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ANIMAL SCIENCE

Lontra longicaudis (Carnivora: Mustelidae: Lutrinae): a scientometric analysis

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Abstract: A scientometric analysis of the Neotropical Otter is essential to establish the progress in studies with the species, in order to improve its conservation status. This study aimed to identify, categorize, and evaluate published scientific papers on *Lontra longicaudis*. Quantitative data was analyzed through absolute and relative frequencies, represented by tables and maps. The results showed that the publications on the Neotropical Otter increased since 1993 and have been primarily published in a specific journal (IUCN Otter Spec. Group Bull.) on the subfamily Lutrinae. Most authors reside in countries such as Brazil, Mexico, and Colombia, and publish predominantly in English. The majority of studies were conducted with free-living specimens, notably in the Brazilian state of Rio Grande do Sul and in Mexico. The most commonly used keywords match the most frequent subjects: "place of occurrence" and "diet". Despite the increase in publications, research on the Neotropical Otter is still largely limited to Brazil, Mexico, and sites near research institutions. Gaps on essential information for the species conservation, such as its biology, ecology, and behavior, were identified. The need for further studies on the Neotropical Otter in all the territory it inhabits is evident.

Key words: Conservation, distribution, feeding, Neotropical Otter, neotropical region.

INTRODUCTION

The Neotropical Otter [*Lontra longicaudis* (Olfers, 1818)] is considered a near threatened species (Rheingantz & Trinca 2023) that usually inhabits forest environments, riparian forests, lakes, rivers, and coastal regions with access to freshwater (Bertonatti & Parera 1994). Its distribution is registered from Mexico to southern Latin America, except for Chile (Parera, 1996, Rheingantz et al. 2017). In Brazil, all biomes documented its occurrence (Rodrigues et al. 2013, Rosas-Ribeiro et al. 2017). The Neotropical Otter, a semi-aquatic mammal of the Mustelidae family, has morphological adaptations that enable efficient motion in aquatic environments, where it usually feeds (see Cheida et al. 2011). Feces are deposited on logs and rocks along water bodies, facilitating distribution and feeding habits studies (Fonseca da Silva et al. 2008).

National otter conservation plans must be developed in order to identify regional threats and design specific conservation strategies. In this sense, data obtained from every country can be combined and compared to each regional conservation status (Duplaix & Savage 2018). Promoting the species' conservation requires understanding its biology and ecology, as well as identifying the methodology used by researchers in the field, since different approach patterns may influence conservation strategies.

The existing knowledge about a species can be measured through scientometry; that is,

through the study of the quantitative aspects of science and scientific production. This procedure examines quantitative progress of science, relationships between science and technology, communication structure among scientists, researchers' productivity and creativity, relationships between scientific development and economic growth, among others (Spinak 1998). Analysis of scientometrics data can inform about a country's current orientation, scientific dynamics, and participation in science worldwide (Macias-Chapula 1998). This method closely examines researchers' performance and focuses on specific fields of study, allowing a greater comprehension of research data and identifying fields that require more attention (Vanti 2002). Thus, scientometrics is a bibliographic and exploratory method that enables the classification and analysis of data converted into numbers through quantification during information gathering and by statistical techniques (Richardson 1999). This study aimed to identify, categorize, and evaluate scientific papers, published in peer-reviewed journals, on the species *Lontra longicaudis* (Olfers 1818) using scientometric methodology. Through the survey, we intended to quantify and understand the development of studies on the Neotropical Otter and indicate potential gaps and tendencies regarding the subjects of the publications, considering two hypotheses: a) the Neotropical Otter is one of the less studied species within its subfamily, Lutrinae; and b) the most studied subject about the species is its diet.

METHODS

Data collection

For the scientometric evaluation, only open access papers (available to the general public or through a Higher Education Institution access) published in scientific format papers from 1964 (the oldest publication date found) to 2022 were contemplated. The articles were found in scientific databases, such as Scielo, Google Scholar, and Portal Capes, in the bibliographic references of the publications themselves, and in websites of journals related to the subject. The terms "Neotropical Otter", "lontra Neotropical" (in Portuguese), "*Lontra longicaudis*", and "*Lutra longicaudis*" were used as keywords in the searches. Each article analysis examined information such as title, year of publication, and location, that were later compiled into online spreadsheets. To quantify the information and evaluate the articles, eight variables, listed and described in Table I, were created.

