

Social perceptions of carnivores across the globe – a literature review

Amy Newsom^a, Jorge Lozano^b, and Berta Martín-López^c

^aCopernicus Institute of Sustainable Development, Utrecht University, Utrecht, The Netherlands; ^bDepartment of Biodiversity, Ecology and Evolution, Faculty of Biological Sciences, Complutense University of Madrid, Madrid, Spain; ^cFaculty of Sustainability, Leuphana University of Lüneburg, Lüneburg, Germany

ABSTRACT

To explore the factors underpinning human–carnivore relations, we reviewed 146 scientific publications recording associations of 34 socio-economic, actor-related, and species-related variables with people's views on the beneficial and detrimental contributions of carnivorous terrestrial mammals to people. The associations with respective variables were coded as positive, negative, not significant, or mixed. They were then compared between geographic regions and carnivore families in a descriptive analysis and tested for significant differences among regions and carnivore families. The results indicate a pattern of associations that differs more strongly between regions than between carnivore families. This suggests that personal and societal aspects such as individuals' personal beliefs and socio-economic situation have a stronger impact on their view of carnivores than animals' biological characteristics. Consequently, we identify leverage point realms to improve human–carnivore relations, in particular re-connecting humans to nature and re-structuring institutions to improve carnivore management.



KEYWORDS

Human-wildlife conflict; human-carnivore interactions; human-wildlife coexistence; nature's contribution to people; perception of nature

Introduction

Throughout human history, carnivores have been a source of fear, hatred, and fascination alike for communities that coexist with them. While early hominids were habitual prey of several large carnivores (Schaller & Lowther 1969), in the modern age humans have intensely persecuted many carnivore species, purposefully eradicating species or rendering them locally extinct (e.g. Fritts et al., 2003; Lozano et al., 2013; Riley et al., 2004). At the same time, charismatic carnivore species play an important part in the folk beliefs, stories, and symbols of many communities coexisting with them. Their images appear on everything from ancient cave paintings (Swart, 2004) to modern beer bottle designs (Feldhamer et al., 2002), representing strength, freedom, and even deities (Khan, 2004).

While carnivore conservation and reintroduction efforts have recently increased (Stepkovitch et al., 2022), conflicts between humans and carnivores remain a defining feature of human–carnivore relations (Lozano et al., 2019; Peterson et al., 2010).

CONTACT Amy Newsom  a.newsom@uu.nl  Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, Utrecht 3584 CB, The Netherlands

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Carnivores can compete with humans over food and space, and even attack and occasionally kill humans (Inskip & Zimmermann, 2009; Lozano et al., 2019; Zimmermann et al., 2010). Persecution resulting from these conflicts, as well as the decline of their prey species and habitat, have led to shrinking carnivore populations worldwide (DiMarco et al., 2014). A better understanding of how humans view the impacts that carnivores have on their lives could help practitioners implement effective management strategies that reduce conflicts, benefit both humans and carnivores (Expósito-Granados et al., 2019; Lozano et al., 2019), and foster coexistence in shared lands (Pooley, 2021).

The majority of scientific studies on human–carnivore relations have been carried out at the national or subnational (e.g., state, province, and region) level, focusing on one or few carnivore species (Lozano et al., 2019; Palacios-Pacheco et al., 2024). Large carnivores are also occasionally the subject of both qualitative and quantitative global-scale studies (Can et al., 2014; Carter & Linnell, 2016; Lozano et al., 2019; van Eeden et al., 2018). Similarly, case studies from North America and Europe are prevalent in the scientific discourse (Dressel et al., 2015; Expósito-Granados et al., 2019; Linnell et al., 2001). Past research on human–carnivore relations has more often focussed on conflicts and the costs of coexisting with carnivores (e.g. Treves & Karanth, 2003; Ugarte et al., 2019; van Eeden et al., 2018; Zimmermann et al., 2010) than their beneficial contributions to people (e.g. Lozano et al., 2019; Nelson, 2009; Sillero-Zubiri & Laurenson, 2001). In the last decade, efforts have been made to address this bias toward human–carnivore conflicts by widening the research of human perceptions toward carnivores to include both beneficial and detrimental contributions of carnivores to people (e.g. Bruskotter & Wilson, 2014; Lischka et al., 2019; Palacios-Pacheco et al., 2024).

The idea of the dual role of carnivores as providers of both detrimental and beneficial contributions to people follows the paradigm of nature’s contributions to people (NCP) introduced by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2018). In the context of our review, NCP describe both the positive and negative impacts that carnivores have on people’s lives. These contributions can either improve (beneficial NCP) or worsen (detrimental NCP) people’s wellbeing and are classified as material, non-material, or regulating (Díaz et al., 2018). Beneficial NCP include materials such as fur and meat, contributions to ecosystem stability by, for example, regulating other mammal populations, and the spiritual or personal joy people may gain from the species. For detrimental NCP, examples include the loss of livestock to carnivore predation and mental anxiety caused by the fear of carnivore attacks (Díaz et al., 2018; Palacios-Pacheco et al., 2024).

Although several studies have been carried out to understand social perceptions toward carnivores, particularly in the contexts of conflicts (e.g. Manfredo & Dayer, 2004), there is scarce information available on global patterns of perceptions of carnivores derived from both beneficial and detrimental NCP, and the precise factors influencing them. For example, Manfredo and Dayer (2004) found that social, political, and psychological factors strongly influence human perceptions of wildlife in contexts of conflict. In addition, based on interviews documenting the great importance of the socio-political landscape for respondents’ attitudes toward carnivores, Treves and Karanth (2003) identified fear and economic interests as the dominant factors fueling negative attitudes toward carnivores. As human-carnivore coexistence depends on how people perceive carnivores’ contributions to their lives (Bennett, 2016; Červený et al., 2019; Marchini & McDonald, 2012), we believe the

study of the social-ecological circumstances underpinning social perceptions is critical for carnivore conservation worldwide.

The main aim of this study is to describe the socio-ecological factors associated with people's perceptions of the benefits and harms associated with carnivores at the global scale by reviewing available scientific evidence. To carry out this review, we adopted the definition of perception given by Bennett (2016) to the context of carnivores and considered perceptions as the way an individual observes, understands, interprets, and evaluates carnivore species. We selected this broad definition due to the wide spectrum of human-wildlife interactions considered in the literature, such as “perceptions” (e.g. Lucherini & Merino, 2008), “beliefs” (e.g. Jhamvar-Shingote & Schuett, 2013) or “attitudes” (e.g. Zimmermann et al., 2005). Applying a wider umbrella definition allowed us to work with this lack of linguistic clarity in the literature, something already studied by Glikman et al. (2021). Ultimately, we intend to shed light on the social and ecological factors that underpin perceptions of carnivores across regions and taxonomic groups along the spectrum of beneficial to detrimental NCP.

