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**HUMAN- WILDLIFE CONFLICTS OF TWO EMBLEMATIC SPECIES IN LATIN
AMERICA: THE CASE OF JAGUARS (*Panthera onca*) AND ANDEAN BEARS
(*Tremarctos ornatus*)**

TDK paper

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Introduction

As the world population increases, animals and humans face a competition for the limited resources available (Ceballos et al., 2015; Margulies & Karanth, 2018). Also, humans have expanded their settlements and agricultural areas to meet their needs. According to the Economic Commission for Latin America and the Caribbean from the United Nations (2021), in Latin America and the Caribbean, forest cover declined from 53 % to 46 % of its land area, between 1990 and 2020; this is explained by the new uses of land for agriculture, forestry and livestock ranching (Ballejo et al., 2022; Debebe et al., 2023). This situation changes the interaction between humans and wildlife, causing not only human-wildlife conflict (HWC), but conflicts between different groups of people (Madden & McQuinn, 2014; FAO, 2015; Frank et al., 2019).

Wildlife can be seen as a threat to human wellbeing, especially in rural areas (Mekonen, 2020), which generates the HWC (Brackowski et al., 2023). HWC is defined by the IUCN SSC Human-Wildlife Conflict & Coexistence Specialist Group as “struggles that emerge when the presence or behaviour of wildlife poses actual or perceived, direct and recurring threats to human interests or needs, leading to disagreements between groups of people and negative impacts on people and/or wildlife” (IUCN SSC HWCTF, 2023).

HWC involves species such as big cats, elephants, primates, crocodilians, bears, rhinos and many more (IUCN SSC HWCTF, 2023). These conflicts are not new, because wildlife and people have coexisted for millennia (Dickman and Hazzah, 2016). However, they have become a global concern for conservation issues (Can et al., 2014; Marchini, 2014), trying to achieve sustainable solutions for the problems it may cause and guaranteeing species survival and the protection of livelihoods for human populations. These efforts are reflected even when shifting the conservation language to a more positive one, using words such as “coexistence” instead of “conflict” (Venumière-Lefebvre et al., 2022).

In Latin America, farming and livestock are considered important economic activities to contribute to food security (Rodriguez et al., 2016). Therefore, it is a key step to find solutions to HWC related to livestock predation and wildlife damage on crops (Karanth et al. et al., 2013), not just for the economic benefits of farmers, but to prevent and control biodiversity loss in the region.

The jaguar (*Panthera onca*) and the Andean bear (*Tremarctos ornatus*) are two of the most symbolic species of large mammals in Latin America; but individuals are being hunted by farmers or ranchers in retaliation for damages caused by them to livestock or crops (FAO, 2015; Hernández,

2016; Knox et al., 2019). In this region there is a significant number of research carried out on HWC, most of them aimed at analyzing the problem between felines (such as the jaguar) and other carnivores with livestock and agricultural production; however, in countries like Ecuador, studies have focused on conflicts related to the Andean bear (Iñiguez-Gallardo et al., 2021).

The jaguar is categorized by the IUCN (2016a) as “Near Threatened” on the Red List. According to Zimmermann et al. (2005), in Latin America, conflict between jaguars and ranchers not only leads to livestock losses, but the killing on many jaguars (Marchini & Macdonald, 2012). This is one of the main threats to jaguars in the region (Pooley et al., 2016). On the other hand, the Andean bear, is categorized as “Vulnerable” by the Red List of the IUCN (2016b). It is the only ursid (bear) in South America (Peyton et al., 1999) and habitat loss and illegal hunting due to human-bear conflicts are some of the main reasons of that categorization (Can et al., 2014), like it is for the jaguar.

Due to the need to comprehensively address HWC involving these two species, we reviewed findings from articles about HWC in Latin America related to jaguar or Andean bear in order to (i) determine the countries where the research projects were conducted, (ii) identify the type and extent of problem(s) caused by the species, (iii) recognize the common problems caused by both species, (iv) identify the proposed and/or applied strategies to solve the problem(s), (v) establish if there are common strategies for both species and (vi) determine the effectiveness of the proposed and/or applied strategies, in case they were assessed by the article.

Objectives

General

Assess the current knowledge on HWC related to jaguar and Andean bear in Latin America and the strategies applied to manage them, through a systematic review.

Specifics

1. Determine the countries where the research projects about HWC related to jaguar and Andean bear in Latin America were conducted.
2. Identify the type and extent of problem(s) caused by the two species in the selected papers, recognizing the common problems caused by them.

3. Identify the proposed and/or applied strategies to solve the problem(s), establishing if there are common strategies for both species.
4. Assess the effectiveness of the proposed and/or applied strategies, in case they were assessed by the articles.

Literature Review

Human- Wildlife conflicts, the concept

Human and wildlife conflicts are not a new phenomenon. They have existed for as long as humans and animals have shared areas and resources. As a response to those conflicts, people kill, capture or harm the “problematic” wildlife (Marchini, 2014; Madden, 2004). These conflicts have intensified in the last decades, due to the human population growth and with it the expansion of agricultural and industrial activities, but also due to the growth of some wildlife populations (Gutierrez et al., 2016). In the last two decades, scientists have started to address these negative interactions as human- wildlife conflict (HWC) (Marchini, 2014).

For humans, the consequences of the HWC are economic costs, direct costs in terms of human life and a negative perception of coexistence with wildlife (Lorand et al., 2022). An important aspect related to the HWC is the emotional impact of the conflict, that is related to the size and charismatic status of the species involved; for example, in human- large carnivore conflicts, there is the presumption that large carnivores might be a danger to human and livestock (Nyhus, 2016; Venumière-Lefebvre et al., 2022).

To address the HWC, it is important to work jointly with local communities affected by wildlife. The first important tool is the identification of stakeholders, it is also important to map and understand the conflict and finally, test and adapt strategies (like education and compensation) according to the context, being these very specific for each case (Gutierrez et al., 2016; Lozano et al., 2019). The effectiveness of these strategies is challenging because every case is different and there’s a knowledge gap and lack of consistency in the results of the studies assessing it (Khorozyan and Waltert, 2020).

Human- Wildlife conflicts around the world

Carnivores are one of the major wildlife species involved in HWC. Large carnivores play a key direct or indirect role in ecosystem services but are threatened on a global scale. The decreasing of

the large carnivores' populations may bring significant imbalance in ecosystems, especially when they are top predators (Ripple et al., 2014). Since 2000, the number of articles about human-carnivore conflicts have increased, probably due to the growing interest in carnivore conservation, but also due to the concerns that come from the increasing number of human- carnivore conflicts. Most of these studies have been conducted in the Global North and are about grey wolf, brown bear and American black bear (Lozano et al., 2019; Su et al., 2022).

Regarding Europe, some research reports that carnivore populations are recovering, even outside of protected areas, due to the more protective legislation across the continent (Chapron et al., 2014; Palacios-Pacheco et al., 2024). Brown bear is the most abundant large carnivore in Europe, followed by the grey wolf and both species are persisting in human-dominated landscapes (Chapron et al., 2014), which aggravates human wildlife conflicts with these species. Even when carnivore management is a recurrent topic in human-carnivore publications and several studies recommended social measures, only some of them evaluated their effectiveness (Palacios-Pacheco et al., 2024). When talking about the management of these conflicts in Europe, based on the experience of the LIFE Program from the European Commission, research indicate that social and environmental context can influence the effectiveness of measures to prevent human- carnivore conflict, for example, the availability of natural prey, the breed of domestic animals, the carnivores' space use and their habituation to human presence (Oliveira et al., 2021; Grossmann & Patkó, 2024).