In order to assign a specific percentage of data for each variable, the number of times each group of data occurred in a variable was summed and then divided by the total data for the variable. For example, for the location of the studies, the number of times a given country was cited was summed up and then divided by the total number of mentions of countries where studies were conducted. Studies that addressed more than one country were computed together as "More than one country". The same occurred for the geopolitical states of Brazil and Mexico, where studies conducted in multiple states were grouped. For keyword standardization, only terms in English were considered.

The title, abstract, and keywords of the articles were used to determine the subjects specified in Table I.

Data analysis

In order to determine how the studies are conducted, the most common subjects and tendencies (in terms of perspectives for future studies based on existing ones), the BioEstat 5.3 software (Ayres et al. 2007) was used to conduct an analysis of the absolute frequency (number of articles for each variable and, particularly for the

Table I. List and description of each variable established to evaluate the articles on the Neotropical Otter.

Variable	Description
Year	Year of publication
Journal	Journal name
Author's residence for correspondence	First author's country of professional affiliation or residence at the time of publication
Language	Original language
Study site	Country or geopolitical state in which the studies were conducted
Condition in which studies were conducted	State A = free-living animals State B = captive animals State C = theoretical studies
Keywords	When available in the articles
Subject	Geographical distribution; Diet; Threat; Habitat; Biology; Genetics; Review; Behavior; Conservation; Ecology; Home range

subjects, the number of articles for each variable established in Table I), and analysis of relative frequencies (percentage value of the number of articles for each variable and subject category in relation to the total number of articles) were conducted for each variable in Table I, sometimes represented graphically. To analyze research trends, a word cloud containing the keywords of the articles was generated through the "Wordclouds.com" website. To analyze the studies in terms of place of occurrence, a map was generated through the *Qgis* 3.22 software (QGIS Development Team 2022).

RESULTS

A total of 278 articles (see References https://drive.google.com/file/d/1NZAbgB-LhIXDezsYnlKbvKcnY0ysw4Kn/view?usp=drive_link) involving studies on the *Lontra longicaudis*, published in journals between 1964 and 2022, were identified (Fig. 1). The first 29 of 58 years of study were marked by a single publication every two years, with a substantial subsequent increase (X^2= 224.82; g.l.= 1; p<0.0001).

The journal with most publications on the species was "IUCN Otter Spec. Group Bull.", from Luxembourg, with 70 articles (25.2% of the identified articles), followed by the Mexican journals "Therya", with 19 publications (6.8%) and "Revista Mexicana de Biodiversidad", with 11 publications (4%); the journals "Mastozoologia Neotropical" (Argentina), "Iheringia, Série Zoologia" (Brazilian), "Mammalia" (French), and "Check List" (Brazilian) presented five articles each (1.8%). The remaining journals account for less than 1.5% each (Supplementary Material - Table SI).

Regarding the residence of the authors responsible for correspondence, Brazil represents almost half of the publications on *Lontra longicaudis*, with 46.6% (n= 129 articles) of the articles, followed by Mexico (26.4% n=73 articles), Colombia (6.9%, n=19 articles), Argentina (4.7%, n=13 articles), and the United States (3.6%, n=10 articles). Additionally, 16 other countries had publications about the species; however, each of them accounted for less than 3% of the articles (Table SII).

For approximately 35 years (since the publication of Cockrum 1964), the publication rate concerning the species was one article per year, increasing from the year 2000 onwards (Fig. 2), with an average of 10 publications per year.