Methods

Selection of Papers

This study is based on the dataset of a literature review previously compiled by two of the authors, which was published by Lozano et al. (2019). The dataset, which is comprised of papers published between 2000 and 2016, was created following the guidelines for systematic reviews defined by Pullin and Stewart (2006) and is available on ResearchGate. To compile their dataset, Lozano et al. (2019) conducted a systematic review by searching for relevant English-language scientific articles published between 2000 and 2016 on the Scopus database. They applied a search string combining terms related to beneficial and detrimental NCP, such as “ecosystem services” and “conflicts,” respectively, with the names of mammalian families and species belonging to the *Carnivora* order, excluding marine carnivores. The full search string (see Appendix 1), which was applied to title, abstract, and keywords, led to an initial set total of 1358 publications. Then, the dataset derived from Lozano et al. (2019) was expanded by applying the same search string to the years 2017 to 2020 on Scopus, resulting in an additional 839 publications.

We then applied a two-step process in which we first screened the title and abstracts and then the full text to determine the relevance of the study. We used several criteria to include/exclude papers in the dataset. First, we only considered studies dealing with perceptions, attitudes, and values toward carnivores that collected quantitative (i.e. collecting and analyzing numerical data), empirical (i.e. data collected by conducting concrete research in the field) data to ensure that the results of the papers we considered in this review were comparable. Second, we further filtered the set of papers by including only those that specifically address human perceptions of carnivores' contributions to people (both detrimental and beneficial). Finally, we further excluded papers that did not distinguish between species, or between variables related to human perceptions of carnivores' contributions to people by, for example, only recording views on wildlife without testing for correlation with other recorded variables. Following these criteria, the screening returned a final set of 148 publications.

A flowchart of our dataset refining process can be found in [Appendix 2](#), and a full list of the analyzed publications is in the supplementary material.

Coding of Papers

Besides the general characteristics of the articles (i.e. year of publication, country where the research was conducted), the papers were coded according to (1) the carnivore species covered in the research, (2) the carnivore families, (3) the geographic region (defined at the continental or sub-continental scale) in which the study was conducted. We distinguished between 12 geographic regions: South America, Central America, North America, Eastern Europe, Northern & Western Europe, Southern Europe, Eastern Asia, South & Western Asia, Eastern Africa, Western Africa, Southern Africa, and Oceania. Given that Oceania was only represented with two publications, this region was excluded. A full list of the countries analyzed for each region can be found in the supplementary material.

Many papers ($n = 28$) researched several carnivore species or, in one case, more than one region, which we coded as individual cases as results could vary between species and regions. In total, we coded 220 species-by-region “cases” from the set of 146 papers. We used an inductive coding approach to describe variables underpinning social perceptions toward carnivores recorded in the papers in our dataset, coding all variables that were included in each respective study. We thus expanded our coding system each time a new variable appeared in a paper from our dataset. We further coded whether the studies found that the respective variable had positive, negative, not significant, or mixed associations (e.g. both positive and negative simultaneously) with people’s perceptions of carnivores. For example, when the variable was coded as positive, it meant that this variable was significantly associated with positive perceptions of carnivores’ contributions to people. For this, we relied on the reported results of each paper and did not evaluate or compare the methodology applied in these publications. In total, we identified 51 variables associated with social perceptions toward carnivores. However, we excluded 17 variables from further analyses since they appeared in less than five publications, such as, e.g. knowledge of laws about wildlife and loss of livestock to illness or other species. The remaining 34 variables (see supplementary material) were grouped into three categories: socio-economic variables, actor-related variables, and species-related variables (variables referring to knowledge, values, and previous experiences with carnivore species).

Concerning quantitative variables such as age and income, we recorded the association of higher levels of this variable: for example, the effects listed under the variable *age* refer to the perceptions of older respondents compared to those who were younger. The carnivore families *Eupleridae*, *Procyonidae*, and *Viverridae* were also excluded from the analysis, as no variable occurred in more than one publication on one of these families. The full coded datasheet is available on ResearchGate.

Analysis

Alongside counting the number of cases that reported an association between a variable and perceptions of carnivores as beneficial or harmful, we also evaluated the level of confidence for the findings. In doing so, we adapted the methodological approach suggested by IPBES assessments to measure and communicate the level of confidence, which is based on the

quantity of evidence and the level of agreement regarding that evidence (IPBES, 2018a, 2018b, 2018c, 2018d, 2019). In this review, we measured the quantity of evidence as the number and proportion of publications showing statistically significant ($p < .05$) association of a particular variable with the social perceptions toward carnivores and the level of agreement between different studies regarding that association. Then, to depict the level of confidence that exists in the scientific literature for each variable, we specifically followed the approach of the IPBES Assessment for Europe and Central Asia (see Martín-López et al., 2018). Thus, we represented the level of agreement with bar diagrams, in which the bar indicates the proportion of papers that provide evidence of each variable's association with social perceptions regarding carnivores, being those negative (red color), positive (green), not significant (yellow), or mixed (blue) associations. The intensity of the color represented the total number of publications identified, representing the quantity of evidence (categorized into five levels: <2, 2–4, 5–10, 11–15, >15 papers). The strongest level of confidence was presented when only one color is shown (i.e. the strongest agreement) and evidence was presented in more than 15 publications (i.e. the most robust evidence is presented). For those cases showing a sufficient quantity of evidence, we conducted G-tests (McDonald, 2009; Sokal & Rohlf, 1981) to test for significant differences among regions and carnivore families of the studied variables.

To synthesize the implications of our findings for improving human–carnivore relations in the discussion section, we classified the variables according to the three realms of leverage points. Leverage points are defined as places in complex systems where a small shift may lead to fundamental changes in the system as a whole (Abson et al., 2017; see also Meadows, 1999). Abson et al. (2017) identified three realms of deep leverage points for transformation, namely *re-connect*, which examines the role of humans' relationship to nature, *re-structure*, which focuses on the role of institutions and institutional failure, and *re-think*, which considers the impact of knowledge production and – transfer for sustainability transformations.

Results

Temporal and Geographic Distribution

The general increase in publications on perceptions of carnivores over the 2000–2020 period as well as the expansion of the combined research areas over different geographic regions might indicate that this field of research has gained in importance over time (Figure 1). The number of studies on variables influencing carnivore perceptions increased rapidly from 2007 onwards, with the highest number of papers recorded in 2016 (Figure 1a). Most of the research was carried out in North America and Asia, while Eastern Europe and Central America received less attention. Western Africa and Oceania were comparatively underrepresented (Figure 1b).

