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## The geographic bias of mammal studies: a comparison of a half a century of research on Palearctic and Neotropical mammals

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### ABSTRACT

**Introduction:** There are no studies that specifically compare research output of Palearctic and Neotropical mammalogy; such comparison would be useful for informed decisions in conservation and management.

**Objective:** To compare the scientific documents and citations about Palearctic and Neotropical mammals over half a century. **Methods:** We compared 50 years (1970-2019) of documents on 60 medium and large-sized (heavier than 1 kg) mammal species, in Scopus and the Web of Science (WoS) Core Collection, considering number of documents and four citation indicators at the species level (*h*-index, citation rate, total citations, and citations per year). **Results:** We retrieved 13 274 documents in Scopus and 12 913 in WoS. We found that Palearctic mammals have 3.77 times more documents than Neotropical species in Scopus (3.91 times in WoS), and that the documents recorded 5.95 more total citations in Scopus (6.93 times more in WoS). Palearctic documents also record more yearly citations and a higher *h*-index in both Scopus and WoS. Scopus retrieved more articles for Neotropical species (2782 vs. 2631 in WoS) and had more citations (28 120 vs. 24 977 in WoS); differences for the citation indicators between regions were marker in WoS. The *h*-index and total citations are greatly affected by how many studies are published, i.e. the region with more production is the one with higher values. The Neotropical articles showed a greater growth rate in the last decade, decreasing the gap between both regions. **Conclusion:** There is a regional bias in WoS and Scopus, which retrieve more articles and citations about Palearctic mammals than about Neotropical mammals; this bias is worse in WoS and means that an urgent increase in indexed research about Neotropical species is needed to be *on par* with Palearctic research.

**Key words:** citation; geographical bias; Mammalia; research impact; scientometrics; wildlife conservation.

Previous studies have shown that, in the field of natural resources, some regions of the world are much more studied than others. Forest biomes of North America and Europe are generally more studied, whereas many tropical ecosystems are severely understudied (Lawler et al., 2016; Christie et al., 2020); and therefore, the most biodiverse countries (often

located in tropical regions) are underrepresented in the biodiversity conservation literature (Wilson et al., 2016; Reboredo, Romano, & Armsworth, 2020). Reducing publication biases could help to mitigate biodiversity loss in tropical regions, often more threatened, yet less studied (Sitas, Baillie, & Isaac, 2009; Christie et al., 2020), because peer-reviewed

publications are an important component of evidence-based policy to ensure the effectiveness of conservation actions (Pullin, Knight, Stone, & Charman, 2004; Wilson et al. 2016; Christie et al., 2020).

There are multiple causes explaining differential research effort among regions or countries, including geographical and environmental variables such as the remoteness and accessibility of the study area, the presence of protected areas, and biodiversity indexes (such as the number of vertebrates species) of the area (Martin, Blossey, & Ellis, 2012; Hickisch et al., 2019), or socio-economic variables of the countries such as the per capita income, the research and development (R&D) investment, funding availability, and the number of researchers itself (King, 2004; Guerrero-Casado, 2017; Vinkler, 2018; Allik, Lauk, & Realo, 2020). Concerning wild animal species, there are also important biases: birds and mammals, threatened species, more abundant species, organisms with larger distribution ranges, charismatic or emblematic species, and large-bodied species are overrepresented in the scientific literature when compared with other animal groups (Brooke, Bielby, Nambiar, & Carbone, 2014; Donaldson et al., 2016; dos Santos et al., 2020). In addition to the total number of publications, the region also influences the citation in conservation research papers: the countries with a high gross domestic product (GDP) and governance quality are more cited (Meijaard, Cardillo, Meijaard, & Possingham, 2015). The previously cited authors argued that countries with these features invest more money in science and usually have better scientific infrastructure, facilitating the science production with a visible high impact.

Currently, the most widespread indicators used to measure the scientific impact of research, universities, or journals, are based on the number of citations and its derived indices, such as the journal impact factor and the *h*-index, defined as the number of papers with citation number  $\geq h$  (Hirsch, 2005). However, these indicators are debated by a part of the scientific community owing to some weaknesses

and limitations (Alberts, 2013; Wouters et al., 2019). One of these weaknesses is that there are many variables not directly related to the impact of articles (e.g., the article's length, the number of the authors, author's academic rank, gender, race, and age) which affect the number of citations (Borsuk, Budden, Leimu, Aarsen, & Lortie, 2009; Padial, Nabout, Siqueira, Bini, & Diniz-Filho, 2010; Tahamtan, Afshar, & Ahamdzadeh, 2016). Several studies have also identified that the authors' country of affiliation is an important predictor of the number of citations, meaning that citations are positively related with high-income countries (Pasterkamp, Rotmans, De Kleijn, & Borst, 2007; Tahamtan et al., 2016). This could be explained by the better scientific infrastructure and greater financial support of more developed nations (Padial et al., 2010; Tahamtan et al., 2016). For instance, papers from the United States of America usually attain higher citation rates simply by the force of numbers, because that country has a large research output, a phenomenon known as 'national citation' (Pasterkamp et al., 2007; Abramo, D'Angelo, & Di Costa, 2020).

But there are other reasons why researchers in richer countries appear to have a higher impact. When impact indicators are calculated only from databases such as *Scopus* or *Web of Science* (WoS), many citations are missed because they are in scientific papers not included in these "first world" databases (Monge-Nájera, & Ho, 2018). For example, even though most Latin American journals are indexed in regional databases such as Latinex, Scielo or Redalyc, they are missing from Scopus and WoS (Crespo-Gascón, Tortosa, Guerrero-Casado, 2019), and, therefore, the citations in Scopus and WoS are only a fraction of the real impact of Latin American research (Monge-Nájera, 2014).