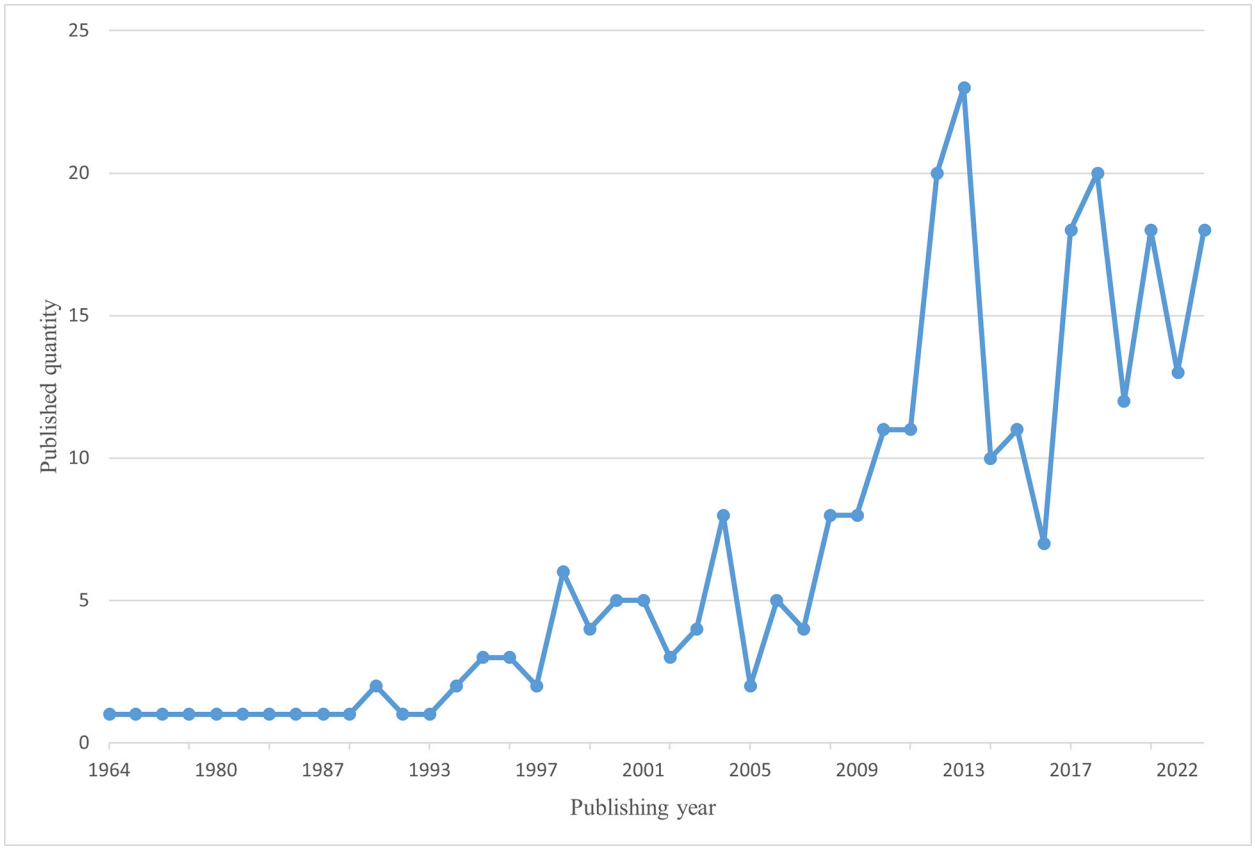

Figure 1. Number of publications on the *Lontra longicaudis* between 1964 and 2022.

Brazil was the country with the highest increase in publications during this period, with a peak in 2012, followed by Mexico, which presented a peak in 2013.

The language in the published articles was predominantly English (70%, n=195 articles), followed by Spanish (19%, n=53), and Portuguese (10%, n=29).

The vast majority of the publications (79.4%, n= 220) were conducted with free-living specimens, while 16.6% (n=46) were theoretical studies, including reviews and laboratory studies. Only 4% (n=11) of the studies used captive animals.

Among the 20 countries that encompass the Neotropical Otter geographic distribution, 16 had published studies on the species; Brazil published almost half of them (45.5%, n=126), followed by Mexico (27.4%, n=76), Colombia (7.2%, n=76), and Argentina (5.1%, n=14). Other studies (n=24) were conducted in 10 countries but accounted for no more than 2% each. In 12 other papers (4.3%), the research was conducted in more than one country. Theoretical studies on the Neotropical Otter were also conducted outside its geographical distribution, in Germany and in the United States (0.8%, n=2).

Since Brazil and Mexico were the countries with the most studies, the publication frequency in both countries' states was evaluated (Fig. 4). Of the 31 Mexican states, 18 had papers on the species; Veracruz, in the eastern region, accounted for the largest number of publications (18.4%, n=14 articles), followed by the state of Oaxaca in the southwest (11.8%, n=9 articles), Jalisco in the west (7.9%, n=6 articles), and Campeche in the southeast together with Sonora in the northwest (6.6%, n=5 articles).