Research has also been conducted about the human- mesopredator conflicts in Europe, like raccoons, red foxes and striped skunks, finding that the most common problem are wildlife and livestock killing and the predation on eggs of birds and turtles; for example, more than 30 % of deaths of red foxes in Europe cities are due to animals being killed as a response to any HWC (Bateman & Fleming, 2012). About its mitigation, researchers have found a strong support for a positive effect size for mitigation measures in 74% percent of studies, which according to them would indicate that conflicts with mesopredators are easier to manage than with large carnivores (Lazure & Weladji, 2024).

In North America, human- bear interactions are one of the most common HWC and a priority for wildlife agencies (Spencer et al., 2007). Black and brown bears can adapt easily to human modified places and this situation increases the opportunities for conflicts, like livestock predation and property damage (Can et al., 2014; Ripple et al., 2014). Some of the most effective strategies to

manage these conflicts are those that restrict bear access to anthropogenic food sources, especially during natural food shortage, such as bear-resistant trash cans, electric fencing and livestock husbandry (Kurth et al., 2024).

It is also well known that human- wolf conflicts are common in North America. In the last decade, wolves have recolonized Washington state, and with it, human-wolf conflicts have increased, such as cattle and other domestic animal predation, although in small numbers (WDFW, 2019). To manage these conflicts, researchers propose economic mechanisms that pay to allow rural people to tolerate wolves, instead of compensating them for losses, but highlighting that is key to work about addressing social and cultural concerns of these communities (van Eeden, 2021).

Regarding Australia and New Zealand, these are biodiverse places with HWC related to indigenous and exotic species. For example, rabbits, that coexist with introduced mammals like feral cats, red foxes and mustelids, which consume them as their primary prey (Doherty et al., 2015; Barron et al., 2024). Government agencies have undertaken programs for trapping these predators to protect indigenous species, but rural communities believe that these programs have led to the increase of rabbit abundance, which is causing HWC (Norbury & Jones, 2015). On the other hand, in Southern Australia HWC about snakes are very common, especially with cobras, mambas and taipans, species that possess highly toxic venom and, because of these, attitudes towards snakes are very negative and many people kill them due to perceived danger, ignoring their beneficial effects as pest-controllers (Shine et al., 2024).

Besides the mentioned above, dingoes in Australia are a native species with evolutionary, ecological, cultural identity, which is considered of high conservation priority (Cairns, 2021). This important species is linked to HWC with ranchers (“graziers” in Australia), because they harm and kill livestock. The main strategies to control dingoes are lethal ones: shooting, trapping and poisoning, generating high ecological impacts and worsen the crisis that biodiversity faces in Australia (Boronyak & Jacobs, 2023).

On the other hand, in Asia, the greatest direct threat for the carnivore population is the retaliation killing by farmers in places where livestock husbandry is a dominant land use. In Pakistan, for example, most of the carnivores are present in the northern region and the biggest conflict is with the common leopard (more common than black bear, brown bear, grey wolf and snow leopard). Most of the attacks were at night and when big herds are allowed to graze freely (Danish et al., 2023). In the same country, in the Baltistan region, regarding snow leopards, attacks on livestock

occurred where no herder was present, so vigilance and regulation of livestock intensity can help reduce the conflict (Zaman et al., 2024).

In the case of China, the high overlapping between snow leopard and livestock, perpetuated the persistent predation of livestock by snow leopards, exacerbating human-snow leopard conflict. This is affecting the tolerance of local herders (Wang et al., 2024). For Türkiye, the brown bear is one of the most abundant large mammals, therefore human and brown bear conflicts are also common. Researchers found that this high incidence of conflicts arises from limited protected area coverage, insufficient resources available to brown bears and human encroachment in vital brown bear's habitats (Sıkdokur et al., 2024).

Regarding Africa, for example, the habitat of wildlife in Ethiopia is very fragmented, which has led the species to live in patches (Amaja et al, 2016; Kidane et al., 2024). In the Kafta-Sheraro National Park, the key conflict-causing species are the spotted hyena, leopard, African elephant, common jackal, vervet monkey, anubis monkey, warthog and greater kudu (Kidane et al., 2024). For its part, in Kenya and Tanzania, the elephant population has grown since 1988, so the conflicts with farmers have also increased (Western & Waithaka, 2005; Ngene et al., 2013). In this case, crop raiding is the most common type of human and elephant conflict and about management, even when fencing is the most common tool, it is not necessarily the most effective one (Osipova et al., 2018; Montero-Botey et al., 2024).

As mentioned above, livestock predation is a global problem and is one of the main sources of human- carnivore conflicts. The severity of these conflicts increases with the predator body mass and, in the case of Latin America, the jaguar and the puma, the largest terrestrial predators in the region, are the most important species when talking about HWC (Inskip & Zimmermann, 2009). In the region, the interactions between human activities and carnivores increase with human settlements along the edges of protected areas, increasing also the risk of predation of livestock (Chinchilla et al., 2022).

On the other hand, crop-feeding puts at risk the food security of local communities and affects their economy, causing also a reduction in human tolerance to wildlife (Mekonen et al., 2018; Virtanen et al., 2020). About this kind of conflict researchers have found that the main species related to includes rodents like lowland paca (*Cuniculus paca*), carnivores such as the coati (*Nasua narica*), wild boar (*Sus scrofa*) as an invasive species, the collared peccary (*Pecari tajacu*) and the Andean bear (Cuesta-Hermira & Michalski, 2022).

In this systematic review, HWC caused by the jaguars and the Andean bears in Latin America were analyzed, including its management and the effectiveness of these measures.

The jaguar and the Andean bear

The jaguar is categorized as “Near Threatened” by the Red List of the IUCN (Quigley et al., 2016). It is the largest felid in the Neotropics, and the only living representative of the genus *Panthera* in the New World (Nowell & Jackson, 1996). The jaguar’s historic distribution range included Arizona, New Mexico and Texas in the South-western USA to central Argentina, but currently, the jaguar is distributed from southern Arizona and New Mexico to northern Argentina, it is extinct in Uruguay and El Salvador (Morato et al., 2023). Jaguars are known to range over approximately 8.75 million km² (46% of their historic range), broken into 48 separate areas that range in size from 114 km² to over 7 million km² (Sanderson et al., 2002).

Jaguars can be found in a variety of habitats, such as tropical humid and dry forest, subtropical forest, mangroves, marshlands, mountain forests and savannahs. Its social system is based on territoriality (Morato et al., 2023). Jaguars are associated with the presence of water and are good swimmers. There are some reports about jaguars hunting caimans *Caiman sp.* and capybaras *Hydrochaeris hydrochaeris* in and under the water (Nowell & Jackson, 1996; Morato et al., 2023). Jaguars’ diet consists of more than 85 species; large prey like peccaries, tapirs and deer are preferred by them, but they’ll eat almost any animal that they can catch. In many areas, cattle are ranches in essential habitats for the jaguar, so it is also a very frequent prey species (Nowell & Jackson, 1996). This is why the retaliation killing is a significant threat to jaguar populations across their whole range, as a response to the cattle predation (Quigley et al., 2023; Morato et al., 2023; Zimmermann et al., 2021).