Nearctic and Palearctic mammals are more studied than mammals from other zoogeographic regions (Amori & Gippoliti, 2000), and even though Neotropical mammals represent 29 % of all mammal species, only 12 % of mammal conservation articles are focused

on them (Di Marco et al., 2017). These differences could be partly attributed to the different scientific output between Palearctic (European) and Neotropical (Latin American) countries. However, there are no studies that specifically compare research effort and citation among Neotropical and Palearctic mammals. Our goal in this paper is, therefore, to compare the number of Palearctic and Neotropical papers, and their citation rates, for large mammals' research, and to do it over a long period of time (1970-2019).

## MATERIALS AND METHODS

**Palearctic and Neotropical species selection:** Considering that latitude affects the biodiversity conservation literature (Di Marco et al., 2017), we compared mammals from the Western Palearctic region, which ranges from Ireland to Western Russia (Baquero & Tellería, 2001; Holt et al., 2013), with Neotropical mammals, from central Mexico to central Argentina (Holt et al., 2013; Noguera-Urbano & Escalante, 2017). For a valid comparison, we only used medium and large-sized native mammal species (i.e. with an adult body mass over 1 kg; Weng et al., 2020), because larger animals are the most studied (Brooke et al., 2014), and therefore better candidates for a valid comparison. Twenty-eight Palearctic species met these selection criteria (Baquero & Tellería, 2001), excluding exotic species whose native distribution range is located outside of this region (e.g. *Procyon lotor*), and species native to Palearctic Region but also located in other biogeographical regions (e.g. *Alces Alces* or *Rangifer tarandus*, also found in the Nearctic region).

Considering that the number of mammal species is much higher in the Neotropical Region, a similar number of mammal species (32 species) was randomly selected to avoid an unbalanced design. This selection was made using the mammals of the Neotropical realm including in the IUCN red list as a baseline database, in which the 30 species were randomly selected. Similarly, exotic species located in the Neotropical region were excluded, and

Neotropical native species that also occur in others regions were also not considered (e.g. *Pecari tajacu* and *Puma concolor* also occur in the Nearctic). The 60 selected species were listed in Digital Appendix 1.

**Scientific literature search & citation indicators:** Using the scientific and common names for each of the 60 species in the article title, we retrieved all journal articles, conferences and proceedings papers, books, and book chapters published from 1970 to 2019, and included in Scopus and the Web of Science (WoS) Core Collection (the search was carried out on April 2020), thus only primary scientific literature was considered in the study. In both databases and for each species separately, the search used the scientific name and the most used common names in the article title, which ensured that the article topic is focused on the species. Previous scientific works whose aims were to identify patterns in wildlife research efforts also used the scientific and common names in the search criteria (e.g. Fleming & Batemandos, 2016; Jarić, Roberts, Gessner, Solow, & Courchamp, 2017; dos Santos et al., 2020). The search criteria for every species were detailed in Digital Appendix 1.

The first step was to obtain, from Scopus and WoS separately, and for each document, the publication year and the number of times it has been cited according to the particular database. From these data we calculated the average document citations per year (Cai, Chang, & Yip, 2020) with this formula (Formula 1):

### Formula 1

$$\text{Average document citations per year} = \frac{\text{Number of times cited}}{2020 - \text{publication year}}$$

Then, for each species and for the whole study period, in Scopus and WoS separately, we obtained the total number of documents per species ("documents"), how many times the documents were cited ("total citations"), the *h*-index (defined as the number of documents with a citation number  $\geq h$ , Hirsch, 2005), the citation rate (Formula 2), and the average citations per year (citations/year).

## Formula 2.

$$\text{Citation rate} = \frac{\text{Total citations}}{\text{Total number of documents}}$$

For each indicator, we also calculated a regional ratio by dividing the mean values of each indicator (documents, total citations, citations per paper, *h*-index and citations/year) for all the Palearctic mammal species, by the mean values for all the Neotropical mammals. This ratio can be considered as a measure of the difference between both regions for each indicator.

**Statistical analysis:** To compare the growth in document production between both regions, the study period was divided in five decades (1970-1980; 1981-1990; 1991-2000; 2001-2010; 2011-2019), and we calculated the growth rate using the slope of the regression (*b*) between years and the number of documents. The greater slope, the greater growth rate: this allowed us to check the trend in each decade. These calculations were done separately for Scopus and WoS.

Three different statistical analyses were applied: a) for each region, we compared WoS and Scopus (independent variable) with Wilcoxon paired tests (paired by species) for the number of documents, citation rate, citations/year, *h*-index, and total citations, which were the dependent variables; b) Mann-Whitney *U* tests were applied to compare the same five indicators (dependent variables) between Palearctic and Neotropical species (independent variable) separately for Scopus and WoS; c) four linear models (four for Scopus and four for WoS) were applied to assess the influence of number of documents on the other four indicators (*h*-index, citation rate, total citations and citations/year), which were used as response variables. Bonferroni correction for multiple comparisons were applied by multiplying the original p-value by the number of simultaneously tested hypotheses (response variables) (Chen, Feng, & Yi, 2017).

