Collaboration for Environmental Evidence

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Systematic Review Protocol

Title
How effective are interventions to reduce attacks on people from large carnivores? A Systematic Review Protocol

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carnivore attack, human-carnivore impact, mitigation, large carnivores, systematic review

Background
Instances of attacks from large carnivores that lead to human injury or death are increasingly reported worldwide. Ensuring human safety when people and carnivores co-occur is central to minimizing human suffering but is also essential to support sustainable carnivore conservation. Various interventions are available intended to alter either the behaviour of large carnivores or people, in order to reduce the likelihood of a risky encounter and an attack. Collated evidence on best practices is still lacking, and this protocol outlines a systematic review of evidence for intervention effectiveness to reduce the risk or severity of direct attacks on humans by large carnivores. Specifically, the review seeks to answer the question: How effective are evaluated interventions in reducing large carnivore attacks on people? Intended users of review findings are wildlife managers and conservationists, as well as other people who may interact with large carnivores in the wild.

Theory of change or causal model
If wildlife managers and conservationists, as well as other people who may interact with large carnivores, would have accessible knowledge of available interventions and their effectiveness, then improvement in the recommendations can be made regarding the most appropriate interventions and its correct implementation, leading to a decrease in risky encounters.

Stakeholder engagement
The review is commissioned by the Wildlife Damage Centre at the Swedish University of Agricultural Sciences and is funded by the EU project LIFE - Wild Wolf (LIFE21-NAT-IT-LIFE WILD WOLF). SWDC representatives are engaged in the review work group and introduced the research question in addition to determine the scope and focus. As co-authors on the project, SWDC representative(s) have worked on developing the search strategy and search string. Collaboration is continuous throughout every part of the review process, and feedback provided through written communication alongside multiple workgroup meetings.

Objectives and review question
The review seeks to answer the following question: 1. How effective are evaluated interventions in

reducing the prevalence of large carnivores near humans and/or attacks on people?

Definitions of the question components
Population: People interacting with large carnivores. In the review context, included large carnivores are wild animals within the order Carnivora with a body mass > 15 kg. In addition to species listed by Ripple et al. (2014) we also include coyotes (Canis latrans). Intervention: Any method, action, or technology implemented to reduce the likelihood of risky encounters between large carnivores and people, or attacks from large carnivores on people. Comparator: Intervention/control comparison where at least one treatment (exposure to focal intervention) setting is compared to at least one control (no exposure to focal intervention) setting. Outcome: Quantitative measures and comparisons of the prevalence of large carnivores in or near human settlement, the occurrence/intensity of close encounters between large carnivores and people, changes in flight initiation distance of carnivores before/after treatment, or attacks on people, in the treatment and control settings.

Search strategy
Zoological Record & BIOSIS Citation Index (using WoS search engine): TS= ((human* OR people OR public OR man OR men OR woman OR women OR child OR children OR worker* OR victim* OR waste OR trash OR bin OR “anthropogenic food source” OR bait* OR residential OR urban) AND (protect* OR prevent* OR mitigat* OR manag* OR intervention* OR action* OR remov* OR repel* OR scare OR scaring OR displace OR displacing OR haze OR hazing OR conditioning OR divert* OR deter* OR barrier* OR hunt* OR “buffer zone*” OR translocation* OR guard* OR warn* OR noise*) AND (trial* OR experiment* OR evaluat* OR effect* OR test* OR efficacy OR evidence) AND ((“large carnivore*” OR wolf OR wolves OR “African wild dog*” OR dhole* OR dingo* OR tiger* OR lion* OR jaguar* OR cheetah* OR leopard* OR puma* OR “mountain lion*” OR “Florida panther*” OR cougar* OR lynx OR bear* OR giant panda OR hyena* OR wolverine* OR coyote*) AND (predat* OR attack* OR kill* OR injur* OR maraud* OR fatal* OR safety OR threat* OR nuisance OR encounter* OR conflict* OR visit* OR intrude OR intrusion))) The Scopus search will be undertaken based on the same search string as the WoS-search, but using the search option: TITLE-ABS-KEY, and limitations: (LIMIT-TO (SUBJAREA,"AGRI") OR LIMIT-TO (SUBJAREA,"ENVI") OR LIMIT-TO (SUBJAREA,"MULT") OR LIMIT-TO (SUBJAREA,"SOCI") OR LIMIT-TO (SUBJAREA,"EART") OR LIMIT-TO (SUBJAREA,"VETE") OR LIMIT-TO (SUBJAREA,"Undefined") OR LIMIT-TO (SUBJAREA,"PSYC")) AND (LIMIT-TO (LANGUAGE,"English"))