Carnivore Families

Of the eight carnivore families represented in the dataset, the majority of studies focussed on three families: *Felidae* (cats, 37% of publications), *Canidae* (wolves and foxes, 33%), and *Ursidae* (bears, 22%), while *Viverridae*, *Mustelidae*, and *Hyaenidae* were covered by between

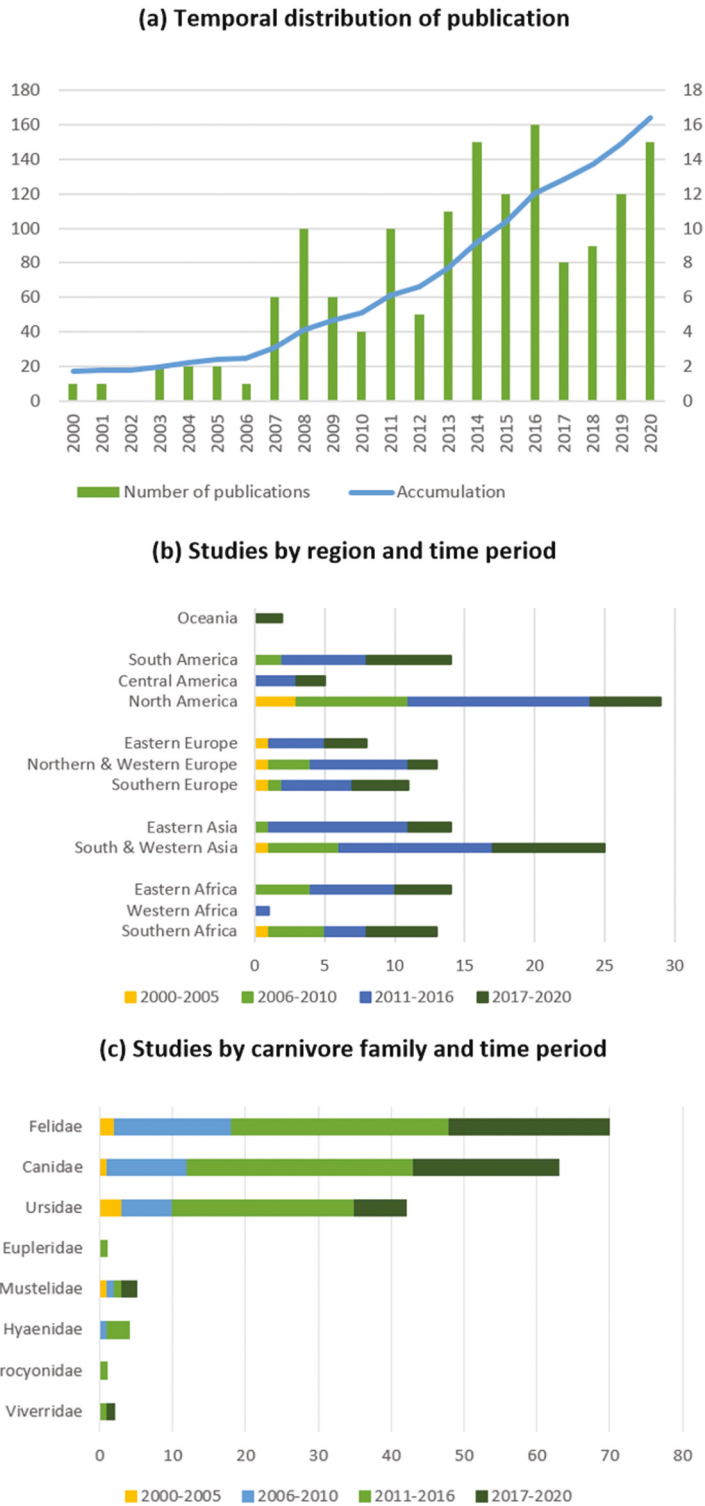


Figure 1. Temporal distribution of publications, grouped by geographic region (1b) and carnivore family (1c). Publications covering more than one region/species may appear multiple times in Figure 1b,c.

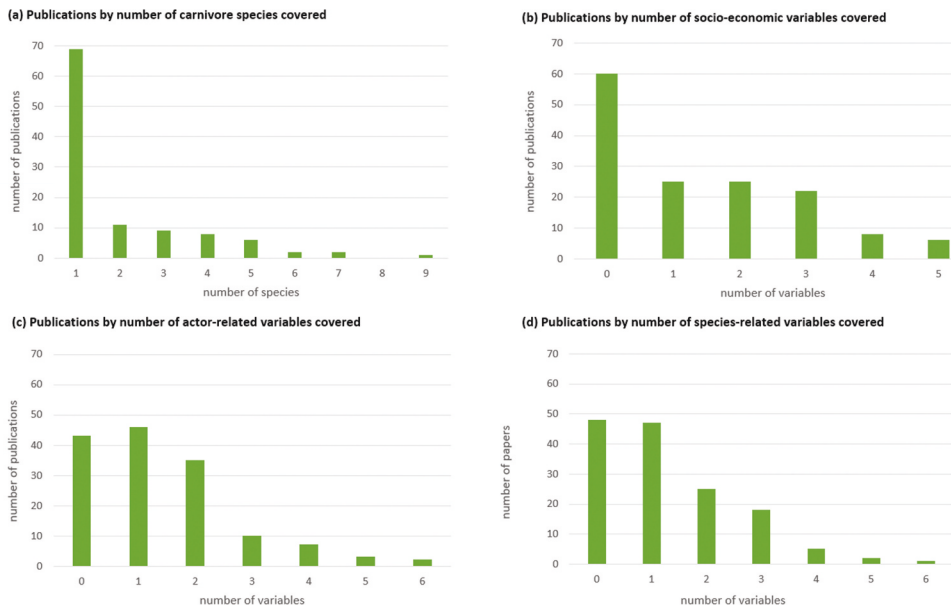


Figure 2. Number of species covered by the publications on human–carnivore relations (a), and socio-economic (b), actor-related (c), and species-related (d) variables found in the publications considered in this review as influencing human–carnivore relations.

1% and 2.6% of publications, respectively (Figure 1c). *Procyonidae* and *Eupleridae* were only covered in one study each. Seventy percent of the studies focussed on only one carnivore species (Figure 2a).