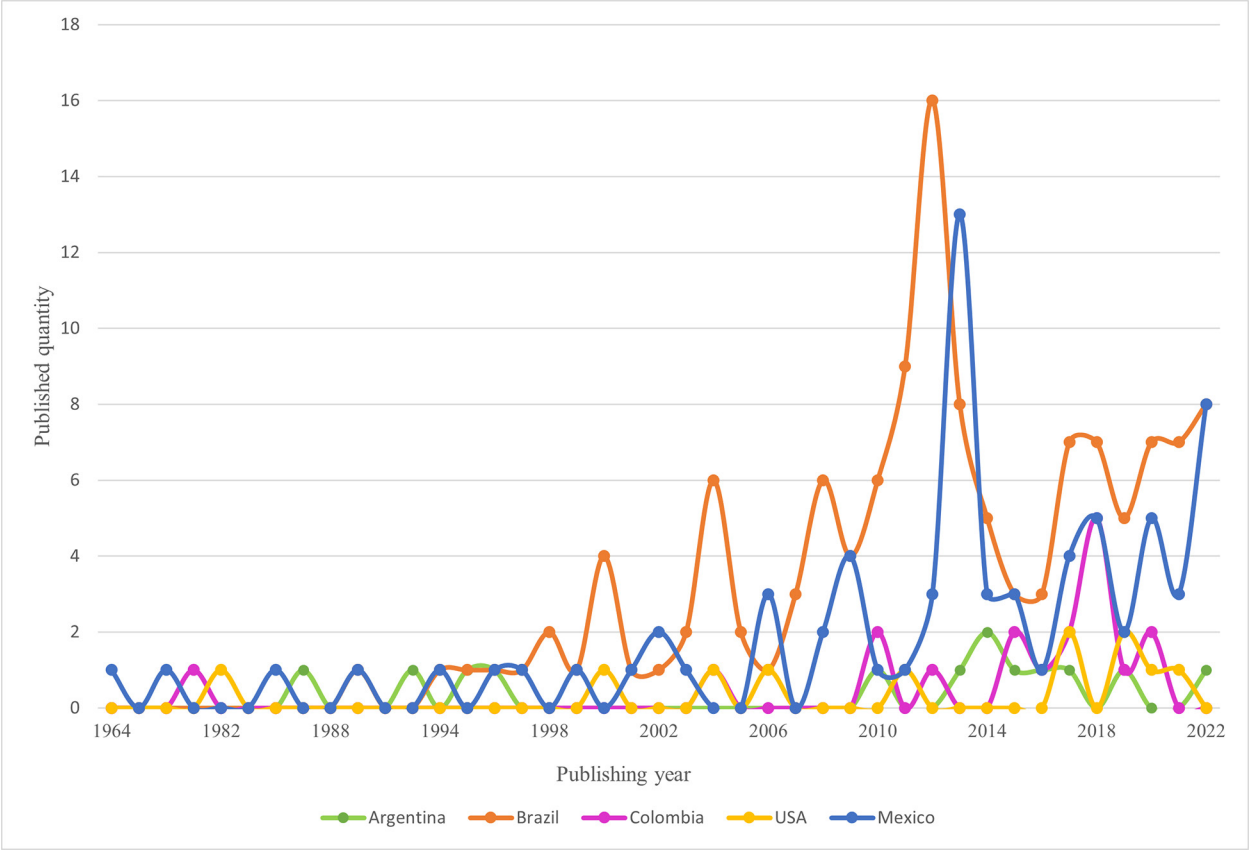

Figure 2. ***Lontra longicaudis*** **studies in the five most frequent countries regarding authors' residence.**

The remaining states accounted for less than 6%, and 13 studies (17.1%) covered more than one state.

In Brazil, 18 of the 26 states, besides the Federal District, were represented. The Brazilian state of Rio Grande do Sul had the highest proportion of published articles (23%, n=29), followed by the states of Santa Catarina (18.3%, n=23), São Paulo (11.9%, n=15), Amazonas (6.3%, n=8), and Paraná (5.6%, n=7). Other states accounted for less than 5% and 15 studies (11.9%) covered more than one state.