On the other hand, the Andean bear or Spectacled bear is categorized as “Vulnerable” by the Red List of the IUCN (Velez-Liendo & García-Rangel, 2016). It is the only ursid (bear) in South America (Peyton et al., 1999) and illegal hunting due to human-bear conflicts is one of the reasons of that categorization (Can et al., 2014). The Andean bear is endemic of the Andes, from the Cordillera de Merida in Venezuela to the Argentine- Bolivian border (Peyton et al., 1999), showing a continuous distribution along the Occidental, Central and Oriental Andes of Colombia and Peru, Sierra de Perijá and Cordillera de los Andes in Venezuela, both slopes of the Ecuadorian Andes and the eastern slope of the Andes in Bolivia (García-Rangel, 2012).

According to Peyton et al. (1999), the Andean bear can be considered an umbrella species in the Andes; for example, from Venezuela to Bolivia its range is only 3,2 % of the land area in South America, but it contains 76 % of the mammalian species of the continent, including 63 % of endemic mammals in South America. In relation to the habitat use of the species, it is present in lowland, submontane and montane/deciduous, semideciduous and ever-green forests, moors, páramos and puna grasslands, and even coastal deserts to the northwest of the Peruvian Andes (García-Rangel, 2012).

Andean bears are omnivorous, mainly frugivorous with occasional consumption of animal protein. They have an opportunistic feeding strategy with a very diverse diet, based on the resources in the different habitat types that they inhabit (García-Rangel, 2012). The occasional consumption of domestic animals and crops has led to HWC, with retaliation poaching as a result, representing a big challenge for the species' conservation.

Materials and Methods

Sources of data collection

The systematic review was conducted following the PRISMA 2020 Statement (Page et al., 2021) (Figure 1). The search of articles from which 22 articles were selected was performed on October 21, 2023. For this review, diverse databases were consulted: Scopus, Science Direct, Web of Science and Google Scholar. All databases were consulted in “all fields” and filtered for articles or research articles. For Scopus, Web of Science and Google Scholar, the same key words and search string were used: *human-wildlife AND conflict AND ((Andean AND bear) OR jaguar OR (Tremarctos AND ornatus) OR (Panthera AND onca)) AND (Latin AND America)*. Science Direct did not allow too many Booleans connectors, so key words were modified: *human-wildlife AND conflict AND ((Andean bear) OR jaguar OR (Tremarctos ornatus) OR (Panthera onca)) AND (Latin America)*.

The filtering process of the articles selected is shown in Table 1 and Figure 1. We screened the title and the abstract of each article on Scopus first, then Science Direct, Web of Science and, finally, Google Scholar. From that initial screening, the records identified in each database that were directly related to the topic “Human- wildlife conflict in Latin America” with the species *Panthera onca* or *Tremarctos ornatus*, were selected for a deeper review, i.e. an assessment for eligibility (Table 1). After the detailed review of each one of the 27 articles selected, three articles on Scopus

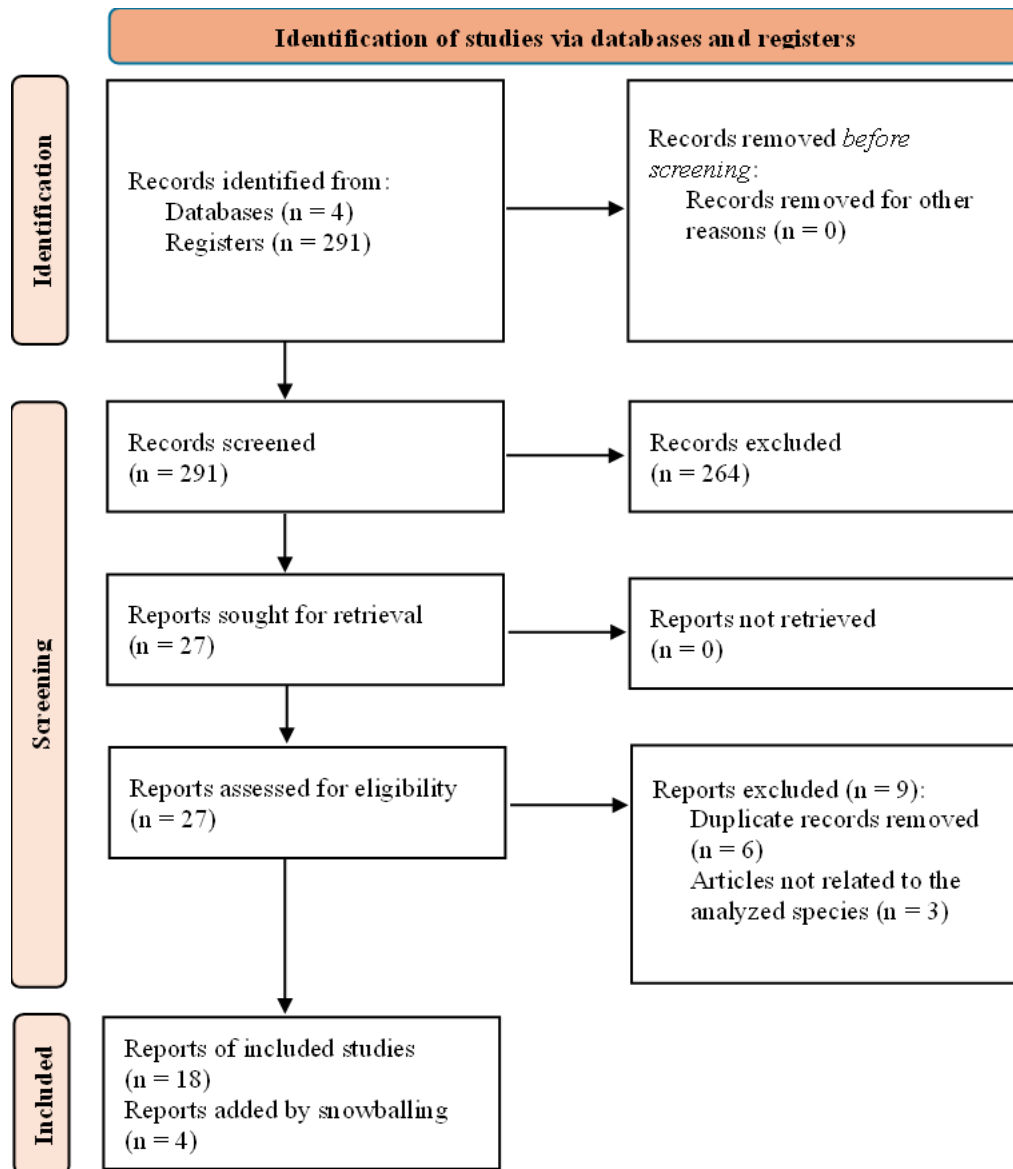
were not related to the analyzed species, two articles already included from Scopus were repeated on Science Direct, two articles on Web of Science and two more papers on Google Scholar.

Table 1. Filtering process for selection of articles for topic review.