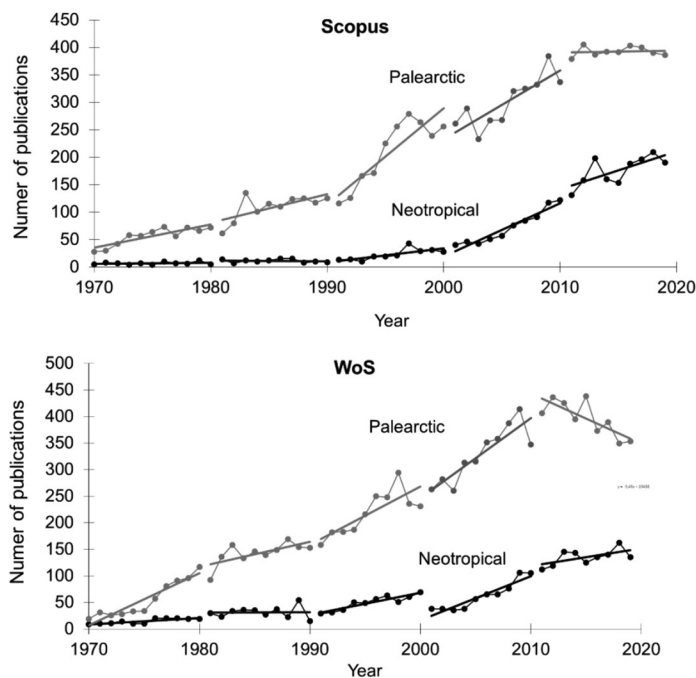
We used general linear models (GLM) for the *h*-index, citation rate, and citations/

year, because the normality of the residuals was confirmed, and generalized linear models (GLM) for total citations as response variable, using a negative binomial distribution with log-link function, in which the homocedasticity and the lack of overdispersion of the residuals were confirmed. In all these models, the independent variables were the documents, the region (Neotropical & Palearctic), and the interaction (*Region\*Documents*). Scatterplots were generated to illustrate the effect of the *Region\*Documents* interaction on the response variables. In all the statistical analysis, the species was the experimental unit (*N* = 60) and the statistical software was InfoStat (Di Rienzo et al., 2020).

## RESULTS

**Overall results:** The selected species accounted for 13 274 and 12 913 documents in Scopus and WoS respectively, of which 5 413 belong to Neotropical species (2 782 in Scopus and 2 631 in WoS) and 20 774 to Palearctic species (10 492 in Scopus and 10 282 in WoS). Palearctic mammals have 3.77 and 3.91 times more documents than Neotropical species in Scopus and WoS, respectively. Palearctic articles accumulated a total of 228 069 and 167 546 citations in WoS and Scopus, respectively, whereas Neotropical articles have 24 977 and 28 120 citations, which means 9.13 and 5.95 times more total citations for Palearctic species.

**Temporal trends:** In the 1970's and 1980's, the number of documents in the Neotropical region was exceptionally low (75 and 112 documents in Scopus in 1970's and 1980's respectively) with a poor increase (*b* 1970's = 0.2; *b* 1980's = -0.157 ), but in the last decade the Neotropical growth rate was higher than the rate for Palearctic articles (Table 1; Fig. 1). The P/N Ratio was much greater in the first three decades than in the last two, and it was greater for WoS than Scopus, suggesting that the differences between both regions are getting smaller (Table 1). In the last decade, the growth rate of Palearctic articles is near zero



**Fig. 1.** Temporal variation in the number of documents in Scopus and WoS for Paelearctic (grey) and Neotropical (black) mammal species selected in our study. The dashed lines indicate the tendency in each decade.

( $b = 0.333$ ) in Scopus and negative in WoS ( $b = -9.45$ ), whereas for Neotropical articles the growth rate was positive and more evident in Scopus ( $b = 6.83$ ) (Table 1; Fig. 1).

#### Comparison between WoS and Scopus:

For Neotropical species, Scopus had a greater number of documents, total citations, and  $h$ -index than WoS, whereas no significant differences were obtained in the citation rate and citations/year (Table 2). For Paelearctic species, the number of documents was similar in both databases, citations were greater in Scopus, and after Bonferroni correction, citation rate,  $h$ -index, and citations/year, marginally significant differences between both databases were obtained (Table 2). In both databases, Paelearctic mammals had more documents and total citations, and higher citation rates,  $h$ -index values and citations/year than Neotropical species (Table 3). The Paelearctic/Neotropical ratio showed that the Paelearctic mammals had 4.47

and 4.31 more articles and 7.95 and 6.79 more citations in WoS and Scopus respectively, but differences are less marked for citation rate,  $h$ -index and citations/years (Table 3).

**Effect of the number of documents and region on the citation indicators:** In all the models, the variable *Region* was significant, with greater values obtained for the Paelearctic mammals (Table 4). The variable *Documents* influenced positively the  $h$ -index values and total citations in both databases (Table 4). However, the interaction between the variables *Region* and *Documents* was also significant in some models, which means that documents affected the response variables in a different way depending on the region (Table 4; Fig. 2). According to these interactions, the number of documents was more correlated with the  $h$ -index in the Neotropical Region, and with the total number of citations in the Paelearctic (Fig. 2).



TABLE 1  
Growth rate and regression slope value (*b*) for articles about Neotropical and Palearctic mammals in Scopus and Web of Science (1970-2019)

Decade	Neotropical		Palearctic		Ratio P/N
	N° Documents	<i>b</i>	N° Documents	<i>b</i>	
Scopus					
1970-1980	75	0.2	618	4.24	8.24
1981-1990	112	-0.157	1 093	5.15	9.76
1991-2000	227	2.56	2 098	17.55	9.24
2001-2010	726	9.68	3 016	12.54	4.15
2010-2019	1 583	6.83	3 533	0.333	2.23
WoS					
1970-1980	162	1.22	613	9.77	3.78
1981-1990	313	0.103	1 429	4.67	4.57
1991-2000	494	4.15	2 185	10.95	4.42
2001-2010	622	8.33	3 290	15.07	5.29
2010-2019	1 216	3.38	3 564	-9.45	2.93

P/N Ratio = Palearctic articles / Neotropical articles.