Influence of Socio-economic Variables on Perceptions

Associations of socio-economic variables with human perceptions of carnivores varied between continents but were remarkably similar among carnivore families (Figure 3). *Age* ($n = 48$, referring to the number of articles that included this variable), *sex* ($n = 44$), and *education level* ($n = 42$) were the variables most often researched in the reviewed publications overall. *Age* was negatively associated with carnivore perceptions in America and Asia ($G = 18.66$, $df = 3$, $p < .001$), with 14/26 and 7/14 cases, respectively, showing that elderly people tend to have negative perceptions of carnivores. *Age* had no significant effect in Africa, where 17/18 cases recorded no effect. Differences in the effect of age on people's perceptions of carnivores among carnivore families were not statistically significant ($G = 7.47$, $df = 4$, $p > .05$).

Concerning *sex*, the variables' associations with women's perceptions of the different carnivore families did not differ significantly ($G = 2.86$, $df = 4$, $p > .05$), nor men's ($G = 1.33$, $df = 4$, $p > .05$). The data indicated geographic differences, however, with being female being associated with more negative perceptions of carnivores in America (13/23 cases) and Asia (8/14 cases) than elsewhere ($G = 21.57$, $df = 6$, $p < .01$), corresponding to men's comparatively more positive perceptions in these regions ($G = 24.4$, $df = 6$, $p < .001$). In Africa, *sex* did not significantly impact respondents' perception of carnivores in 11 out of 14 cases.



Figure 3. Influence of socio-economic variables on social perceptions of carnivores according to continents and according to taxonomic families. The bar indicates the proportion of papers that provide evidence of the effect of each variable on social perceptions regarding carnivores, being those negative (red color), positive (green), no effect (yellow), or mixed (blue) effects and representing the level of agreement. Statistically significant results are marked with a black frame. The intensity of the color represents the total number of publications identified (i.e., solid colors indicate over 15 papers, whereas faded colors indicate few (2–4, 5–10, and 11–15 papers in rising order of color intensity) and blank space indicates less than two studies), thus, representing the quantity of evidence. The level of confidence is also represented by indicating the level of agreement (i.e. The strongest agreement is presented when only one color is shown) and the quantity of evidence (i.e. The most robust evidence is presented when the assessment is validated by more than 15 multiple independent papers, which is represented by dark solid colors).

Being the parent of a young child seemed to have a negative association with the perception of carnivores (Figure 3).

In nearly all cases, *education* either had no significant effect (25/71 cases) or was positively associated (45/71 cases) with carnivore perceptions (Figure 3). Furthermore, the distribution of associations between education and perception exhibited no significant differences among continents ($G = 2.02$, $df = 3$, $p > .05$) or carnivore families ($G = .58$, $df = 2$, $p > .05$). Beyond the statistically significant results, Figure 3 shows some trends that may be of interest for further research. The influence of other socio-economic variables, such as *income* ($n = 19$), *rural* ($n = 19$) or *urban* ($n = 16$), and *culture* ($n = 11$), was recorded in relatively few publications. Overall, *income* seemed to be associated with more positive perceptions (18/32 cases) but largely did not influence carnivore perceptions in Africa (5/6 cases). Furthermore, current evidence seems to suggest a global trend in the negative perceptions of carnivores by rural people (20/25 cases) and a generally more positive perception by urban residents (18/22 cases) (Franchini et al., 2021; Kleiven et al., 2004). The studies in this dataset suggest that having a specific culture or religion produced mixed effects in Africa (7/9 cases) and Asia (2/5 cases).

Influence of Actor-Related Variables on Perceptions

Overall, the influence of these variables on the perception of carnivores was poorly represented in our sample of studies. According to published evidence, the associations of actor-related variables seem to be similar across continents and between carnivore

families (Figure 4). The most studied variable, *owning/caring for livestock* ($n = 44$), indicated a negative association with perceptions (54/75 cases), which tended to be higher for *Canidae* (21/25 cases; $G = 7.92$, $df = 4$, $p = .094$). Studies suggest a pattern whereby negative perceptions of carnivores tend to be associated with actors self-identifying as *farmers* (23/30 cases) and *hunters* (21/36 cases) (Figure 4). Yet, other variables might shape how these groups perceive carnivores, such as the *size of the farm* or having a *diversified livelihood*, the latter of which may be associated with more positive perceptions (4/4 cases) (Figure 4).

Additional factors that tended to be associated with positive perceptions of carnivores included *credibility of management actions* ($n = 6$), actors self-identifying as *environmentalists* ($n = 8$), self-reported *participation in conservation projects* ($n = 6$; although this variable only yielded results for America), and *involvement in tourism* ($n = 8$; which only yielded results for *Felidae* species) (Figure 4). Moreover, the variable *activities in nature* ($n = 6$) showed some positive association with perceptions of carnivores in America (3/3 cases) and for *Ursidae* species in particular (4/6 cases); although for other cases, such as in Europe (6/11 cases) and for *Felidae* (2/3 cases), the associations for this variable were mainly mixed. The variables *owning pets* and *distance to species* also tended to be associated with

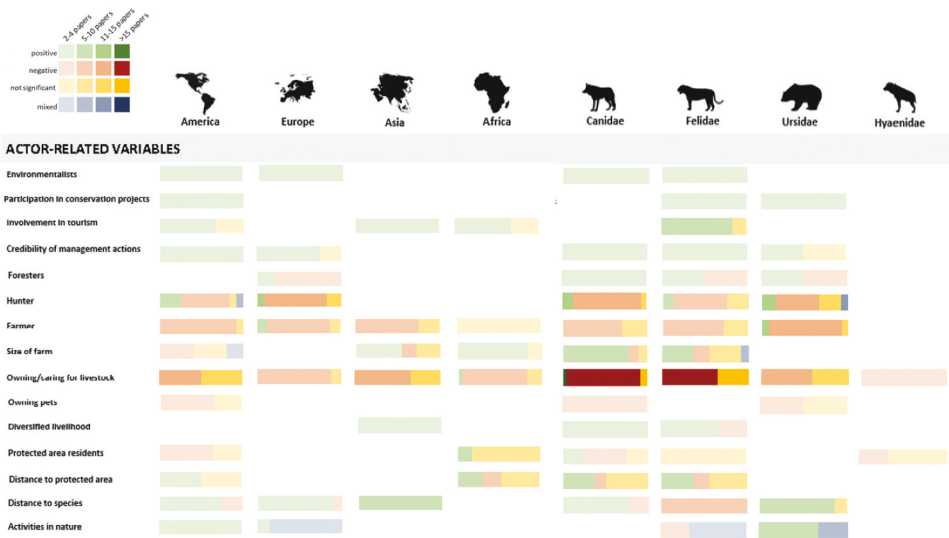


Figure 4. Influence of actor-economic variables on social perceptions of carnivores according to continents and according to taxonomic families. The bar indicates the proportion of papers that provide evidence of the effect of each variable on social perceptions regarding carnivores, being those negative (red color), positive (green), no effect (yellow), or mixed (blue) effects and representing the level of agreement. The intensity of the color represents the total number of publications identified (i.e., solid colors indicate over 15 papers, whereas faded colors indicate few (2–4, 5–10, and 11–15 papers in rising order of color intensity) and blank space indicates less than two studies), thus, representing the quantity of evidence. The level of confidence is also represented by indicating the level of agreement (i.e. The strongest agreement is presented when only one color is shown) and the quantity of evidence (i.e. The most robust evidence is presented when the assessment is validated by more than 15 multiple independent papers, which is represented by dark solid colors). *Mustelidae* were not represented sufficiently in any actor-related variable to appear in this graph.