Database	Records screened	Articles assessed for eligibility	Articles included
Scopus	73	11	8
Science Direct	54	4	2
Web of Science	7	3	1
Google Scholar	157	9	7
Other			4
TOTAL	291	27	22

Finally, 18 articles were chosen for the systematic review, because they addressed the variables related to the objectives of this review (Appendix 1). Four more articles related to the Andean bear were included in the systematic review, through snowballing by checking the reference list of the articles included in the review (Appendix 1). This was done to get a more representative analysis. We considered that due to the geographic scope of the review, it was important to include articles in Spanish. This is the main reason for the use of Google Scholar as a source of information, because in the other data bases, articles in Spanish were not found. The 22 final articles selected were saved in Zotero software for the management of bibliographic references.

Figure 1. PRISMA 2020 flow diagram for this systematic review. Adapted from Page et al. (2021)



Review of sources and extraction of information

Each of the 22 selected articles was reviewed in detail, to identify information related to the variables of interest that could contribute to achieving the goals of this systematic review. An Excel table was designed to extract the information related to the defined variables from each article, including the following data: title of the article, publication year, authors, country and study area of the research, species studied, identified conflict, quantification of the problem, strategy(ies) applied by communities to solve the problem, effectiveness of those strategies (if it was assessed),

strategies proposed by the authors to solve the problem and if it was an existing strategy, identify if the authors evaluated its local effectiveness.

To identify the effectiveness of the strategies none of the articles established a definition about it. For the purposes of this systematic review, this term was defined as the “measure of the success in achieving a clearly stated objective” (McCormick, 1981), understanding the objective as the management of HWC assessed by the authors of the publications.

Finally, we analyzed the frequency distributions of the findings in the case of the different variables.

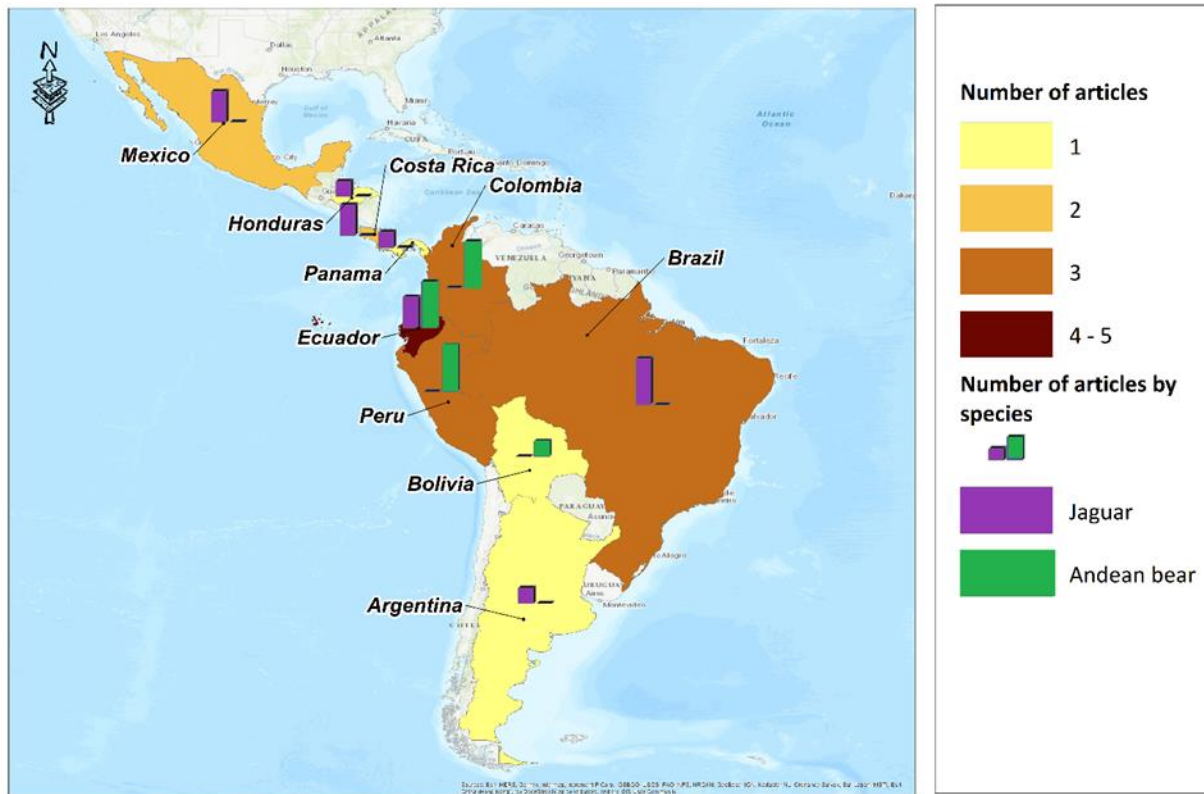
Results and its evaluation

Geographic location of the studies

The 22 research studies (Appendix 1) were conducted in ten Latin-American countries (Figure 2): Ecuador, Brazil, Colombia, Peru, Mexico, Costa Rica, Honduras, Panama, Bolivia, and Argentina. The country with the most articles was Ecuador (five articles); followed by Brazil, Colombia, and Peru (three articles each one); then, Mexico and Costa Rica (two articles) and one article for Honduras, Panama, Bolivia, and Argentina.

Of the analyzed publications, 12 (54.55 %) corresponded to the jaguar (from Ecuador, Brazil, Mexico, Costa Rica, Honduras, Panama, and Argentina) and ten (45.45 %) to the Andean bear (from Ecuador, Colombia, Peru and Bolivia). The only country that has research about both species was Ecuador (two about jaguar and three about Andean bear).

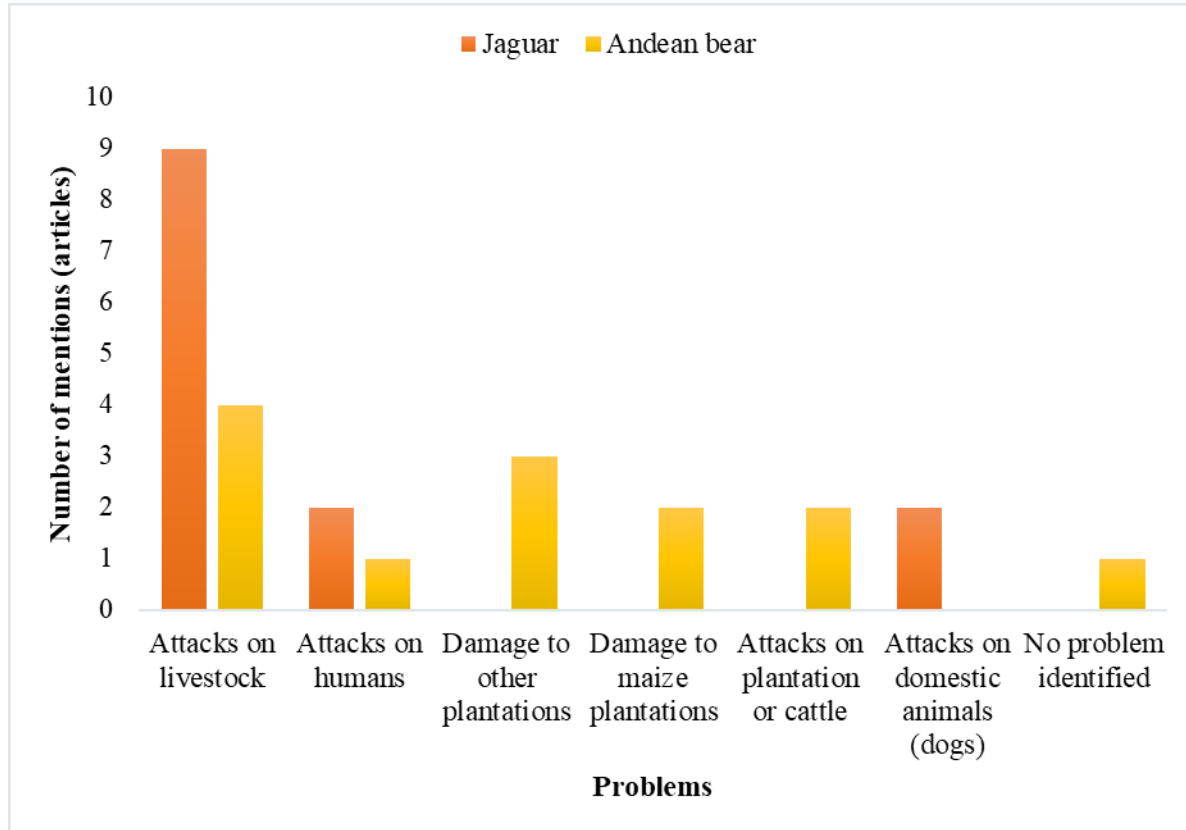
Figure 2. Countries in Latin America where the HWC related to jaguar and Andean bear have been studied. The color of the country indicates the total number of articles, while the bars inside each country show the number of articles by each species.