The most used terms in keywords in the surveyed articles included *Lontra longicaudis*; otter; Neotropical; diet; distribution; and Mustelidae (Fig. 5). Some articles did not contain keywords due to the journals' guidelines. The keywords of the articles containing them (75.8%, n=210) were used to develop a word cloud (Fig. 5).

The most prevalent subjects among the articles were "place of occurrence" (30.1%, n=82 articles) and "feeding" (23.5%, n=64 articles), followed by "threat" (10.3%, n=28 articles), "habitat" (8.8%, n=24), "biology" (7.7%, n=21), "genetics" (5.5%, n=15), and "review" (5.1%, n=14). The remaining articles represent less than 5% for each subject, as in the case of "behavior" (11 articles; 4%), "conservation" (10 articles; 3.7%), "ecology" (seven articles; 2.6%), and "living area" with only two articles (0.7%). The subject "conservation" was usually inserted within the other subjects, as one of the research goals, without necessarily being the only article subject. Figure 6 presents a list of the subjects and their locations, which were already introduced in Figures 3 and 4.

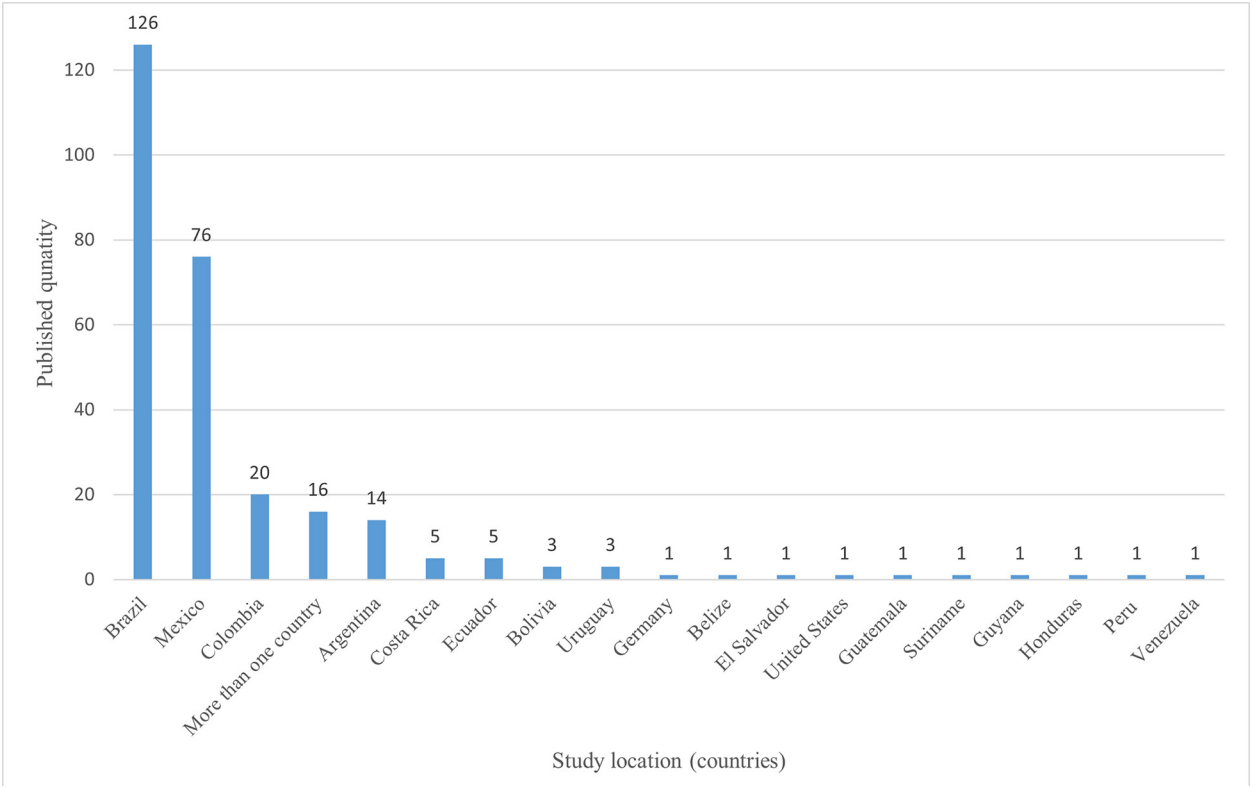

Figure 3. Relation between the studies' location and the number of published papers

DISCUSSION

The first 29 years (since the publication of the article by Cockruim 1964, onwards) of studies concerning *Lontra longicaudis* had little publication effort, as verified through the 278 articles analyzed. However, from 1993, there was a significant increase, despite annual variations.