positive perceptions of carnivores in 6/8 and 20/22 cases, respectively. Finally, the variable *distance to protected areas* ($n = 13$) showed an unclear global pattern (Figure 4).

Influence of Species-Related Variables on Perceptions

The distribution in findings concerning the association between the variables related to the knowledge, values, and previous experiences with carnivores did not differ across continents or families (Figure 5). Overall, variables related to experiencing damages (i.e. *former encounter*, *previous damage/attack*, *the extent of loss*) and to the perception of threat (i.e. *perceived seriousness of the threat* and *perceived increasing trend of species populations*) seemed to be associated with negative perceptions of carnivores. Indeed, the variable showing the highest quantity of evidence was *previous damage/attack* ($n = 44$), which tended to be associated with more negative perceptions in Africa (20/24 cases) and Europe (6/6 cases) ($G = 7.69$, $df = 3$, $p = .053$), with no significant differences among carnivore families ($G = .73$, $df = 2$, $p > .05$). By contrast, variables related to the species' values perceived by people (i.e. *ecological value* ($n = 6$), *economic value* ($n = 5$) and *existence value* ($n = 15$)) and respondents' knowledge of the species (*species/ecological knowledge* ($n = 22$)) and *emotional attachment* ($n = 4$) seemed to be associated with positive perceptions, although quantity of evidence for this was very low (Figure 5). Interestingly, Asia may stand out when examining the effect of *species/ecological knowledge* as two out of six cases

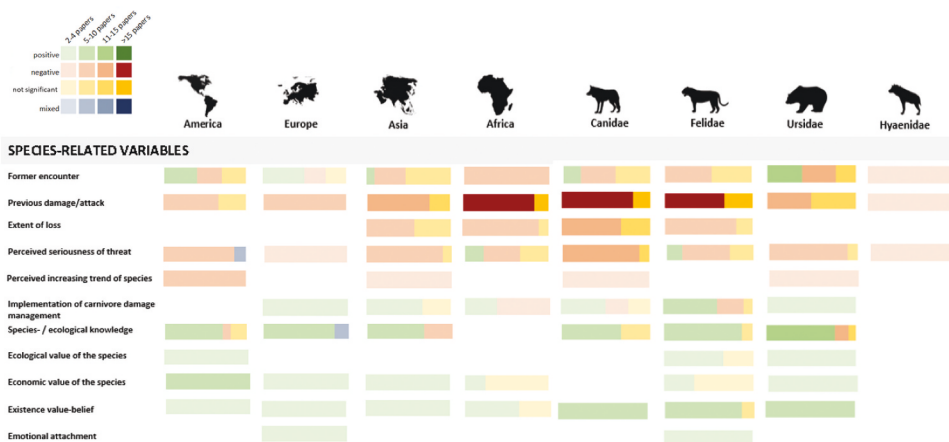


Figure 5. Influence of species-economic variables on social perceptions of carnivores according to continents and according to taxonomic families. The bar indicates the proportion of papers that provide evidence of the effect of each variable on social perceptions regarding carnivores, being those negative (red color), positive (green), no effect (yellow), or mixed (blue) effects and representing the level of agreement. The intensity of the color represents the total number of publications identified (i.e., solid colors indicate over 15 papers, whereas faded colors indicate few (2–4, 5–10, and 11–15 papers in rising order of color intensity) and blank space indicates less than two studies), thus, representing the quantity of evidence. The level of confidence is also represented by indicating the level of agreement (i.e. The strongest agreement is presented when only one color is shown) and the quantity of evidence (i.e. The most robust evidence is presented when the assessment is validated by more than 15 multiple independent papers, which is represented by dark solid colors). *Mustelidae* were not represented sufficiently in any actor-related variable to appear in this graph.

from Asia showed a negative association with carnivore perceptions, while in America (7/10 cases) and Europe (10/12 cases) this association was positive.

Based on available evidence, the influence of *former encounters* ($n = 26$) with carnivores seemed to vary most strongly between continents of all species-related variables. *Former encounter* tended to be associated with positive perceptions in Europe (2/4 cases positive) and America (4/10 cases positive), but with negative perceptions in Africa (10/13 cases were negative). The variable *former encounter* also tended to be positively associated with perceptions of *Ursidae* species (3/5 cases positive) in contrast to other families (Figure 5). Furthermore, the *implementation of carnivore damage management* ($n = 11$) strategies, which seemed to have a unanimously positive association with perceptions in Europe and Asia, had a negative association in five out of eight cases from Africa. This variable also had a unanimously positive association for *Ursidae* (3/3 cases) in comparison to more mixed results for *Felidae* (3/6 cases positive and negative each) and *Canidae* (2/4 cases positive) families (Figure 5). However, none of these patterns were statistically significant.

Discussion

Our research only yielded two statistically significant patterns between socio-economic variables and perceptions of carnivores. These were that increased age was linked to more negative perceptions of carnivores and that being female was linked to holding more negative perceptions in comparison to being male in America and Asia. In the following section, possible explanations for these links are explored. Additionally, we discuss interesting patterns that are suggested by our data.

It is important to note that the strict exclusion of publications that did not examine perceptions of carnivores along the dichotomy of beneficial and detrimental NCP restricted our dataset considerably. It is, therefore, possible that we did not capture the full extent of literature dealing with perceptions, but we are confident about the robustness of our results concerning benefits and harms perceived by people. The comparatively small dataset may have contributed to the low number of statistically significant results our analysis yielded. Nevertheless, we identified several patterns in factors underpinning human perceptions of carnivores that can help identify leverage points to improve people's perceptions of carnivores and indicate potentially fruitful areas of future research.

