author from less developed country as first author, and 136 had a Chilean-based first author. The corresponding role was held by an international coauthor from a developed country in 89 of the 245 articles, by an international author from a less developed country in 13 articles, and by a Chilean-based author in 143 articles. The best model explaining variation in the number of citations per research article based on WoS included the journal impact factor and article age (sub-model 7.1 in Table S2 of Electronic Supplementary Material #3), but no first authorship position or focal gender. Thus, the total number of citations per article increased nonlinearly with the impact factor of the journal and with article age (Table S4 of Electronic Supplementary Material #3, Fig. S2a and S2b), but not with first author type or focal gender. Similarly, we detected no additional effects of international authors from developed countries when holding the corresponding author role on the number of article citations based on WoS (sub-model 8.1 in Table S2, and Table S5 of Electronic Supplementary Material #3, Fig. S3a and S3b). After excluding 17 articles involving authors from less developed countries as first or corresponding authors, we found that first authorship and the corresponding role were positively associated when involving authors from developed countries ( $X^2=171.6$ , 1 d.f.,  $P<0.001$ ; Fig. S4 in Electronic Supplementary Material #3). Whenever authors based in developed countries were first authors, these were more likely to hold the corresponding author role.

Twenty out of the 26 (i.e., 77%) focal researchers contacted also answered the survey. Responses revealed that all have had collaborators from institutions in developed countries, mostly from the United States, and secondarily from Spain, United Kingdom, and Germany. Most focal researchers perceived that holding collaborations with peers from developed countries had positive effects in securing national or international extramural funds, in boosting the number of research papers produced,

**Table 1** Factors and their effects in best models predicting (A) the log-transformed total number of animal behavior papers authored (prediction 1a), and (B) the log-transformed *h*-index (prediction 1b) of Chilean-based focal researchers in the field of Animal Behavior. Predictors in best models are specified in Table S2 of Electronic Supplementary Material # 3 and resulted after fitting linear models to the number of research papers (model 1 and 2) and to log-transformed *h*-index values of focal researchers (models 3 and 4). A total of  $n = 28$  researchers were included in the analyses

**(A) Submodels 1.1 and 2.1**

**Coefficients**

	<b>Estimate</b>	<b>Standard error</b>	<b>t-value</b>	<b>p-value</b>
(Intercept)	0.76	0.09	8.27	< 0.05
Academic age	0.02	0.00	4.97	< 0.05
<b>Residual standard error</b>	0.25			
<b>R<sup>2</sup></b>	0.49			
<b>Adjusted R<sup>2</sup></b>	0.47			
<b>Degrees of freedom</b>	26			

**(B) Submodel 3.1**

**Coefficients**

	<b>Estimate</b>	<b>Standard error</b>	<b>t-value</b>	<b>p-value</b>
(Intercept)	1.38	0.25	5.45	< 0.05
Mean of international co-authors	0.43	0.16	2.79	< 0.05
Academic age	0.03	0.01	2.74	< 0.05
<b>Residual standard error</b>	0.52			
<b>R<sup>2</sup></b>	0.36			
<b>Adjusted R<sup>2</sup></b>	0.31			
<b>Degrees of freedom</b>	25			

**(C) Submodel 4.1**

**Coefficients**

	<b>Estimate</b>	<b>Standard error</b>	<b>t-value</b>	<b>p-value</b>
(Intercept)	1.49	0.27	5.51	< 0.05
Academic age	0.03	0.01	2.39	< 0.05
Mean proportion of international co-authors	1.69	0.94	1.81	0.08
<b>Residual standard error</b>	0.56			
<b>R<sup>2</sup></b>	0.26			
<b>Adjusted R<sup>2</sup></b>	0.20			
<b>Degrees of freedom</b>	25			