Bibliographic databases
Three bibliographic databases will be searched, these are Zoological Record, BIOSIS Citation Index, and Scopus. Literature searches in bibliographical databases are undertaken with the subscriptions of the Swedish University of Agricultural Sciences. A topic search (TS=) will be made in Zoological Record and BIOSIS Citation Index using the Web of Science search engine (exact search option). The topic search includes a search of titles and abstracts alongside other descriptors. Titles, Abstracts, and Keywords will be searched in Scopus within relevant topics. A set of twelve benchmark articles were used to evaluate the ability of the search string to return relevant articles from the databases. Because of the language limitations of the review team, included articles must be written in English, Spanish, or Swedish. Only original studies will be eligible for inclusion whether published as scientific articles, books chapters, proceeding etc. A list of all articles excluded at full-text reading, and the reason for their exclusion, will be provided.

Web-based search engines
N/A

Organisational websites

Grey literature and unpublished studies, are searched through organisational websites and contact with experts in the field. Outreach and requests for studies will be made via colleagues and previous collaborators, and through contacts in main conservation organizations (including but not limited to Panthera https://panthera.org/, African Wildlife Foundation https://www.awf.org/, Wildlife Conservation Society https://www.wcs.org/, Wildlife Conservation Network https://wildnet.org/, and Bear Smart https://www.bearsmart.com/) that focus at least in part on mitigation of wildlife conflicts. The digital collection of USDA Wildlife Services (https://nwrc.contentdm.oclc.org/digital/collection/NWRCPubs1/search), Norwegian Institute for Nature Research (NINA, https://www.nina.no/english/Publications), Wildlife Institute of India (https://wii.gov.in/) will be searched using population and intervention search terms.

Comprehensiveness of the search

A set of twelve benchmark articles were used to evaluate the ability of the search string to return relevant articles from the databases. The benchmark articles informed amendments of the search string by adding terms to the search categories. The amended and final search string generated the largest return (11 of 12 benchmark articles) from Zoological Record, BIOSIS Citation Index, and Scopus. Searches in Scopus were complementary to the Web of Science searches, despite returning a smaller number of benchmark articles in total. The missing benchmark article was unavailable in all databases subjected to scoping searches.

Search update

If the time and budget allow a search update, an updated search may be performed after the final screening.

Screening strategy

Titles and abstracts returned from the database searches will be imported to an online Rayyan (https://www.rayyan.ai/) account. Exact duplicates will be automatically removed on the import into Rayyan. The remaining articles will then undergo manual screening in two steps. First, all returned titles and abstracts will be screened for including eligible population and intervention. This screening of titles and abstracts will be undertaken in Rayyan, mainly by one screener. For consistency, a minimum of 5 % of the titles/abstracts will be screened by a second screener, and Cohen’s Kappa will be calculated. All disagreements will be resolved by discussion. The second step concerns any publication that is not excluded in the first screening step, each of which will be read in full. All articles subjected to full text reading will be recorded in a purposely designed data sheet. During the full text reading, publication eligibility will be determined with regards to inclusion of a relevant population, intervention, comparator, and outcome. For any article excluded during eligibility assessment, extracted bibliographic information will remain in the datasheet along with the stated reason for exclusion.

Eligibility criteria

Eligibility criteria were developed together with the stakeholders to ensure the relevance for them and their funders and were evaluated through eligibility screening of the benchmark articles. Articles included in the review will report studies with the following elements: Population: People interacting with large carnivores. In the review context, included large carnivores are wild animals within the order Carnivora with a body mass > 15 kg that can pose a direct threat to human safety, and are free-living in the wild (i.e., not captive or tamed). In addition to species listed by Ripple et al. (2014) we also include coyotes (Canis latrans). Intervention; Any method, action, or technology implemented to reduce the likelihood of risky encounters between large carnivores and people, or attacks from large carnivores on people. Comparator: Intervention/control comparison where at least one treatment (exposure to focal intervention) setting is compared to at least one control (no exposure to focal intervention) setting. If additional interventions are undertaken in the control

setting these must also be undertaken alongside the focal intervention in the treatment setting, to meet the criteria. Outcome: Quantitative measures and comparisons of the prevalence of large carnivores in or near human settlement, the occurrence/intensity of close encounters between large carnivores and people, changes in flight initiation distance of carnivores before/after treatment, or attacks on people, in the treatment and control settings. Articles must be written in English, Spanish, or Swedish. Original studies are eligible for inclusion whether published as scientific articles, books chapters, proceeding etc.