Problems caused by the jaguar or Andean bear

Related to the conflicts caused by the species, six main problems were identified (Figure 3). The most common was attacks on livestock, for jaguar it was mentioned in nine of the 12 articles and for Andean bear, in four of the ten articles. Another common problem caused by the jaguar and Andean bear was the attacks on humans (two times for jaguar and one for Andean bear). The Andean bear was also connected to problems like damage to plantations, while the jaguar was responsible for attacks on domestic animals (such as dogs).

Figure 3. Problems caused by the jaguar or Andean bear identified in the articles. Note that in one article one or more problems could have been identified.



It is important to mention that in one of the articles about the HWC with Andean bears in Peru, the authors did not identify any problem, because despite bears and cattle were being detected across the same range of elevation, they segregated spatially.

Related to the quantification of the problems caused by the species, authors presented the quantity of killed animals, the number of attacks on livestock or human, the number of plantations damaged; all of those in a given period. The highest number of attacks on livestock by jaguars corresponded to one article from Costa Rica, with 280 attacks until 2014, without annual breakdown (Amit & Jacobson, 2017). This article also stated that the attackers could have also been pumas. For the Andean bear, 250 attacks on cattle were reported from 2009 to 2012 in Ecuador (Jampel, 2016), but the article did not provide information whether it was the same individual or different ones. On the other hand, related to the Andean bear, an article from Colombia registered 190 plants of

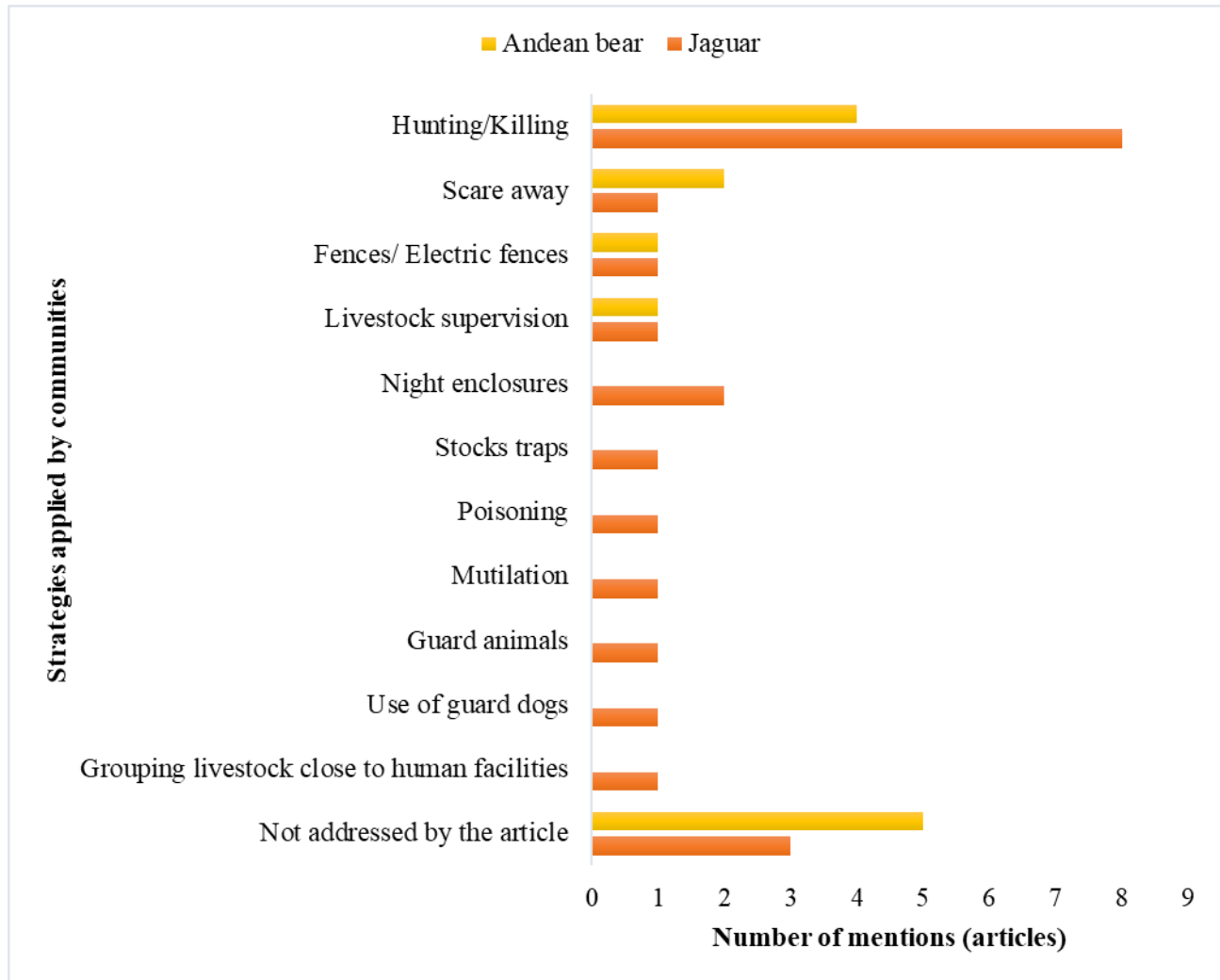
plantain and 47 plants of banana damaged in 198 ha from April of 2017 to March of 2018 (Escobar-Lasso et al., 2020).

Regarding attacks on people, one article from Peru registered two people attacked by Andean bear from 2002 to 2008 (Figueroa, 2015); while in case of jaguar, an article from Brazil described two nonfatal attacks on people from 2007 to 2010 and one fatal attack in 2008 (Campos-Neto et al., 2011).