Between 2013 and 2014, Brazil was ranked 23rd in the world ranking for scientific research (Global Overview 2015). In 2020, the Brazilian publication rate grew 32.2% compared to 2015, taking the country to the 13th place in the ranking. Environmental Sciences, Ecology, and Zoology are research fields with a great number of articles published in this period (CGEE 2021). Since 2010, studies concerning otters have had 10 publications per year on average, a low number compared to the entire scientific production in the country. Other countries inhabited by the Neotropical Otter follow the same trend with a low number of articles on the species, reinforcing the hypothesis of low occurrence of studies with the Neotropical Otter compared to other lutrinean species, such as *Lutra Lutra* with approximately 2300 articles published since 1890 (Camp 2021a), *Lontra canadensis* with around 1300 articles published since 1885 (Camp 2021b), and *Enhydra lutris* with about 800 studies published over a period of 80 years (Camp 2021c). Proportionally, calculating the average number of publications every 10 years, those species still hold a higher number of studies (*Lutra Lutra*: n=174; *Lontra canadensis*: n=92; *Enhydra lutris*: n=75) than *Lontra longicaudis* (n=46).

As a journal of the IUCN Otter Specialist Group, it is no surprise that the IUCN Otter Spec. Group Bull. has been the journal with the highest number of articles published on the Neotropical Otter. The Mexican journal "Therya" is also