Consistency checking
The screening of titles and abstracts will be undertaken in Rayyan, mainly by one screener. For consistency, a minimum of 5 % of the titles/abstracts will be screened by a second screener, and Cohen's Kappa will be calculated. All disagreements will be resolved by discussion. The second step screening, including the main part of full text reading, will be undertaken by one reviewer. However, a random sample of at least 5 % of the articles will be screened in parallel by a second reviewer for consistency checking. Consistency will be estimated through calculation of Cohen's Kappa coefficient. Where disagreements occur, these will be discussed until consensus is reached.

Reporting screening outcomes
Screening decisions will be reported in a ROSES diagram. Screening of articles subjected to full-text reading will be recorded in a purposely designed data sheet. If articles are excluded from inclusion, the reason will be stated in the data extraction sheet. This file and the extracted data file, has machine-readable and human-readable formats, and will be made available on publication of the final review report.

Study validity assessment
Critical appraisal of study validity in the included studies will be undertaken by two reviewers, using the Collaboration for Environmental Evidence Critical Appraisal Tool prototype version 0.3, which is specifically developed for critical appraisal of studies within environmental research (Konno et al. 2021). Disagreements about judgments will be discussed until consensus is reached, or else a third reviewer will be invited to perform an additional critical appraisal of the study and settle the disagreement. Risk of compromised internal validity in the included studies will be appraised according to the tool's seven criteria: 1. risk of confounding biases, 2. risk of post-intervention selection biases, 3. risk of misclassified comparison biases (observational studies only), 4. risk of performance biases (experimental studies only), 5. risk of detection biases, 6. risk of outcome reporting biases, and 7. risk of outcome assessment biases (Konno et al. 2021). Records of judgments for each of the included studies, with responses to each of the tool's questions, will be listed in a decisions sheet and the overall bias judgements included in the data sheet (additional file 4). In the syntheses the judgements will be presented in a table along with concise textual judgement justifications.

Consistency checking
Critical appraisal of study validity in the included studies will be undertaken by two reviewers, using the Collaboration for Environmental Evidence Critical Appraisal Tool prototype version 0.3.

Data extraction strategy
All records of data coding and extraction are documented in a purposely developed data sheet. A pilot test of data extraction in the data sheet was conducted by two reviewers using benchmark articles. Extracted data include records of study context e.g., geographic location, large carnivore species, and intervention type and specifics etc.), experiment detail (e.g., duration of study, statistical unit etc.), and effect estimates (e.g., sample size, effect measures). Some studies are expected to report their results in figures rather than providing exact numbers for measured effects,

and in these cases the online tool PlotDigitizer (https://plotdigitizer.com/app) will be employed to extract values. Two reviewers will extract values using the tool, and potential challenges of using the software will be consider, to enhance the accuracy of value extraction (Aydin & Yassikaya 2022). It is also expected that studies can lack sufficient reports of effect measures. In this instance, the authors of the original article will be contacted by the review team with a request for data. Communications are recorded. If authors do not respond, or if they are unable to share the missing data with the review team, the study will be removed from further analysis, and the reason will be stated in the data extraction sheet. This file and the extracted data file, in machine-readable and human-readable formats, will be made available on publication of the final review report.

Meta-data extraction and coding strategy
All records of data coding and extraction are documented in a purposely developed data sheet. The data sheet is accompanied by an instruction for extraction and coding, and was piloted on 4 benchmark articles during the preparation of the protocol. Meta data that will be extracted are: geographical location, species common name, species latin name, victim category, intervention category, intervention common name, intervention technical name, effect measure type, effect measure unit, duration of pretrial and trial, what measure is used for duration, the number of study periods, the character of the statistical unit, sample size, and number of repeated measures.

Consistency checking
Any uncertainties that arise during data extraction will be discussed in the review team and subject to parallel extraction.