Strategies applied by communities to manage HWC with jaguar and Andean bear

The most common strategy applied by communities to manage HWC with jaguars was hunting or killing the feline (nine articles- 40.91 % of the total), and the same for the Andean bear (four articles- 18.18 % of the total) (Figure 4). The second most frequently mentioned strategy for both species was scaring away (one article- 4.54 % of the total for the jaguars and two articles- 9.09 % of the total for the Andean bear); however, the articles did not establish what type of strategies were implemented to scare the individual. Other, less common, strategies applied for both species were fences/ electric fences and constant livestock supervision (one article- 4.54 % of the total for the jaguars and one article- 4.54 % of the total for the Andean bear for both protection methods)). Exclusively for the jaguar, there were other strategies applied by communities to manage the problems, such as night enclosures (two articles- 9.09 % of the total), stocks traps, poisoning, mutilation, guard animals, use of guard dogs and grouping livestock close to human facilities. The six last were mentioned just in one article.

Figure 4. Strategies applied by communities to manage the HWC related to jaguar and Andean bear in Latin America. Note that in one article, one or more strategies could have been identified as applied by communities.



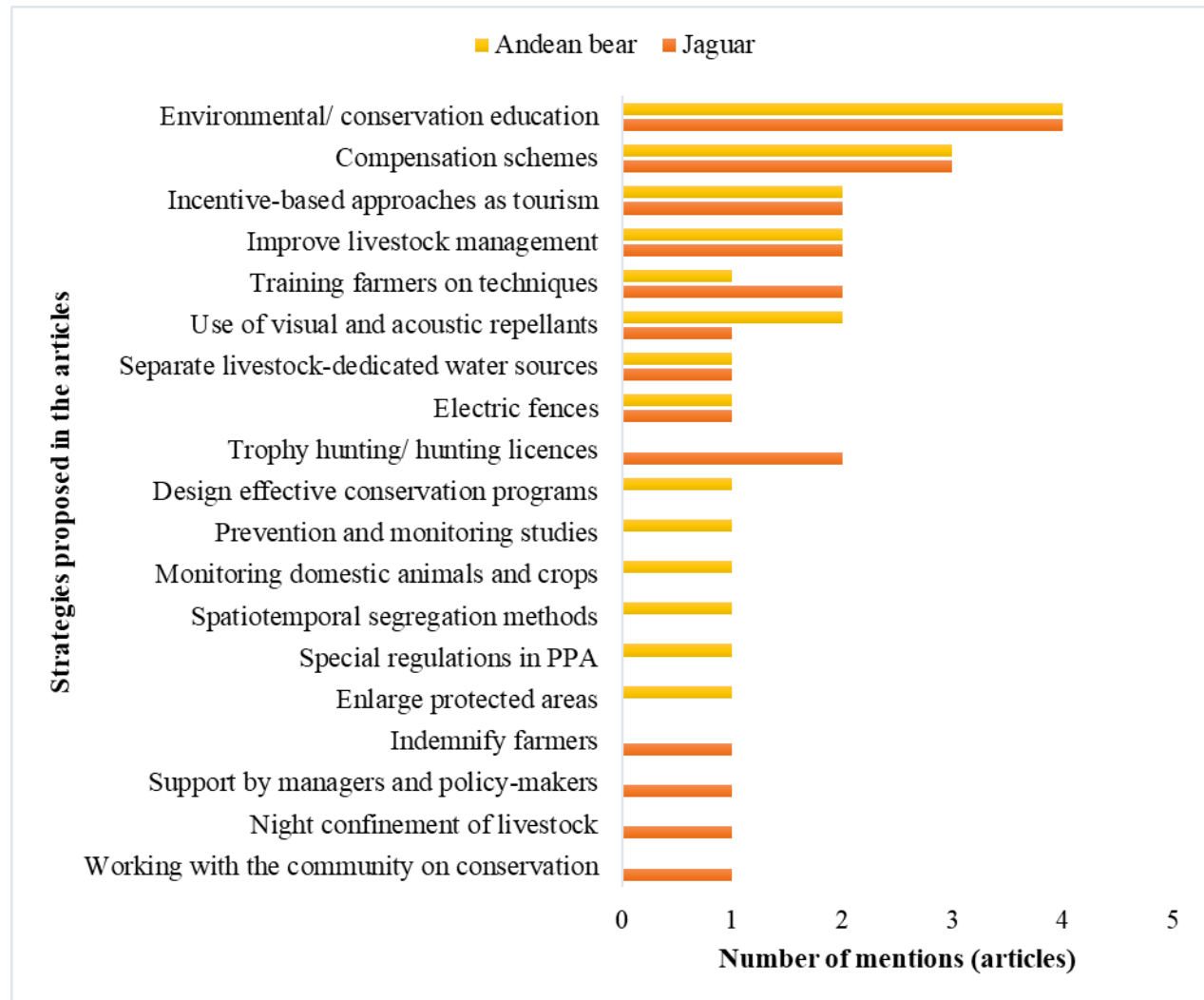
Thirty-six percent of the articles (eight articles) did not include information about the strategies applied by communities to manage the HWC with the two analyzed species.

Strategies proposed by the articles' authors to manage HWC with jaguar and Andean bear

Regarding the strategies proposed by the authors of the publications to manage the HWC with jaguar or Andean bear, the most common strategy was environmental and conservation education, which was addressed in four articles for each species (Figure 5). The proposal of the design of

compensation schemes for farmers and ranchers affected by HWC with the species was the second most common strategy, appearing in three articles for each species. These were followed by incentive-based approaches such as tourism and improved livestock management, mentioned twice for each species.

Figure 5. Strategies proposed by the researchers to address the HWC related to jaguar and Andean bear in Latin America. Note that in one article, one or more strategies could have been proposed.



There were other common strategies proposed by the researchers, but in lower frequency, such as training farmers on techniques to mitigate livestock predation, use of visual and acoustic repellants, separated livestock- dedicated water sources and electric fences and some more others.

Effectiveness of the proposed or applied strategies to manage HWC with jaguar and Andean bear

Only one of the 22 articles (4.55 %) addressed the effectiveness of one strategy applied by communities. This article, related to HWC with Andean bear in Colombia, analyzed the use of fences to manage the conflict. The authors found that it was not an effective strategy, because although the crops were protected by 2-wire fencing to restrict livestock, bears kept entering and damaging the crops (Escobar-Lasso et al., 2020). The same article established that the development of conservation programs (existing strategy) was not effective in the way it was being applied by the government, because although a National Andean Bear Program officially exists in Colombia, its implementation has been insufficient, so communities keep killing bears in retaliation even in absence of the damage.

On the other hand, in relation to the effectiveness of the strategies proposed by the authors in the articles, two of the 22 articles (9.09 %) assessed the effectiveness of two existing strategies. One was the article mentioned above (Escobar-Lasso et al., 2020) and an article related to the jaguar in Mexico found that electric fences and night enclosures to avoid livestock predation were effective strategies because the predation rate was significantly lower after the implementation of the measures (de la Torre et al., 2021). In this article, during the whole monitoring period (167 months), the authors recorded only one predation incident, which happened when the rancher did not enclose the livestock, and four sheep were killed by a jaguar. For them, this indicates a high level of effectiveness of electric fences and night enclosures to prevent attacks on livestock by jaguars.