Social Perceptions of Carnivores: Knowns and Unknowns

High quantities of evidence support that socio-economic characteristics are linked to people's perceptions of carnivores. The age of respondents was frequently associated with negative perceptions of carnivores, except for respondents in Africa. This overall negative association of age remained comparably consistent throughout the considered publication time frame from 2000 to 2020, and it aligns with previous literature (e.g. Kaltenborn et al., 1999; Zeiler et al., 1999). This might suggest that this phenomenon is not linked to a specific generation (a "cohort effect") as previously hypothesized by Williams et al. (2002), but that perceptions instead change throughout respondents' lives (an "age effect"). As fear played an important role in predicting perceptions in the Global North, where the negative association with age was strongest, this may be explained by the increase in anxiousness and heightened risk awareness linked to advanced age (Jakobsson & Hallberg, 2005; Kappes

et al., 2013). This finding suggests that people may be inclined to view carnivores more negatively as populations age, potentially posing a challenge for human-carnivore co-existence in countries with aging populations.

Similarly, there is some evidence suggesting higher levels of fear and anxiety in women. The association between sex and negative perceptions of carnivores linked to fear could be due to differences in brain chemistry and hormonal balance, but most importantly to social conditioning (McLean & Anderson, 2009; Remes et al., 2016). Our research showed statistically significant differences between sexes in Asia and America when it came to carnivore perception. In Asia, women were more likely to hold negative views of carnivores compared to men, a pattern that was also visible in America and Europe, albeit to a lesser degree (Figure 3). Due to traditional gender roles, women in rural Asia often undertake outdoor work in natural areas, which puts them at increased risk from animal attacks (Kushnir et al., 2010). In contrast, women in Europe and North America less often take part in activities in nature and have less outdoor experience than men, a lack of experience which may lead them to overestimate the danger carnivores pose (Thornton & Quinn, 2010; Zinn & Pierce, 2002). These findings illustrate the important and varied effects that lifestyle and economic modernization can have on how carnivores are perceived (Bruskotter et al., 2017). It is, however, also possible that the results on the influence of sex gathered through surveys in the respective studies are not fully representative, as the pressure to conform to social gender stereotypes may discourage men from admitting to fear of carnivores (Blier & Blier-Wilson, 1989). These results must be considered as indications only, as we group publications across whole continents, potentially overlooking nuanced differences between various cultures.

While less robust, the non-significant results also show intriguing patterns that merit further investigation. Both formal education and, though less well-documented, ecological knowledge generally had a positive association with perceptions of carnivores. This finding stands in contradiction to the review by Williams et al. (2002), that analyzed global literature on attitudes to wolves published between 1972 and 2000 and found no positive link between increased knowledge and positive attitudes toward wolves. Though increased knowledge of a carnivore species does not automatically mean it is viewed more positively (Macdonald et al., 2022), it may be possible that people with higher levels of knowledge of natural history and ecology can judge risks posed by carnivores more accurately. As fear of the unknown stokes hostility toward the unfamiliar entity (Carleton, 2016), increased experience and understanding can improve human-carnivore relations. Further, ecological knowledge can include an awareness of carnivores' beneficial contributions to people, which is also associated with a more positive perception of carnivores (Figures 3 and 4) as experimentally demonstrated by Slagle et al. (2013). Higher levels of formal education may also improve respondents' understanding of the importance of carnivores to provide NCP and maintain ecosystem functions, as environmental issues are included in many educational curricula (Barraza, 2001; Eames et al., 2008). Respondents with higher levels of formal education may also be more aware of the economic opportunities surrounding carnivores, encouraging a more positive perception. However, higher levels of formal education may also be linked to other variables that appear to positively impact perceptions of carnivores, namely higher income, living in urban areas, and having professions that are less directly impacted by carnivore damage (Hansen, 2001; Sirin, 2005). The discussion of these potential patterns remains speculative as the quantity of evidence in our dataset was limited.

As the majority of analyzed publications focused on the detrimental contributions of carnivores to people (Lozano et al., 2019), high quantities of evidence supported the notion that professions with high potential for conflict with carnivores, such as farmers and hunters, were associated with negative perceptions of carnivores' contributions to humans (Figure 3). Though the damages carnivores can cause for these professions may help explain their association with more negative perceptions of carnivores, other variables recorded in our study suggest that respondents' vulnerability to these losses may potentially be better predictors of carnivore perceptions, though our review found only a few studies that test this. Through this lens, the differences between geographic regions in the impact of farm size on respondents' perceptions of carnivores (Figure 3) could be linked to the different agricultural structures in the respective regions: while North American farmers are mainly engaged in industrial agriculture, subsistence farming is more common in the Global South (Clay, 2013). As subsistence farmers are largely dependent on their produce for survival, they are more economically vulnerable to damages incurred through carnivores than a larger, commercial farm in the same region. Indeed, the results of this review suggest that the extent of the loss caused by carnivores had a less negative effect in North America than in Africa and Asia (Figure 5). However, depredation levels may also play a role in explaining this geographic pattern, as, for example, cattle depredation by wolves in North America remains low overall, though individual ranchers may be affected unequally (Hanley et al., 2018; Muhly & Musiani, 2009).

The results further show that living in or adjacent to protected areas was more associated with negative perceptions in America than in Africa (Figure 4). A possible explanation for this lies in the benefits that protected areas provide to residents: Naidoo et al. (2019) found that proximity to a protected area in middle-low income countries was linked to benefits such as improved access to food and medicine and increased economic stability. This is likely to increase positive perceptions of carnivores, as in particular large carnivores are charismatic species that attract tourists to protected areas (Okello et al., 2008). Such benefits are likely to be of less importance to rural communities in high-income countries, as they often have access to other established industries for their financial income. However, further research would be necessary to better elucidate these patterns, as the body of evidence analyzed in this study is limited and the results were not statistically significant.

In addition to revealing patterns influencing human perceptions of carnivores' contributions to their lives, the results of this analysis also raise new questions and help to identify research gaps. For instance, articles that included recorded attacks of carnivores on humans frequently failed to measure the impact of such attacks on public perception of the respective carnivore. Further investigation of this link could contribute substantially to the research of human–carnivore relations, as anecdotal evidence indicates there may be significant differences in what effect the realistic danger posed by a carnivore species has on respondents' acceptance of it in different parts of the world. For example, the gray wolf (*Canis lupus*), the most studied species in the reviewed dataset ($n = 44$), triggered a strong response from respondents in the majority of studies, with fear being among the top contributors to negative perceptions and attitudes in Europe and North America (Young et al., 2015; Zimmermann et al., 2001). This level of fear does not necessarily correspond to concrete levels of risk (Johansson et al., 2012). While wolves are regularly known to cause livestock loss, research into the threat they pose to human safety has shown that the risk of attacks on humans in those geographical regions is considerably lower than respondents

estimated (NINA 2002). In contrast, residents of the Sundarbans, where tigers (*Panthera tigris*) habitually prey on humans, show a high level of tolerance toward the species (Inskip et al., 2016). This suggests that it is not concrete negative experiences that determine the acceptance and corresponding tolerance of a carnivore species, but instead the beliefs and cultural associations connected to the species, as the wolf traditionally carries negative connotations in Western folktales and beliefs (Wallner, 1998), while the tiger is associated with deity and considered a spiritual guardian in the Sundarbans (Khan, 2004).