Potential effect modifiers/reasons for heterogeneity
Heterogeneity is expected among studies, both due to variation in research designs, but also through contextual effect modifiers. Representatives of the SWDC were consulted, in their role as stakeholders and experts on the topic, to list potential sources of heterogeneity. First, it is expected that, even though large carnivores share certain traits (such as their diet) between species, some species-specific traits (including a diversity of behavioural or physical adaptations) will occur. As an example, a previous review of interventions intended to prevent attacks on livestock differences in intervention effectiveness between carnivores that dig (into enclosures) compared to those that climb (Eklund et al. 2017). During the analysis care will also be taken with regards to the object subjected to carnivore attacks, e.g., trash vs. humans, as these targets could represent different situations to large carnivores. Intervention effect may also vary with discrepancies in their implementation or maintenance (Frank & Eklund 2017). Within intervention categories we may also expect different types and designs between studies, i.e., different types of fencing or scaring approaches (Eklund et al. 2017). Potential heterogeneity stemming from discrepancies in intervention implementation and design, will be considered in the analysis and discussed in the final report. Finally, various biological factors (e.g., gender, age, or reproductive status) and behaviour of individual animals could also be expected effect modifiers, but these are difficult to identify in the review analysis. Nevertheless, the potential influence of individual states and traits may be discussed in the review report.

Type of synthesis
Review outcomes will be synthesized in a narrative, and if possible, a quantitative synthesis.

Narrative synthesis methods
The narrative synthesis will provide reference to all included articles, and describe in text the carnivore population (species, location), context (target object, intervention model), as well as the design and reported results of each study. Narrative presentations will be made based on the intervention category specified in the data extraction sheet. Visualization of the review outcomes

will also be made through a diagram of intervention effect in each original study, and a map may be provided over the geographical distribution of studies, providing reference to the original studies, focal species, and intervention category.

Quantitative synthesis methods
The quantitative synthesis will include a summary statistic, preferably logarithmic risk ratio, calculated for each original study. The risk ratio will be calculated as the ratio of the probability of attacks on humans (alternatively carnivore intrusion to settlements or other areas with high risk of encounters) between the treatment and the control setting. Provided that enough data is available and that it complies with its assumptions, a meta-regression analysis will be undertaken using metafor package in R software (Viechtbauer 2010), using a multilevel model (Nakagawa et al. 2023). Separate models will be created for different interventions. To account for heterogeneity, categorical variables will be added to the model, including carnivore species and damage object. Including categorical values in the model rather than conducting multiple models increases statistical power (Nakagawa et al. 2023). In the case that meta-regression is not possible, original studies will be grouped according to similarities (e.g., intervention category, species, and damage object) and the summary statistics presented jointly in tables and figures. A forest plot will be created to visualize study outcomes, as well as judgments of critical appraisal (Deeks et al. 2022).

Qualitative synthesis methods
We will only include quantitative data.

Other synthesis methods
N/A

Assessment of risk of publication bias
To identify potential publication bias, a funnel plot where, for each study, the effect measure plotted against the standard error of the effect measure. Provided that grey literature is obtained during the review, the outcomes of these studies may be analyzed in contrast to the scientifically published studies and using the Egger test (Egger et al. 1997), asymmetry may be detected. Possible causes of the asymmetry and potential publication bias will be discussed (Page et al. 2022).

Knowledge gap identification strategy
N/A

Demonstrating procedural independence
Reviewers who appear as authors of original papers will not review their own work, nor undertake eligibility assessment and validity judgments of the publication. In instances where reviewers occur as the authors of a publication, another member of the review team will be engaged in screening the article. If the number of reviewers is not sufficient or all reviewers are co-authoring the article, a review panel consisting of additional researchers are available for consultation.

Competing interests
A.E., J.F., and J.V.L.B. have all previously published research articles within the field, and in situations where associated articles are returned in the literature search, an external panel of fellow researchers will be available to evaluate the publication for inclusion in the review. The authors have no further competing interests to declare.

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Author's contributions

A.E. developed the search string, undertook the scoping searches, and wrote the main part of the manuscript. J.F. directed the scope of the review, contributed to development of the search string, and contributed to the final version of the manuscript. J.V.L.B advised the revision of the protocol, and contributed to the final version of the manuscript.

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The work on this review is inspired by, and undertaken in parallel with, a systematic review evaluating intervention effectiveness to prevent damage from herbivorous wildlife on agricultural crops (Eklund et al. 2023). We would like to thank Eklund et al. (2023) co-author J.M. for providing good input and assisting in the piloting the data sheet which is also used as the foundation of the data sheet in this review.

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