Another article is highlighted because it assessed the theoretical effectiveness of a proposed strategy (non-existing). This one was related to the jaguar in Brazil. For the authors, a compensation scheme related to tourism was an effective strategy, because their findings demonstrated the financial feasibility of a relatively doable compensation scheme through wildlife tourism (Tortato et al., 2017). They found that the proposed scheme would generate a three-fold higher revenue than the approximate land-use revenue from traditional cattle ranching estimated for a typical farm across the Brazilian Pantanal. However, the authors suggested that it would be necessary to improve management practices, including the application of anti-predation methods in terms of livestock management, before developing a compensation scheme through wildlife tourism.

Based on the results presented above and the analysis of the data, the country with the most research carried out related to the topic of this systematic review is Ecuador, being the only country with publications about both species, jaguar and Andean bear. The other countries only had publications about one of the two species and in a lower number compared to Ecuador.

About the problems identified by authors, it can be established that even jaguar is a more researched species, Andean bear is related to a broader range of problems. Both species were related to attacks on livestock and humans, but additionally, Andean bear was related to damage to plantations, because it is an omnivorous species (Figuerola, 2015; IUCN, 2016b). Based on that, it is vital to work with rural communities to assess those problems, and apply conservation education tools about the environmental services and importance of these two species (Zimmermann et al., 2005; Albarracín & Aliaga-Rossel, 2018; Fort et al., 2018; Andrade et al., 2019; Caruso et al., 2020; Alvarez & Zapata-Rios, 2022; Macias & Vera, 2023) and with them, implementing solutions to manage the HWC, that put people's livelihoods at risk.

However, some research found that, although education and law enforcement are commonly used to change human behavior to reduce human-wildlife conflicts, education had little impact in changing human behavior, so its effectiveness should be carefully assessed (Baruch-Mordo et al., 2011). This is why the evaluation of wildlife-related education programs should be a long-term assessment (Espinosa & Jacobson, 2012) and focus on outcomes that relate to an increase or decrease in HWC rather than measuring only the delivery of education messages (Gore et al., 2006). According to the analyzed literature, in Latin America, people decide to solve HWC by applying strategies that are within their reach to protect their economy and livelihoods. In this review, we found that communities apply 11 different strategies to avoid or solve HWC with jaguar and Andean bear. There were some common strategies used for both species, such as scaring away, fences and constant vigilance of the livestock, but an important finding to highlight is that hunting or killing the individual was a more frequent solution for the problems related to jaguar (Sáenz-Bolaños et al., 2022) than to Andean bear.

The above-mentioned finding could be explained in a way that big cats tend to be more violent than bears, so it is the fear of human of being attacked by an animal that promotes these attitudes (Pooley et al., 2016; Sáenz-Bolaños et al., 2022). In the same way, one of the articles about the HWC with Andean bear in Colombia, presented a historical reconstruction of the problem (Garrido-Corredor et al., 2021).

Based on this review, commonly HWC is more than an economic reason for the retaliation kills, but a sociocultural (social norms and identity) and historical background that motivate people to act in a defined way, including past experiences, culture, political factors and identities. This is why an effective resolution of the HWC will need an interdisciplinary approach, including the socio-economic, ecological and cultural conditions under which these conflicts arise (Dickman, 2010; Marchini & MacDonald, 2012; Escobar-Lasso et al., 2020; Zimmermann et al., 2021).

On the other hand, publications' authors proposed a wide range of strategies to solve HWC in Latin American countries related to jaguar and Andean bear (19 strategies). Environmental and conservation education were the most common option for both species, but this will not be effective without including the human dimensions perspective for understanding and solving HWC (Dickman, 2010; Marchini & MacDonald, 2012; Marchini, 2014; Figueroa, 2015; Escobar-Lasso et al., 2020; Zimmermann et al., 2021; Painter et al., 2022).

Other interesting strategies proposed by the authors include compensation scheme as a compensatory solution (Jampel, 2016; Caruso et al., 2020; Escobar-Lasso et al., 2020). It would be interesting to explore how a more preventive approach could diminish the occurrence of HWC; however, according to the results of this systematic review, solutions are mainly focused on mitigation, compensation or corrective strategies.

Unfortunately, most of the existing and analyzed publications did not evaluate the effectiveness of the strategies applied by communities or the strategies proposed by the authors (de la Torre et al., 2021), although in some cases those strategies existed and were being executed. For example, night penning of livestock, enclosures, support by managers and policymakers and economic compensation were existing strategies in some study areas, but their local effectiveness were not assessed in the articles. In some articles the effectiveness of the measures in other areas was highlighted. For example, the use of visual and acoustic repellants and electric fences were considered effective in a different study in Mexico, where after applying those techniques, the benefit–cost ratios ranged from 1.2 to 26.6, documenting efficacy in reducing losses, without lethal control of jaguars (Chinchilla, 2022).

According to the findings of this systematic review, more research needs to be done about HWC in Latin America related to jaguar and Andean bear. It is key to analyze the roots of the conflicts to understand them and give them the proper management. Only in this way adequate solutions can be implemented.

However, also, research need to be focused on the effectiveness of the strategies applied and proposed, to get a better approach to the problem and to be able to propose and implement real effective management measures to avoid impacts not only on people, but on wildlife. As it was shown, one of the most common measures applied by communities to solve those HWC is killing or hunting the animal, which puts the conservation of the species at risk, that is why working with communities is a key aspect in HWC, so non-lethal measures can lead to manage the problem appropriately. For this, conservation education, as proposed by the authors of the articles, is the key.

Summary

Forest cover in Latin America has decreased in recent years due to the expansion of agriculture, forestry, and livestock ranching, affecting the interaction between humans and wildlife, exacerbating human-wildlife conflicts. Wildlife can be seen as a threat to well-being of human wellbeing, especially in rural areas. This generates conflict between people and wildlife, commonly known as human-wildlife conflict (HWC). HWC are defined by the IUCN SSC Human-Wildlife Conflict & Coexistence Specialist Group as “struggles that emerge when the presence or behaviour of wildlife poses actual or perceived, direct and recurring threats to human interests or needs, leading to disagreements between groups of people and negative impacts on people and/or wildlife” (IUCN SSC HWCTF, 2023).

For humans, the consequences of the HWC are mainly economic costs, direct costs in terms of human life and a negative perception of coexistence with wildlife. Therefore, an important aspect related to the HWC is the emotional impact of the conflict, that is related to the size and charismatic status of the species involved; for example, in human- large carnivore conflicts, there is the presumption that large carnivores might be a danger to human and livestock.

The first important tool to address the HWC is the identification of stakeholders. It is also important to map and understand the conflict and finally, test and adapt strategies, according to the context. The effectiveness of these strategies is challenging because every case is different.

In Latin America, the jaguar (*Panthera onca*) and the Andean bear (*Tremarctos ornatus*) are two of the most symbolic species, and their populations are affected by hunting in retaliation for damage caused to livestock or crops. Due to the need to comprehensively address HWC involving these two species, I reviewed findings from articles about HWC in Latin America related to jaguar or

Andean bear in order to (i) determine the countries where the research were conducted, (ii) identify the problem(s) caused by the species and how it is quantified, (iii) establish if there are common problems caused by both species, (iv) identify the proposed and/or applied strategies to solve the problem(s), (v) establish if there are common strategies for both species and (vi) determine the effectiveness of the proposed and/or applied strategies, in case they were assessed by the article.