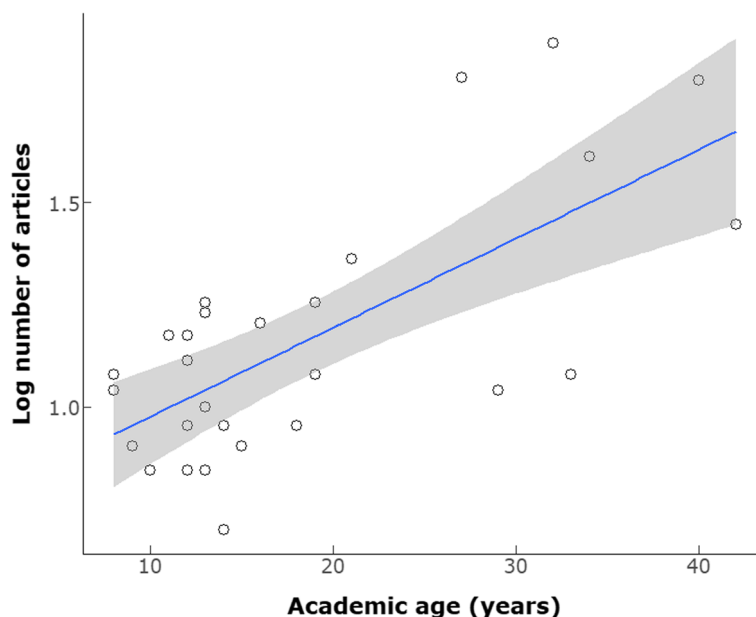
in successfully targeting higher-impact journals, and in increasing the chance of maintaining an active research program within their Chilean-based institution. Focal researchers also ranked high the alternative that establishing collaborations with peers from developed countries allows tackling questions that otherwise would not be possible (Table S1 in Electronic Supplementary Material #2).

## Discussion

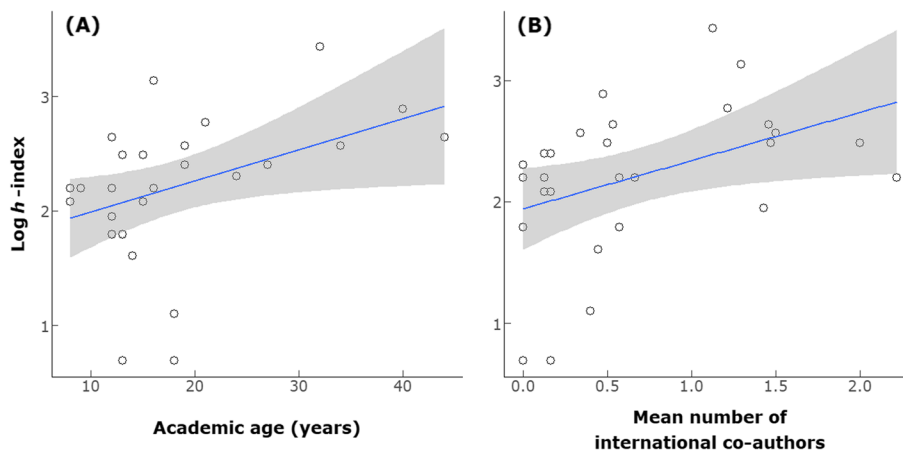
Our examination of 30 Chilean-based researchers in the field of animal behavior highlighted some factors associated with their productivity and impact. Focal researchers with longer academic careers were more productive, publishing more research articles, and attained higher impact, as revealed by relatively high *h*-values. These

measures of scientific productivity and impact were similar in women and men. We also recorded that the number of citations accumulated by researchers similarly increased with the mean number (but not with the mean proportion) of co-authors from developed countries, and that citations attained by research articles increased when these were published in higher impact journals, and with an increasing number of years since publication. However, the impact of individual articles was not influenced by the inclusion of co-authors from developed countries. Thus, our analyses provided some support to the hypothesis that international collaborations boost the research impact of Chilean-based animal behaviorists.

Previous studies from developed countries supported the positive effects of international collaboration on productivity and impact of publications [17,



**Fig. 2** Effect of academic age of focal researchers on the log-transformed number of articles published by focal researchers in the field of Animal Behavior. Dots represent observed data of a linear regression analysis, and the grey shadowed area highlight 95% confidence intervals. A total of 28 focal researchers served as replicates in the model