TABLE 2  
Wilcoxon paired tests comparing indicators for Scopus and WoS separately. Corrected p-value was calculated multiplying the p-value by 5

Indicator	Neotropical				Palearctic			
	Mean-dif	SD	Z	Corrected p-value	Mean-dif	SD	Z	Corrected p-value
Documents	4.72	23.12	2.76	0.022	7.5	36.12	1.05	0.2974
Total citations	161.78	381.89	3.46	0.001	289.5	596.11	3.14	0.004
<i>h</i> -index	0.88	1.48	2.74	0.025	1	3.64	2.5	0.062
Citation rate	-0.05	3.5	1.8	0.34	0.52	1.14	2.41	0.076
Citation/year	-0.17	1.56	2.19	0.143	0.07	0.18	2.44	0.055

Mean-dif indicates the mean difference between Scopus and WoS calculated as Scopus - WoS (e.g. Scopus documents - WoS documents). SD = standard deviation.

## DISCUSSION

When comparing Neotropical and Palearctic mammals, our results indicate that both databases reported more articles about Palearctic mammals. This result matches previous findings from the last two decades: biodiversity and the financial resources to study it are concentrated in opposite latitudes, and, as a result, the lower biodiversity of Northern biomes is far more studied than the higher biodiversity of the less industrialized Tropical countries (Amori

& Gippoliti, 2000; King, 2004; Hickisch et al., 2019; Christie et al., 2020). The Palearctic realm is mainly formed by countries with high per capita incomes, leading to a higher investment in research and development, and more researchers, which in turn produce a higher number of papers and citations (Prathap, 2017; Allik et al., 2020). Therefore, the greater number of papers and citations of Palearctic species could be to a good extent be explained by the highest R&D investment of the countries of this realm. Our results also showed that articles

TABLE 3

Mann-Whitney *U* tests comparing scientific impact indicators for Neotropical and Palearctic articles in WoS and Scopus. Corrected p-value was calculated multiplying the p-value by 5

Web of Science	Neotropical			Palearctic			<i>U</i>	Corrected p-value	Ratio (P/N)
	Mean	SD	Median	Mean	SD	Median			
Documents	82.22	160.08	28	367.21	585.47	171.5	172.5	0.0005	4.47
Total citations	718.78	1501	254.5	5694	10462	2608	130	0.0005	7.92
Citation rate	8.23	4.09	8.34	13.96	4.6	14.01	149	0.0005	1.70
<i>h</i> -index	10.91	9.11	8.5	29.64	17.96	26	120.5	0.0005	2.72
Citations/year	0.72	0.32	0.74	1.13	0.32	0.98	150	0.0005	1.57
Scopus	Mean	SD	Median	Mean	SD	Median	<i>U</i>	Corrected p-value	Ratio (P/N)
Documents	86.94	150.17	34	374.71	574.89	173	171	0.0005	4.31
Total citations	880.56	1872	306.5	5983	10498	2990	139	0.0005	6.79
Citation rate	8.18	3.77	8.58	14.48	4.94	14.72	138	0.0005	1.77
<i>h</i> -index	11.78	9.85	9.5	30.64	17.87	28	132	0.0005	2.60
Citations/year	0.83	0.36	0.86	1.2	0.38	1.06	213	0.0025	1.45

SD = standard deviation. Ratio (P/N) is the result of dividing the mean values of Palearctic Region (P) by the mean values of Neotropical Region (N).

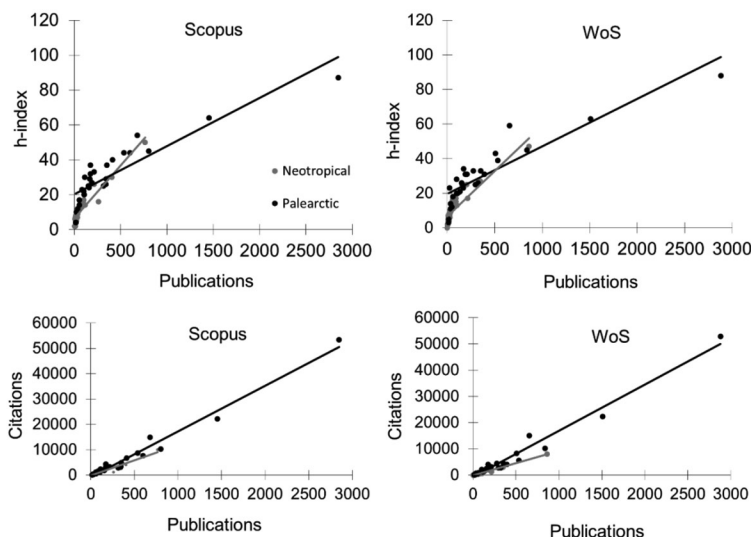
TABLE 4

Eight linear models using the different scientific impact indicators, separately obtained in Scopus and WoS, as response variables. Corrected p-value was calculated multiplying the p-value by 4