22 articles about HWC in Latin America related to these two species were analyzed in this systematic review, following the PRISMA 2020 Statement. The countries, problems caused, and the strategies proposed and/or applied to resolve them were identified, and their effectiveness was determined. About the results, Ecuador was the country with more publications and the most frequent problem for both species was attacks on livestock. In addition, regarding the strategies, the most common one applied by communities to manage the HWC was hunting the animal, and the most common strategy proposed by the authors was conservation education. Unfortunately, only one of the 22 articles addressed the effectiveness of a strategy applied by communities.

Based on the results of the review, I concluded that more research on HWC in Latin America is needed, particularly on evaluating the effectiveness of management strategies, to better understand the problem and implement effective management measures that prevent negative impacts on people and wildlife. The student research paper is in English.

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Appendix 1. Summary of the literature on human-wildlife conflict, related to *Panthera onca* or *Tremarctos ornatus*.

#	Author(s)/ Year	Title	Species	Country	Study Area
1	Tortato <i>et al.</i> , 2017	The numbers of the beast: Valuation of jaguar (<i>Panthera onca</i>) tourism and cattle depredation in the Brazilian Pantanal.	Jaguar (<i>Panthera onca</i>)	Brazil	Encontro das Aguas State Park and its surrounding landscape
2	Campos-Neto <i>et al.</i> , 2011	Attacks by Jaguars (<i>Panthera onca</i>) on Humans in Central Brazil: Report of Three Cases, with Observation of a Death.	Jaguar (<i>Panthera onca</i>)	Brazil	Midwestern Brazil
3	Zimmermann <i>et al.</i> , 2005	Cattle ranchers' attitudes to conflicts with jaguar <i>Panthera onca</i> in the Pantanal of Brazil.	Jaguar (<i>Panthera onca</i>)	Brazil	Administrative districts of Cáceres, Poconé and Barão de Melgaço in the Brazilian state of Mato Grosso
4	Sáenz-Bolaños <i>et al.</i> , 2022	Human-wildlife conflict in indigenous communities of the Nairi Awari Indigenous Territory of East Central Costa Rica.	Jaguar (<i>Panthera onca</i>)	Costa Rica	Cabécar territory called Nairi Awari Indigenous Territory (NAIT)
5	Amit and Jacobson, 2017	Understanding rancher coexistence with jaguars and pumas: a typology for conservation practice.	Jaguar (<i>Panthera onca</i>)	Costa Rica	Costa Rica
6	Macias and Vera, 2023	Conflictos fauna silvestre-humanos en el área de influencia al Bosque Protector Cordillera Chongón Colonche.	Jaguar (<i>Panthera onca</i>)	Ecuador	Buffer area of Bosque Protector Cordillera Chongón Colonche
7	Alvarez & Zapata-Rios, 2022	Do social factors influence perceptions of the jaguar <i>Panthera onca</i> in Ecuador?	Jaguar (<i>Panthera onca</i>)	Ecuador	8 communities in the buffer area of two protected areas, El Pambilar Wildlife Refuge and Cotacachi-Cayapas Ecological Reserve

#	Author(s)/ Year	Title	Species	Country	Study Area
8	Painter <i>et al.</i> , 2022	Land use change and its implications for biodiversity and jaguar conservation.	Jaguar (<i>Panthera onca</i>)	Mexico	Reserva de la Biosfera Sierra del Abra Tanchipa and a 10 km buffer of the surrounding landscape
9	de la Torre <i>et al.</i> , 2021	A cost-effective approach to mitigate conflict between ranchers and large predators: A case study with jaguars in the Mayan Forest.	Jaguar (<i>Panthera onca</i>)	Mexico	Lacandona Rainforest in Mexico's state of Chiapas
10	Caruso <i>et al.</i> , 2020	People and jaguars: new insights into the role of social factors in an old conflict.	Jaguar (<i>Panthera onca</i>)	Argentina	10 protected areas in northern Argentina
11	Chinchilla <i>et al.</i> , 2022	Livestock–Carnivore Coexistence: Moving beyond Preventive Killing.	Jaguar (<i>Panthera onca</i>)	Honduras	Moskitia Hondureña
12	Fort <i>et al.</i> , 2018	Factors influencing local attitudes and perceptions regarding jaguars <i>Panthera onca</i> and National Park conservation in Panama.	Jaguar (<i>Panthera onca</i>)	Panama	Cerro Hoya National Park and Darién National Park
13	Garrido-Corredor <i>et al.</i> , 2021	Oso, Osito ¿A Qué Venís? Andean Bear Conflict, Conservation, and Campesinos in the Colombian Páramos.	Andean bear (<i>Tremarctos ornatus</i>)	Colombia	Páramos surrounding the capital city of Bogotá
14	Escobar-Lasso <i>et al.</i> , 2020	Is the banana ripe? Andean bear–human conflict in a protected area of Colombia.	Andean bear (<i>Tremarctos ornatus</i>)	Colombia	Barbas-Bremen protected area in the central mountain range of Colombia
15	Robles and Gómez-Carrillo, 2017	Conflicto del oso andino (<i>Tremarctus ornatus</i>) con actividades antrópicas en Zetaquirá- Boyacá.	Andean bear (<i>Tremarctos ornatus</i>)	Colombia	Zetaquirá, Boyacá
16	Andrade <i>et al.</i> , 2019	Percepción de actores clave acerca del conflicto ser humano-oso andino en la	Andean bear (<i>Tremarctos ornatus</i>)	Ecuador	Parish Plaza Gutiérrez, valley of Íntag, province of Imbabura

#	Author(s)/ Year	Title	Species	Country	Study Area
		parroquia Plaza Gutiérrez, Íntag, Imbabura, Ecuador.			
17	Bazantes-Chamorro <i>et al.</i> , 2018	Conflicto humano-oso andino (<i>Tremarctos ornatus</i>) en San Francisco de Sigsipamba, Provincia de Imbabura, Ecuador.	Andean bear (<i>Tremarctos ornatus</i>)	Ecuador	Parish San Francisco de Sigsipamba, province of Imbabura. North of Ecuador
18	Jampel, 2016	Cattle-based livelihoods, changes in the taskscape, and human–bear conflict in the Ecuadorian Andes.	Andean bear (<i>Tremarctos ornatus</i>)	Ecuador	Canton of Pimampiro, Ecuador
19	Aurich-Rodriguez <i>et al.</i> , 2022	Threatened Andean bears are negatively affected by human disturbance and free-ranging cattle in a protected area in northwest Peru.	Andean bear (<i>Tremarctos ornatus</i>)	Peru	Laquipampa Wildlife Refuge, a protected area in northwest Peru
20	Rojas-VeraPinto <i>et al.</i> , 2022	Living high and at risk: predicting Andean bear occurrence and conflicts with humans in southeastern Peru.	Andean bear (<i>Tremarctos ornatus</i>)	Peru	Southeastern Peru
21	Figuerola, 2015	Interacciones humano–oso andino <i>Tremarctos ornatus</i> en el Perú: consumo de cultivos y depredación de ganado.	Andean bear (<i>Tremarctos ornatus</i>)	Peru	Buffer areas of 16 protected areas in Peru
22	Albarracín & Aliaga-Rossel, 2018	Bearly Guilty: Understanding Human–Andean Bear Conflict Regarding Crop Losses.	Andean bear (<i>Tremarctos ornatus</i>)	Bolivia	Two indigenous Aymara communities, Chuñavi and Lambate, Bolivia