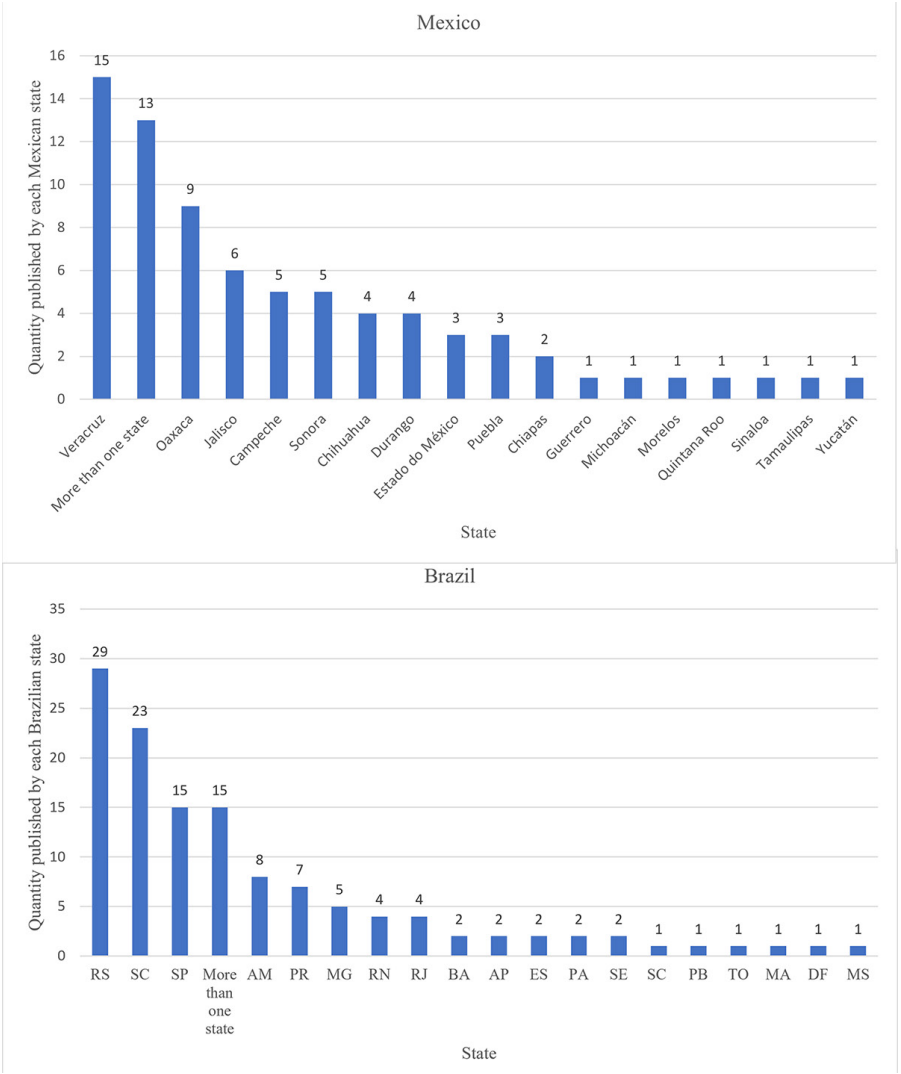

Figure 4. Mexican and Brazilian states with studies on *Lontra longicaudis* and the amount of published articles (RS - Rio Grande do Sul; SC - Santa Catarina; SP – São Paulo; PR - Paraná; AM - Amazonas; MG - Minas Gerais; RJ - Rio de Janeiro; RN - Rio Grande do Norte; AP - Amapá; BA - Bahia; ES - Espírito Santo; SE - Sergipe; DF - Distrito Federal; MA - Maranhão; MS - Mato Grosso do Sul; PA - Pará; PB - Paraíba and TO - Tocantins).

worth mentioning, as most of its publications were submitted by Mexican authors, including the studies on otters mentioned throughout this article, demonstrating an appreciation of national production.

The scientific articles in Latin America, indexed by the Web of Science, indicated that, in 2018, Brazil was the country with the most articles published in the scientific field (Albornoz et al. 2018), which reflects the proportion of studies with the Neotropical Otter. When compared to Brazil, Mexico has less than half the number of scientific publications (Albornoz et al. 2018); however, its publications on the Neotropical Otter are equivalent to two-thirds of Brazilian publications on the subject. It should be noted that four Neotropical countries with the confirmed presence of the Neotropical Otter (Nicaragua, Panama, French Guiana, and Paraguay) do not have published data in scientific articles on the species. Conversely, the United States, leading nation in research at the time (Nature 2021), registers 11 authors in articles on the species, despite not being suitable as a habitat.

Besides the water resources — which allow the Neotropical Otter to survive in different ecosystems — the large amount of studies

located in Brazil may be associated with the high number of research institutions in the country, especially in the Southeast and South, where a large number of studies on the species are concentrated (Fig. 5). According to the last census of the Directory of Research Groups in Brazil, published in 2016, 531 institutions registered 37,640 research groups and, out of this total, 42.5% (16,009) are located in the Southeast and 22.9% (8,637) in the South (CNPq 2023). This scenario may be related to research funding, as explained by Ángel Badillo, lead analyst at the Royal Elcano Institute, who reports that "70% of investment in R&D (Research and Development) throughout Latin America comes from Brazil and the main source of funding is the public sector" (OEI 2021).

Similar to the place of residence of the authors, where the research institutions are located, the locations of the studies are influenced by research funding and, in this case, the concentration of study centers in certain places, such as Mexico and Brazil. Particularly in Brazil, as shown by the results of this study in Figure 6, the states of the Southeast and South regions present more studies, especially the latter. These are the states where the research institutions that have published the most in recent years are concentrated (Sidone et al. 2016). With this perspective, the lack of studies in the Pantanal and Amazon biomes (central and northern Brazil) is noticeable.

Rheingantz et al. (2017) reported the presence of *L. longicaudis* in almost every Central American country, but little information

Figure 5. Word cloud with the most used terms in keywords in the articles published on *Lontra longicaudis* between 1964 and 2022. The bigger the word, the higher its frequency.

is available in this region — an unchanged scenario in the last five years according to the present study. Costa Rica is a good example of the relevance of research institutions in Central America. The results obtained by studies from the Centro de Investigación en Biodiversidad y Ecología Tropical (CIBET), in one of the oldest universities of the country, which has the biodiversity catalog of Costa Rica and its surroundings as a field of research corroborate this importance (CIBET 2021).

Three countries presented an increase in research with the species between 2010 and 2015, with only Colombia peaking after 2015. The Colombian scientific production increased its publications on digital platforms from 2006 to mid-2012, but still needs international exposure (Massarani et al. 2021), which is reflected in otter research.