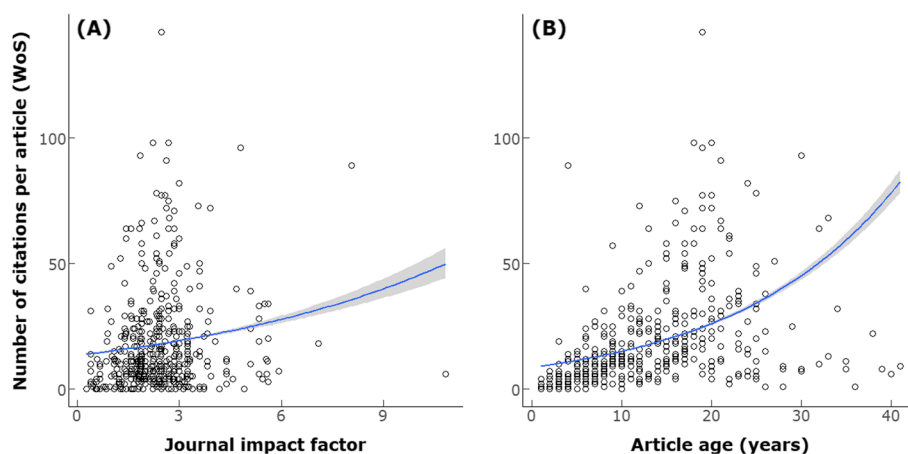
**Fig. 3** Effects of academic age (A) and of mean number of international co-authors in research articles (B) on the log-transformed *h*-index of focal researchers in the field of Animal Behavior. Dots represent observed data after conducting a linear regression analysis and the grey shadowed area highlight 95% confidence intervals. A total of 28 focal researchers served as replicates in the model

20, 55]. However, evidence from less developed countries may be research community specific. For instance, while networks of international collaboration in the field of Marine Biodiversity remain less developed in Latin America compared with those in countries of the European Union [56], Moya and Rau [57] noted that the most productive marine science researchers in four main research centers of Latin America target researchers affiliated to academic or research institutions of their own country as collaborators. Previously (1984–1998), Labra et al. [30] reported that animal behavior research papers

on studies conducted in Chile were more cited when all authors were affiliated to international institutions compared with papers by authors with Chilean affiliation, exclusively. Thus, Labra et al. [30] favored the establishment of academic links with foreign colleagues. Our findings based on a larger database revealed no effects by the proportion of co-authors from developed countries on individual research papers. However, we cannot rule out that this potential effect may be hidden by “intellectual” dependency among international collaborators within research papers. Multiple international co-authors with

**Table 2** Factors and their effects in best model predicting the number of citations attained by research papers published by Chilean-based focal researchers in the field of Animal Behavior (based on WoS). Akaike Information Criteria, Delta, and Weight values of best model 5.1 selected are specified in Table S2 of Electronic Supplementary Material # 3. Results were obtained through the application of generalized mixed models with focal researcher ID as a random factor. Model 5.1 had marginal and conditional  $R^2$  of 0.54 and 0.59, respectively. A total of 596 observations served as replicates

Random effects		Variance	Standard Deviation			
Focal ID		0.06	0.25			
Fixed effects		Estimate	Standard Error	Z value	P value	VIF
(Intercept)		0.79	0.13	5.93	< 0.05	
Journal impact factor		0.25	0.03	7.14	< 0.05	1.05
Article age		0.10	0.01	17.02	< 0.05	1.05



**Fig. 4** Effects of Journal impact factor (A) and years since publication, or article age (B) on the number of citations attained by individual research articles based on Web of Science (WoS). The model response was fitted to a negative binomial distribution, and where 95% confidence intervals are highlighted by the grey shadowed area. Dots represent 596 observations from 489 research articles published by 30 focal researchers examined

shared institutional (and “lab”) affiliations within a same research paper may inflate this number, and similarly so, the variance in impact factor of research papers.

On the other hand, we did find that the mean number of co-authors from developed countries enhances the impact of focal Chilean-based researchers (Fig. 3b), suggesting medium- to long-term benefits of these collaborations to researchers, but less so to individual papers, as stated before. Likely, focal researchers and their productivity accumulate additional citations from enhanced international visibility. This effect may result initially from readers quoting those presumably better-known international collaborators (i.e., program directors, or main authorities in specific research areas) and their publications co-authored with focal researchers. In this scenario, research programs of Chilean-based researchers and their publications may reach a wider audience and similarly achieve a higher impact, regardless of the affiliation of their collaborators. The extent to which

Chilean-based animal behaviorists conduct most of their research on local, and potentially less known model species or local populations of widely distributed species may further attract the scientific interest of international collaborators tackling similar questions. As a result, local scientific knowledge is enhanced, and existing theory is expanded and becomes more integrative [58, 59]. Contrary to previous studies [19, 60], we did not find evidence that international co-authors from developed countries increased citation of publications when being the first author or held the corresponding role. Thus, these aspects of researcher motivation do not seem a key element for busting the impact research career. Instead, research conducted may be of higher quality and organisms examined novel and challenge previous findings [58, 59]. The observation that first authorship and/or the corresponding role was held by authors from developed countries in 42% of 226 articles suggests that Chilean-based researchers likely led most of these collaborations.