	Scopus				WoS			
	Estimate	SE	t-value	Corrected p-value	Estimate	SE	t-value	Corrected p-value
Response variable: Citation rate								
Intercept	7.51	0.88	8.54	0.004	8.081	0.867	9.321	<0.001
Region	6.32	1.31	4.82	0.004	5.249	1.305	4.024	0.0002
Documents	0.01	0.01	1.51	0.136	0.002	0.005	0.371	0.7118
Region* Documents	-0.01	0.01	-1.13	0.265	-0.0001	0.005	-0.018	0.9855
Response variable: <i>h</i> -index								
Intercept	6.51	1.31	4.99	0.004	6.6	1.22	5.39	<0.001
Region	13.79	1.95	7.08	0.004	12.96	1.84	7.03	<0.001
Documents	0.06	0.01	7.95	0.004	0.05	0.01	7.61	<0.001
Region* Documents	-0.03	0.01	-4.17	0.004	-0.02	0.01	-3.48	0.004
Response variable: Citations/year								
Intercept	0.751	0.074	10.186	0.004	0.69	0.06	10.85	<0.001
Region	0.449	0.11	4.081	0.004	0.39	0.1	4.04	<0.001
Documents	-0.001	0.0001	2.111	0.156	0.001	0.001	0.99	0.3268
Region* Documents	-0.001	0.0001	-2.038	0.184	-0.001	0.001	-0.62	0.5369
Response variable: Total citations								
Intercept	5.31	0.181	642.6	0.004	5.23	0.179	29.28	0.004
Region	2.10	0.269	204.2	0.004	2.11	0.268	7.861	0.004
Documents	0.008	0.001	256.1	0.004	0.008	0.001	8.122	0.004
Region* Documents	-0.006	0.001	-192.8	0.004	-0.006	0.001	-5.968	0.004

Estimates of the categorical variable Region were calculated using Palearctic as a reference value. SE = standard error.





**Fig. 2.** Relationship between total number of documents and citation indicators in WoS and Scopus for Neotropical (grey spots) and Palearctic (dark spots) mammals. Only statistically significant effects are shown.

about Palearctic mammals received more total citations, more citations/year, and had a higher *h*-index than articles about Neotropical mammals. Taken at face value, this seems to reflect the fact that researchers in Northern countries are better financed and more cited thanks partly to their access to journals included in Scopus and the WoS (Borsuk et al., 2009; Pasterkamp et al., 2007; Padial et al., 2010; Tahamtan et al., 2016). However, it is important to highlight that a proportion of articles about tropical regions are written in collaboration with authors affiliated with foreign institutions, mainly from North America and Europe (Tydecks, Jeschke, Wolf, Singer, & Tockner, 2018; Reboredo et al., 2020). Indeed, the scientific output of some Neotropical countries (e.g. Panama, Ecuador and Peru) is highly dependent on international collaboration (Chinchilla-Rodríguez, Sugimoto, & Larivière, 2019), and a great proportion of the articles are led by researchers from temperate countries (Dangles et al., 2016; Chinchilla-Rodríguez et al., 2019). Therefore, the biases concerning the number of articles and citations are only partly explained by the scientific wealth of the Neotropical and Palearctic countries, and therefore, other

factors must be causing these differences and need study.

Just like invertebrates are underrepresented in research when compared with birds and mammals (Donaldson et al., 2006; Monge-Nájera, 2017), Neotropical mammals are understudied when compared with their Palearctic relatives (Di Marco et al., 2017). Furthermore, the growth in the number of articles was more constant for the Palearctic region during the whole study period, whereas the growth in the number of Neotropical articles was more evident from the year 2000, suggesting a certain geographic delay in the production pattern for scientific literature. However, it is also noteworthy that, in the last decade, the output increase was greater in the Neotropical region, and that the gap between both regions is becoming smaller, i.e. the P/N ratio is smaller, or the difference in number of documents between regions is falling.

One important consideration to properly interpret our results is the different number of species found in both biogeographic realms. According to the IUCN red list, in the Neotropical realm there are 1691 species of terrestrial mammals, whereas in the Palearctic realm there

are 870 species (IUCN, 2020). This entails that the number of papers about Palearctic mammals per species could be greater due to the lower number of species to study, and for the same reason, the number of papers per species of Neotropical mammals could be lower owing to the higher species richness of this region. Nevertheless, we deem that our results, based on total number of documents per species and their derivative citations indicators, could be useful to quantify by how much the neotropical mammals are less studied and their publications less cited than Palearctic mammals.

It is often assumed that quality and research impact are correlated (e.g. Padial et al., 2010; Tahamtan et al., 2016), but is it fair to use the number of citations to compare the *quality* of articles about Neotropical and Palearctic mammals? Our results show that the probability of being cited is a clear function of another factor: quantity; in our data, citation impact is strongly biased towards papers about Palearctic species because the total citations and the *h*-index were positively correlated with the *total number* of documents (Table 4; Fig. 2). Hence, if the Palearctic mammals are more studied than Neotropical mammals, these indicators should be therefore interpreted with caution. This does not mean that the citation is not among possible objective indicators within the context of these two databases, but this bias should be considered when comparing articles produced by institutions or researchers from different regions. Additional criteria should be tested in the future to compare the impact of articles from both regions, such as the social impact measured by Altmetrics or the citations received in other databases such as Google Scholar.

Additionally, De Groote, & Raszewski (2012) previously noticed that Scopus and WoS produce inconsistent impact factors; both databases fail to cover the majority of the world's journals, and this has a strong impact in the resulting *h*-index values (Vieira & Gomes, 2009; Martín-Martín, Orduna-Malea, Thelwall, & López-Cózar, 2018). In the case of Latin America, an important amount of the scientific

literature is published in journals not included by Scopus or WoS, missing the large majority of citations (Monge-Nájera, 2014; Monge-Nájera & Ho, 2018). This bias also exists in Europe, but it may be less marked there (Mongeon & Paul-Hus, 2016).

Our results also provide additional information about the use of Scopus and the WoS for bibliometric research. While the number of Palearctic articles was similar in both databases, the Palearctic/Neotropical ratio indicated a greater difference between both regions in WoS. By including more journals, Scopus produced a less biased result, identifying more articles and more citations. Particularly, our results also showed that in the last two decades the growth rate was greater in Scopus than WoS for the Neotropical articles, which also supports the less biased results obtained in Scopus. This does not mean that Scopus is a satisfactory database to study Neotropical science, because it still misses most publications that are produced in Latin America. For instance, Central America (excluding Mexico) publishes over 8 000 academic journals according to Latindex, of which only one, *Revista de Biología Tropical*, is included in WoS (Monge-Nájera & Ho, 2018). Other studies have found that Google Scholar presents a better view of current science, followed distantly by Scopus and, even more distantly, by the WoS (Falagas, Pitsouni, Malietzis, & Pappas, 2008; Meho, & Sugimoto, 2009; Martín-Martín, et al., 2018).