The impact of culture and religion on carnivore perceptions is overall under-researched (Figure 3), but the often mixed results reported in the analyzed articles indicate there are differences between geographic regions and communities. While evidence on this variable's effect on carnivore perception collected in this analysis is still thin, it suggests patterns that merit further investigation. In Africa, respondents who were affiliated with Abrahamic religions, most often Christianity, generally had more negative perceptions of carnivores than respondents with traditional beliefs (Dickman et al., 2014; Hazzah et al., 2009). This could link to the existing and intensely disputed research into the adverse effects that belief in Abrahamic religions, which contain strong references to human domination over nature, have on environmental attitudes and behavior (Hayes and Marangudakis 2001; Morrison et al. 2015). However, more research would be necessary to verify such a phenomenon. Other research indicates that various types of beliefs, norms, and values may be more important than religious factors (Dickman et al., 2013; Kaltenborn & Bjerke, 2002; Nilsson et al., 2020); however, as most studies are conducted within countries, it could also be that religious factors are more important for explaining between-country variation. The currently limited evidence on the impact of religion and beliefs on human perceptions of carnivores is sufficiently persuasive to justify further, more structured research into this topic.

The way that carnivores are managed also apparently influences how they are perceived, as the implementation of management schemes to deal with carnivores and the damages they cause showed a striking contrast between overwhelmingly positive associations in Europe and to a lesser extent Asia, and often negative associations in Africa (Figure 3). It is not evident whether this is due to management schemes not being implemented consistently in studied regions in Africa or whether management strategies are generally better adapted to European conditions.

Finally, the noticeable lack of meso-carnivores in the analyzed literature may have allowed variables related to characteristics of different carnivore species to fall under the radar. This research gap is of particular interest as there is evidence that characteristics such as carnivores' size and presence in proximity to humans, which divide meso-carnivores from better-studied large species (Červinka et al., 2014; Lozano et al., 2019), might impact how carnivores are perceived by humans (Czech & Krausman, 2001; Kellert, 1996; Knight, 2008).

Leverage Points to Foster Positive Perceptions of Carnivores

While the factors influencing human perceptions of carnivores are complex and interlinked, this review shows that socio-economic and actor-related variables were more strongly associated with the perception of carnivores' contributions to people than the characteristics of the respective carnivore families. These findings bode well for the alleviation of

human-carnivore conflicts arising from detrimental NCP since human factors such as socio-economic conditions and cultural beliefs are variables that can be shaped by intervention measures. Considering the results of this analysis, it is possible to identify leverage points at which interventions are possible to improve the perceptions of NCP connected to carnivores, which in turn can contribute to alleviating human-carnivore conflict and foster successful co-existence (Bruskotter & Wilson, 2014).

The realm of *re-connect* can be considered the most pivotal of deep leverage points to improve human-carnivore co-existence in the future. Considering the positive effect that the recognition of beneficial NCP can have on fostering positive perceptions of carnivores, worldviews in which wildlife is valued because of their positive contributions to people are more likely to sustain tolerant human-carnivore coexistence (Bruskotter et al., 2017). For example, by analyzing the projects of the EU Platform on Coexistence between People and Large Carnivores, Hovardas and Marsden (2018) found that raising awareness is one of the most relevant good practices to improve perceptions of carnivores. Moreover, we found that the emotional attachment to carnivore species plays a role in fostering positive perceptions of carnivores, which might mean that experiences that nurture emotional relationships with carnivore species can improve human-carnivore coexistence. Previous research on the connection of humans to nature suggests that factors such as direct experience of natural environments and awareness of the benefits that nature provides to humans, such as nature-based tourism, are important in strengthening positive perceptions of nature generally, and carnivores specifically (Abson et al., 2017; Slagle et al., 2013). In communities where there is already much direct exposure to nature, innovative approaches such as the participatory co-learning program for human-wildlife coexistence implemented by Kansky et al. (2024) or the experience-based coyote education program described in Sponarski et al., (2016) can help transform human-carnivore relations. These authors found that training social actors in nonviolent communication and framing interactions with wildlife in the context of empathetic connections can both increase tolerance for wildlife and improve relations and collaboration between actors, thus mitigating human-human conflicts that may arise around wildlife management.

Concerning the realm of *re-thinking*, the evidence collected in this study suggests that expanding public education on carnivores, particularly in rural areas, could help foster more positive perceptions of carnivores. While there is evidence to support the positive influence of in particular educational intervention during childhood on human-wildlife relations (e.g. Lyamuya et al., 2016), not all education and awareness programs were able to increase tolerance for wildlife and change human behavior in the long term (e.g. Baruch-Mordo et al., 2011; Espinosa & Jacobson, 2012). However, the influence that cultural/religious context and personal beliefs appear to have on how carnivores are perceived shows that considering deep beliefs when designing management actions is key to facilitating coexistence between humans and carnivores.

Finally, with regards to the realm of *re-structure*, three main interventions can foster human-carnivore coexistence. First, the credibility of management actions among local people was associated with a positive effect across regions and species (Figure 4). Issues like the animosity against government bodies responsible for carnivore management among rural populations recorded in Northern and Western Europe could be alleviated through institutional reform and improved

links to local communities. In Africa, where management schemes had partially adverse effects on human perceptions of carnivores (Figure 4), stronger consideration and incorporation of local communities and their knowledge can mitigate the conflict with carnivores. In fact, there is evidence that collaborative governance systems that engage local communities are more successful in promoting human-carnivore coexistence at regional and local scales (Redpath et al., 2017). Hartel et al. (2019) also found that the capacity of societal actors to self-organize and create new institutional arrangements can be essential to mainstream human-carnivore coexistence. Therefore, increasing local ownership in carnivore management can not only increase its effectiveness through better adaptation to local conditions but also increase acceptance of such schemes. Moreover, we argue that management strategies should be diverse and target not only damage mitigation but also the diversification of local people's livelihoods. In a similar line of thinking, Hovardas and Marsden (2018) identified good practices that can lead to human-carnivore coexistence, including innovative financing and social actors' involvement in management.