The effect of gender on productivity and on impact of researchers generally are pervasive among developed countries (e.g., [2, 37, 61, 62]). For instance, research papers by women affiliated with research institutions in Quebec (Canada) sharing the same mean number of international co-authors, or that are published in similar impact factor journals, attain fewer citations than those of their men colleagues [62]. Results of our study on Chilean-based researchers in the field of animal behavior were similar to that conducted in the subfield of animal cognition in not revealing gender differences in productivity or impact [63]. However, the number of women ( $n=11$ ) included in our analyses represented a third of the total researchers examined, potentially implying that gender biases might characterize other aspects of academic career progression, including recruitment [64], retention [65], or promotion [66].

The observations that the number of articles published across Chilean-based researchers increased with academic age, and that the number of citations attained by individual research articles increased with article age (i.e., since year of publication) may seem unsurprising. However, we noticed that effects (based on estimates) of academic age (Tables 1A, B and C) and article age (Table 2) were relatively low compared with those of other significant predictors such as the mean number of international co-authors and the journal impact factor, potentially implying a relatively low pace in research productivity and impact by Chilean-based animal behavioralists. Contrasts with other research communities of animal behavioralists or of close research fields might be insightful in this context (e.g., [29, 56]). Our findings further revealed a positive influence of the journal impact factor on the number of citations attained by research papers, implying that targeting relatively higher-impact journals contributes to enhance visibility and impact of researchers. This finding departs from previous examinations supporting that the impact factor of journals generally is a weak predictor of the number of citations attained by individual papers and researchers [67, 68]. However, caution is needed because journal impact factors may not capture critical aspects such as research quality [69].

It seems tempting to state firm implications or recommendations based on the positive effects of international collaborations on impact to focal scientists [5, 17, 20]. However, effects may not only be community- and gender-specific [5], but also contingent on stages within the research career. For instance, relatively low levels of collaboration have also been associated with a higher probability of becoming principal investigator within research fields in developed countries [55]. Thus, the nature of effects of collaborations may vary across different steps within the academic career of researchers, and where

incentives placed by academic institutions for academic progression may potentially discourage international collaborations.

## Conclusions

We conducted a bibliometric study that targeted Chilean-based animal behavioralists. Findings supported that career-long measures of impact based on citations of research publications are positively associated with the number of coauthors from economically developed countries, with the journal impact factor of publications, but not with gender of focal researchers. Additionally, the number of citations of research publications was not associated with the role (first or corresponding author) played by collaborators from developed countries.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s40693-023-00121-5>.

**Additional file 1.** Electronic Supplementary Material #1.

**Additional file 2.** Electronic Supplementary Material #2.

**Additional file 3.** Electronic Supplementary Material #3.

## Acknowledgements

We dedicate this article to our beloved colleague and friend, Prof. Francisco Bozinovic, who sadly passed away much too early. "Pancho" not only contributed with high quality research in Animal Behavior, but also supported students, postdocs, and colleagues in this field. Additionally, we highlight that professors Joaquín Ipinza and Elizabeth Chiappa passed away during 2021 and 2022, respectively. We are indebted to Zuleyma Tang-Martínez for her encouragement to conduct this study, to two anonymous reviewers for providing useful suggestions on a previous version of this manuscript, and to all Chilean-based colleague researchers for contributing with scientifically novel and relevant animal behavior research papers, and for answering our invitation to complete the survey.

## Authors' contributions

L.E. and A.L. developed the general project idea, conceived, and designed the specific research questions and methods, retrieved the data from previous publications, designed and conducted the survey, and drafted the original manuscript. A.A.C. conducted the statistical analyses and provided editorial and content revisions. All authors interpreted the results, their implications, read and approved the final manuscript.

## Funding

L.A.E. acknowledges the funding provided by the Faculty of Biological Sciences to support a sabbatical leave and by the Fondo Nacional de Ciencia y Tecnología through grant #1210219. A.A.C. was supported by a doctoral fellowship from ANID Doctorado Nacional/2022 21222138.

## Availability of data and materials

The data set supporting the results will be made available upon reasonable request.

## Declarations

### Ethics approval and consent to participate

The survey and the procedure used to implement it was approved by the Scientific and Ethics Committee of Social Sciences, Arts, and Humanities at PUC, Protocol #211123003. Each colleague received an individual invitation to participate by means of answering anonymously the survey, and each had the option not to do so.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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Received: 4 April 2023 Accepted: 3 August 2023

Published online: 08 September 2023

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