In conclusion, researchers should take into account a regional bias favoring the study and citation of Palearctic mammals in WoS and Scopus, and that this bias is worse in WoS. Citation rate is less biased than the *h*-index and total citations, but still, citation rate and the *h*-index are far from acceptable measures of the importance of research. This bias can be explained by several factors (e.g. research investment, species richness or scientific infrastructure), but whatever the cause, having less scientific information on Neotropical mammals can affect their conservation (dos Santos et al., 2020), because sound research is essential to ensure that conservation efforts are efficient



(Sutherland et al., 2019). Therefore, the worldwide scientific community should reduce this bias, for example, by promoting collaboration between scientists from Palearctic and Neotropical regions, by facilitating the access of Neotropical journals to WoS and Scopus, or by helping increase the financial support to research projects on Neotropical mammals. These measures could increase the scientific knowledge on Neotropical mammals, which in turn could help to ensure its conservation and foster decisions based on science.

**Ethical statement:** authors declare that they all agree with this publication and made significant contributions; that there is no conflict of interest of any kind; and that we followed all pertinent ethical and legal procedures and requirements. All financial sources are fully and clearly stated in the acknowledgements section. A signed document has been filed in the journal archives.

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## RESUMEN

**El sesgo geográfico en el estudio de los mamíferos: comparación de medio siglo de investigación sobre mamíferos paleárticos y neotropicales. Introducción:** No existen estudios que comparen, específicamente, la investigación de la mastozoología paleártica con la neotropical; pero tales comparaciones serían útiles para tomar decisiones informadas en conservación y manejo. **Objetivo:** Comparar los documentos científicos sobre mamíferos paleárticos y neotropicales, y su impacto en citas, durante medio siglo. **Métodos:** Comparamos 50 años (1970-2019) de documentos sobre 60 especies de mamíferos de tamaño mediano y grande (más de 1 kg), en Scopus y la colección principal del Web of Science (WoS), considerando el número de documentos y cuatro indicadores de citas a nivel de especie (índice *h*, tasa de citas, total de citas y citas por

año). **Resultados:** Recuperamos 13 274 documentos en Scopus y 12 913 en WoS, y encontramos que los mamíferos paleárticos tienen 3.77 veces más documentos que las especies neotropicales en Scopus (3.91 veces en WoS), y que los documentos registran 5.95 más citas totales en Scopus (6.93 veces más en WoS). Los documentos paleárticos también registran más citas anuales y un índice *h* más alto, tanto en Scopus como en WoS. Scopus recuperó más artículos para especies neotropicales (2 782 vs. 2 631 en WoS) y tuvo más citas (28 120 vs. 24 977 en WoS). Las diferencias para los indicadores de citas entre regiones fueron más marcadas en WoS. El índice *h* y el total de citas se ven muy afectados por la cantidad de estudios publicados, es decir, la región con más producción será la que tenga indicadores más altos. Los artículos neotropicales mostraron una mayor tasa de crecimiento en la última década, disminuyendo la brecha entre ambas regiones. **Conclusión:** Existe un sesgo regional en WoS y Scopus, que recuperan más artículos y citas sobre mamíferos paleárticos que sobre mamíferos neotropicales; este sesgo es peor en WoS y significa que se necesita un aumento urgente en la investigación indexada sobre especies neotropicales para estar al nivel de la investigación paleártica.

**Palabras clave:** cita; sesgo geográfico; Mammalia; impacto de la investigación; cienciometría; conservación de la vida silvestre.

## REFERENCES

- Abramo, G., D'Angelo, C.A., & Di Costa, F. (2020). The role of geographical proximity in knowledge diffusion, measured by citations to scientific literature. *Journal of Informetrics*, 14, 101010. DOI: 10.1016/j.joi.2020.101010
- Alberts, B. (2013). Impact factor distortions. *Science*, 340, 787. DOI: 10.1126/science.1240319
- Allik, J., Lauk, K., & Realo, A. (2020). Factors Predicting the Scientific Wealth of Nations. *Cross-Cultural Research*, 54(4), 364-397. DOI: 10.1177/1069397120910982
- Amori, G., & Gippoliti, S. (2000). What do mammalogists want to save? Ten years of mammalian conservation biology. *Biodiversity and Conservation*, 9, 785-793. DOI: 10.1023/A:1008971823774
- Baquero, R.A., & Tellería, J.L. (2001). Species richness, rarity and endemism of European mammals: A biogeographical approach. *Biodiversity and Conservation*, 10, 29-44. DOI: 10.1023/A:1016698921404
- Borsuk, R.M., Budden, A.E., Leimu, R., Aarssen, L.W., & Lortie, C.J. (2009). The Influence of Author Gender, National Language and Number of Authors on Citation Rate in Ecology. *The Open Ecology Journal*, 2, 25-28. DOI: 10.2174/1874213000902010025