Conclusions

Human perceptions of carnivores appear to be more strongly associated with variables related to humans than the characteristics of the respective carnivore species. Thus, leverage points in the realms of *re-structuring* institutions to improve carnivore management and *re-connecting* humans with nature are crucial for carnivore conservation and coexistence. Targeted reforms of institutions and the active inclusion of local actors in conservation efforts can alleviate human-human conflict while highlighting beneficial NCP provided by carnivores could provide a positive basis for human-carnivore interactions in the future.

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[10.1371/journal.pone.0134868.t003](https://doi.org/10.1371/journal.pone.0134868.t003)
[10.1371/journal.pone.0134868.t004](https://doi.org/10.1371/journal.pone.0134868.t004)
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Appendices: Social perceptions of carnivores across the globe – A literature review

Appendix 1. List of All of the Keywords Used in the Systematic Review

Ecosystem services

“eco* service*” OR “eco* good*” OR “environment* service*”

OR

Conflict “conflict*” OR “damage*” OR “impair*” OR “harm*”

OR

Human-carnivore relation

“human-wildlife relation*” OR “human-carnivore* relation*” OR “human-felid* relation*” OR

“human-canid* relation*” OR “human-wildlife interact*” OR “human carnivore* interact*” OR

“human-felid* interact*” OR “human-canid interact*”

AND

Carnivores (“carnivore*” AND “mammal”) OR (“Ailurus” OR “Atelocynus” OR “Canis” OR

“Cerdo cyon” OR “Chrysocyon” OR “Cuon” OR “Dusicyon” OR “Lycalopex” OR “Lycaon”

OR “Nyctereutes” OR “Otocyon” OR “Speothos” OR “Urocyon” OR “Vulpes” OR “Cryptopr

octa” OR “Eupleres” OR “Fossa” OR “Galidia” OR “Galidictis” OR “Mungotictis” OR

“Salanoia” OR “Acinonyx” OR “Caracal” OR “Catopuma” OR “Felis” OR “Leopardus”

O R “Leptailurus” OR “Lynx” OR “Neofelis” OR “Panthera” OR “Pardofelis” OR “Prionail

urus” OR “Profelis” OR “Puma” OR “Uncia” OR “Atilax” OR “Bdeogale” OR “Crossarc hus”

OR “Cynictis” OR “Dologale” OR “Galerella” OR “Helogale” OR “Herpestes” OR “Ichneumia

OR “Liberiictis” OR “Mungos” OR “Paracynictis” OR “Rhynchogale” OR “Suricata” OR

“Crocuta” OR “Hyaena” OR “Proteles” OR “Conepatus” OR “Mephitis” O R “Mydaus” OR

“Spilogale” OR “Aonyx” OR “Arctonyx” OR “Eira” OR “Enhydra” OR “Galictis” OR “Gulo”

OR “Hydriictis” OR “Ictonyx” OR “Lontra” OR “Lutra” OR “Lutr ogale” OR “Lyncodon” OR

martes OR “Meles” OR “Mellivora” OR “Melogale” OR “M ustela” OR “Neovison” OR

“Poecilogale” OR “Pteronura” OR “Taxidea” OR “Vormela” OR “Nandinia” OR

“Bassaricyon” OR “Bassariscus” OR “Nasua” OR “Nasuella” OR “Po tos” OR “Procyon” OR

“Ailuropoda” OR “Helarctos” OR “Melursus” OR “Tremarctos” OR “Ursus” OR “Arctictis”

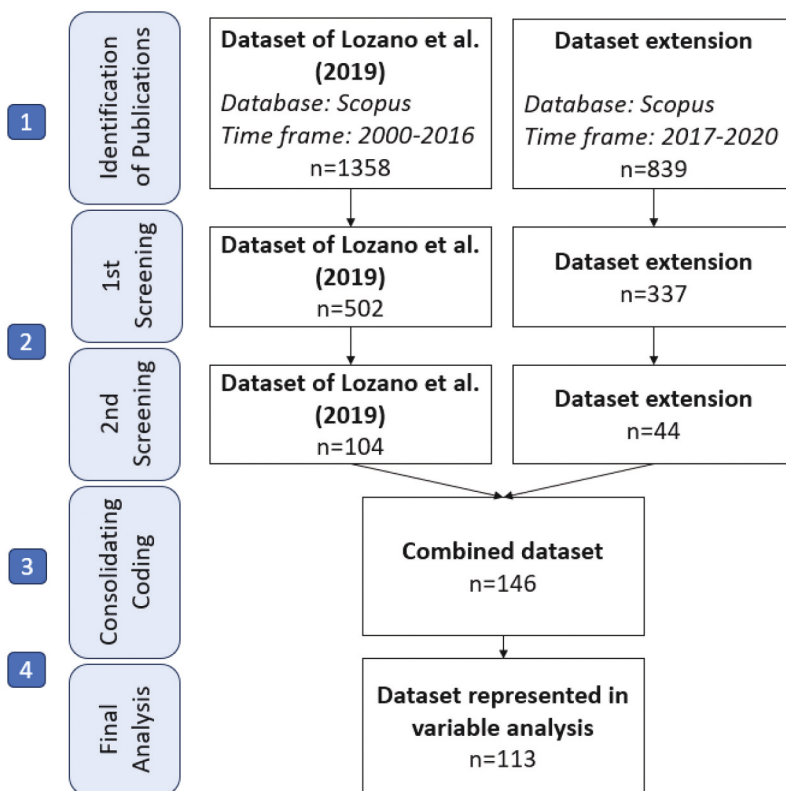
OR “Arctogalidia” OR “Chorogale” OR “Civettictis” OR “Cy nogale” OR “Diplogale” OR

“Genetta” OR “Hemigalus” OR “Macrogalidia” OR “Paguma” OR “Paradoxurus” OR “Poiana”

OR “Prionodon” OR “Viverra” OR “Viverricula”)

Appendix 2

Flow diagram of the dataset creation based on Moher et al. (2009). In step 1, the dataset compiled by Lozano et al. (2019) was extended by re-running the identical search string for an additional four years. In step 2, 148 papers were selected for coding on the basis of our rigorous screening process. In step 3, the papers were coded and combined, leading to a further exclusion of two papers that did not fit into the coding rubric, meaning 146 papers were included in the coding sheet. In step 4, we excluded papers from Oceania, papers on Eupleridae, Procyonidae, and Viverridae due to their low number, as well as papers that only included variables too rare to be analyzed, leaving 113 publications to be mapped in Figures 3–6.



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