English is the main language used for publications, as most of the journals sought by authors are international. These results are consistent with the OEI's 2020 report, in which 84% of researchers located in the Ibero-American region chose to publish their work in English in 2020 (OEI 2021).

Unlike other species, *L. longicaudis* is studied in captivity. The species is known to be present in zoos in Latin America, especially in Mexico and Brazil (Duplaix & Savage 2018). Some zoos and private institutions have their own research projects, such as the Mexico City Zoo (Mexico), the São Paulo Zoo (Brazil), the Ekko Brazil Institute, and the Otter Project in Santa

Figure 6. List of the most frequent themes in articles featuring *Lontra longicaudis* and the location where the studies were conducted. The green shading a projection of the current potential distribution of the species, according to data from occurrence place studies. The circles symbolize these themes and are illustrated with random coordinates within each state.

Catarina (southern Brazil). These locations also develop studies with external support through university researchers and students, mostly requiring permits from competent authorities and bioethical criteria (Distrito Federal 2012). However, researchers often conduct studies on free-living animals, since they are accomplished mostly by collecting traces, without the researcher necessarily having to meet the animal.

Regarding the use of keywords, the scientific name (*Lontra longicaudis*) and the English common name (Neotropical Otter) were the most frequent. Next, the terms "Conservation", "Diet", "Feeding", and "Distribution" appear, which, except for the first, are terms linked to the most frequent subjects — places of occurrence and nutrition.

Studies of places of occurrence were the most numerous, followed by studies related to the otter's diet. This is possibly due to the simple and low-cost logistics of these studies, based on the presence and analysis of feces, commonly found in the field (Kruuk 2006). Geographic distribution studies can take advantage of nutrition data, direct sightings, or even other traces, such as carcasses, museum specimen records, and literature compilations (Parera 1993, Passamani & Camargo 1995, Soutullo et al. 1998, Silva-López 2009, Astúa et al. 2010, Platt & Rainwater, 2011, Duque-Dávila et al. 2013), as well as roadkill records (Mendonça & Medonça 2012, Mesquita & Meneses 2015). It is worth emphasizing that some studies reported the presence of *L. longicaudis* outside the current known geographic distribution area (Fig. 6), reinforcing the importance of scientometrics for understanding the areas occupied by the species.

Despite diet being one of the most studied subjects for the Neotropical Otter, it is still concentrated in some specific regions, such as southern and southeastern Brazil, and only eight Mexico states, refuting the hypothesis that the subject is saturated.

Although "conservation" is not the main subject of the articles, it appears as a keyword in most of them, generating subsidies for effective conservation actions towards the species, which is widely distributed and considered almost threatened with extinction (Rheingantz & Trinca 2023). The large geographic range of the Neotropical Otter covers many different biomes and diverse habitats and relates to the fourth most studied subject (habitat), which seeks to understand how they are used by the species (Quintela et al. 2012). The few articles related to ecology (Kasper et al. 2004, Casariego-Madorell et al. 2006), behavior (Bettoni et al. 2021), and biology (Arcila & Ramírez 2004) reflect the difficulty to detect the species in its natural habitat and observe them directly.

CONCLUSION

Based on the obtained and analyzed data, it is evident that studies with *L. longicaudis* have temporal and effort variations throughout its wide distribution, thus requiring further planning in future research.

The present study has provided an in-depth understanding of research with *Lontra longicaudis* over the last 60 years. Even if "place of occurrence" and "diet" are the subjects studied most, there are still other topics to be explored. Being a near-threatened species (Rheingantz & Trinca 2023), there are still few articles dealing directly with conservation, which are extremely necessary to standardize the legislation and design mitigation measures. Therefore, it is evident r that there is a lack of studies pertaining to various areas that would indicate occurrence locations of the neotropical otter. This highlights a dearth of information

within the potential distribution area of the species.

In short, despite the efforts, the species is poorly studied in regard to its many biology and ecology aspects, even in the countries presenting the largest number of studies. The rare efforts in Central America and in some states of North and Northeast Brazil, which have tropical forests and rivers, are noteworthy. They highlight the need for joint efforts to build understanding of the different biology and ecology aspects of the Neotropical Otter, thus enabling the creation of effective conservation policies.

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SUPPLEMENTARY MATERIAL

Tables SI, SII.

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