- Brooke, Z.M., Bielby, J., Nambiar, K., & Carbone, C. (2014). Correlates of Research Effort in Carnivores: Body Size, Range Size and Diet Matter. *PLoS ONE*, 9, e93195. DOI: 10.1371/journal.pone.0093195
- Cai, Z., Chang, Q., & Yip, P.S.F. (2020). A scientometric analysis of suicide research: 1990-2018. *Journal of Affective Disorders*, 266, 356-365. DOI: 10.1016/j.jad.2020.01.121
- Chen, S.Y., Feng, Z., & Yi, X. (2017). A general introduction to adjustment for multiple comparisons. *Journal of Thoracic Disease*, 9, 1725-1729. DOI: 10.21037/jtd.2017.05.34
- Chinchilla-Rodríguez, Z., Sugimoto, C.R., & Larivière, V. (2019). Follow the leader: On the relationship between leadership and scholarly impact in international collaborations. *PLoS One*, 14, e0218309. DOI: 10.1371/journal.pone.0218309
- Christie, A.P., Amano, T., Martin, P.A., Petrovan, S.O., Shackelford, G.E., Simmons, B.I., Smith, R.K., Williams, D.R., Wordley, C.F.R., & Sutherland, W.J. (2020). The challenge of biased evidence in conservation. *Conservation Biology*, 0, 1-13. DOI: 10.1111/cobi.13577
- Crespo-Gascón, S., Tortosa, F.S., & Guerrero-Casado, J. (2019). Producción de revistas científicas en América Latina y El Caribe en Scopus, Journal Citation Reports y Latindex en el área de los recursos naturales: su relación con variables económicas, ambientales y de inversión en investigación. *Revista Española de Documentación Científica*, 42, 224. DOI: 10.3989/redc.2019.1.1533
- Dangles, O., Loirat, J., Freour, C., Serre, S., Vacher, J., & Le Roux, X. (2016). Research on Biodiversity and Climate Change at a Distance: Collaboration Networks between Europe and Latin America and the Caribbean. *PLoS One*, 11, e0157441. DOI: 10.1371/journal.pone.0157441
- De Groote, S.L., & Raszewski, R. (2012). Coverage of Google Scholar, Scopus, and Web of Science: A case study of the h-index in nursing. *Nursing Outlook*, 60, 391-400. DOI: 10.1016/j.outlook.2012.04.007
- Di Marco, M., Chapman, S., Althor, G., Kearney, S., Besancon, C., Butt, N., Maina, J., Possingham, H., von Bieberstein, K., Venter, O., & Watson, J.E.M. (2017). Changing trends and persisting biases in three decades of conservation science. *Global Ecology and Conservation*, 10, 32-42. DOI: 10.1016/j.gecco.2017.01.008
- Di Rienzo, J.A., Casanoves, F., Balzarini, M.G., Gonzalez, L., Tablada, M., & Robledo, C.W. (2020). *InfoStat* (versión 2020). Universidad Nacional de Córdoba, Argentina. Recuperado de <http://www.infostat.com.ar>
- Donaldson, M.R., Burnett, N.J., Braun, D.C., Suski, C.D., Hinch, S.G., Cooke, S.J., & Kerr, J.T. (2016). Taxonomic bias and international biodiversity conservation research. *Facets*, 1, 105-113. DOI: 10.1139/facets-2016-0011
- dos Santos, J.W., Correia, R.A., Malhado, A.C.M., Campos-Silva, J.V., Teles, D., Jepson, P., & Ladle, R.J. (2020). Drivers of taxonomic bias in conservation research: a global analysis of terrestrial mammals. *Animal Conservation* (in press). DOI: 10.1111/acv.12586
- Falagas, M.E., Pitsouni, E.I., Malietzis, G.A., & Pappas, G. (2008). Comparison of PubMed, Scopus, web of science, and Google scholar: strengths and weaknesses. *The FASEB Journal*, 22, 338-342. DOI: 10.1096/fj.07-9492LSF
- Fleming, P.A., & Bateman, P.W. (2016). The good, the bad, and the ugly: which Australian terrestrial mammal species attract most research? *Mammal Review*, 46(4), 241-254. DOI: 10.1111/mam.12066
- Guerrero-Casado, J. (2017). Producción científica latinoamericana indexada en Scopus en el área de las ciencias agropecuarias: Análisis del período 1996-2016. *Idesia (Arica)*, 35, 27-33. DOI: 10.4067/S0718-34292017000400027
- Hickisch, R., Hodgetts, T., Johnson, P.J., Sillero-Zubiri, C., Tockner, K., & Macdonald, D.W. (2019). Effects of publication bias on conservation planning. *Conservation Biology*, 33, 1151-1163. DOI: 10.1111/cobi.13326
- Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America*, 102(46), 16569-16572. DOI: 10.1073/pnas.0507655102
- Holt, B.G., Lessard, J.P., Borregaard, M.K., Fritz, S.A., Araújo, M.B., Dimitrov, D., Fabre, P.H., Graham, C.H., Graves, G.R., Jönsson, K.A., Nogués-Bravo, D., Wang, Z., Whittaker, R.J., Fjeldsø, J., & Rahbek, C. (2013). An update of Wallace's zoogeographic regions of the world. *Science*, 339, 74-78. DOI: 10.1126/science.1228282
- IUCN (2020). *The IUCN Red List of Threatened Species* (Base de datos). Recuperado de <https://www.iucn-redlist.org>
- Jarić, I., Roberts, D.L., Gessner, J., Solow, A.R., & Courchamp, F. (2017). Science responses to IUCN Red Listing. *PeerJ*, 2017(11), e4025. DOI: 10.7717/peerj.4025
- King, D.A. (2004). The scientific impact of nations. *Nature*, 430, 311-316. DOI: 10.1038/430311a
- Lawler, J.J., Aukema, J.E., Grant, J.B., Halpern, B.S., Kareiva, P., Nelson, C.R., Ohlert, K., Olden, J.D., Schlaepfer, M.A., Silliman, B.R., & Zaradic, P. (2006). Conservation science: a 20-year report card. *Frontiers in Ecology and the Environment*, 4, 473-480.
- Martin, L.J., Blossey, B., & Ellis, E. (2012). Mapping where ecologists work: biases in the global distribution of terrestrial ecological observations. *Frontiers in Ecology and the Environment*, 10, 195-201. DOI: 10.1890/110154



- Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & López-Cózar, E.D. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of Informetrics*, 12(4), 1160-1177. DOI: 10.1016/j.joi.2018.09.002
- Meho, L.I., & Sugimoto, C.R. (2009). Assessing the scholarly impact of information studies: A tale of two citation databases—Scopus and Web of Science. *Journal of the American Society for Information Science and Technology*, 60, 2499-2508. DOI: 10.1002/asi.21165
- Meijaard, E., Cardillo, M., Meijaard, E.M., & Possingham, H.P. (2015). Geographic bias in citation rates of conservation research. *Conservation Biology*, 29(3), 920-925. DOI: doi.org/10.1111/cobi.12489
- Monge-Nájera, J. (2014). La invalidez del Factor de Impacto como indicador del impacto de las revistas científicas latinoamericanas. *Revista de Biología Tropical*, 62, 407-412.
- Monge-Nájera, J. (2017). The power of short lectures to improve support for biodiversity conservation of unpopular organisms: an experiment with worms. *Cuadernos de Investigación UNED*, 9(1), 145-150.
- Monge-Nájera, J., & Ho, Y.S. (2018). Guatemala articles in the Science Citation Index Expanded: bibliometry of subjects, collaboration, institutions and authors. *Revista de Biología Tropical*, 66, 312-320. DOI: 10.15517/rbt.v66i1.29875
- Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, 106, 213-228. DOI: 10.1007/s11192-015-1765-5
- Noguera-Urbano, E.A., & Escalante, T. (2017). The Neotropical region sensu the areas of endemism of terrestrial mammals. *Australian Systematic Botany*, 30, 470-484. DOI: 10.1071/SB16053
- Padial, A.A., Nabout, J.C., Siqueira, T., Bini, L.M., & Diniz-Filho, J.A.F. (2010). Weak evidence for determinants of citation frequency in ecological articles. *Scientometrics*, 85, 1-12. DOI: 10.1007/s11192-010-0231-7
- Pasterkamp, G., Rotmans, J.I., De Kleijn, D.V.P., & Borst, C. (2007). Citation frequency: A biased measure of research impact significantly influenced by the geographical origin of research articles. *Scientometrics*, 70, 153-165. DOI: 10.1007/s11192-007-0109-5
- Prathap, G. (2017). Scientific wealth and inequality within nations. *Scientometrics*, 13, 923-928. DOI: 10.1007/s11192-017-2511-y
- Pullin, A.S., Knight, T.M., Stone, D.A., & Charman, K. (2004). Do conservation managers use scientific evidence to support their decision-making? *Biological Conservation*, 119(2), 245-252. DOI: 10.1016/j.biocon.2003.11.007
- Sitas, N., Baillie, J.E.M., & Isaac, N.J.B. (2009). What are we saving? Developing a standardized approach for conservation action. *Animal Conservation*, 12(3), 231-237. DOI: 10.1111/j.1469-1795.2009.00244.x
- Sutherland, W.J., Taylor, N.G., MacFarlane, D., Amano, T., Christie, A.P., Dicks, L.V., Lemasson, A.J., Littlewood, N.A., Martin, P.A., Ockendon, N., Petrovan, S.O., Robertson, R.J., Rocha, R., Shackelford, G.E., Smith, R.K., Tyler, E.H.M., & Wordley, C.F.R. (2019). Building a tool to overcome barriers in research-implementation spaces: The conservation evidence database. *Biological Conservation*, 238, 108199. DOI: 10.1016/j.biocon.2019.108199
- Reboredo, A.L., Romano, D., & Armsworth, P.R. (2020). Who studies where? Boosting tropical conservation research where it is most needed. *Frontiers in Ecology and the Environment*, fee.2146. DOI: 10.1002/fee.2146
- Tahamtan, I., Afshar, A.S., & Ahamdzadeh, K. (2016). Factors affecting number of citations: a comprehensive review of the literature. *Scientometrics*, 107, 1195-1225. DOI: 10.1007/s11192-016-1889-2
- Tydecks, L., Jeschke, J.M., Wolf, M., Singer, G., & Tockner, K. (2018). Spatial and topical imbalances in biodiversity research. *PLOS ONE*, 13(7), e0199327. DOI: 10.1371/journal.pone.0199327
- Vieira, E.S., & Gomes, J.A. (2009). A comparison of Scopus and Web of Science for a typical university. *Scientometrics*, 81, 587. DOI: 10.1007/s11192-009-2178-0
- Vinkler, P. (2018). Structure of the scientific research and science policy. *Scientometrics*, 114(2), 737-756. DOI: 10.1007/s11192-017-2568-7
- Wen, Z., Cai, T., Feijó, A., Xia, L., Cheng, J., Ge, D., & Yang, Q. (2020). Using completeness and defaunation indices to understand nature reserve's key attributes in preserving medium- and large-bodied mammals. *Biological Conservation*, 241, 108273. DOI: 10.1016/j.biocon.2019.108273
- Wilson, K.A., Auerbach, N.A., Sam, K., Magini, A.G., Moss, A.S.L., Langhans, S.D., Budiharta, S., Terzano, D., & Meijaard, E. (2016). Conservation research is not happening where it is most needed. *PLOS Biology*, 14(3), e1002413. DOI: 10.1371/journal.pbio.1002413
- Wouters, P., Sugimoto, C.R., Larivière, V., McVeigh, M.E., Pulverer, B., de Rijcke, S., & Waltman, L. (2019). Rethinking impact factors: better ways to judge a journal. *Nature*, 569, 621-623. DOI: 10.1038/d41586-019-01643-3

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