Collaboration for Environmental Evidence

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Systematic Review Protocol

Title
How effective are interventions to reduce damage to agricultural crops from herbivorous wild birds and mammals? A Systematic Review Protocol

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wildlife damage prevention, wildlife impact mitigation, human wildlife conflict, crop damage, herbivore

Background
In response to global biodiversity loss, conservation science and practice is actively seeking to improve the status of native wildlife (in our context, wild animal species) populations under threat, often dependent on land sharing with other human interests and practices in multiuse landscapes. One of the main conservation challenges when humans and wildlife co-occur is the mitigation of negative impacts that wildlife can have on human property, referred to as wildlife damage. Wildlife damage, often captured under the umbrella-term Human-Wildlife Conflicts (HWC), occurs on all continents with permanent human settlements and involves wildlife species of conservation concern that have negative impacts on human interests in both marine and terrestrial environments. In the terrestrial context impacts include damage caused by birds and mammals (such as elephants, primates, wild boar, geese) on agricultural crops, which is the basis for human food production. Consequently, conservation and management of wild birds and mammals often focus on developing and implementing practical and technical interventions to limit the amount and severity of damage, not least on agricultural crops. Among interventions there are examples of physical and psychological barriers, deterrents, scaring actions, or removal of wildlife from particularly problematic areas. Evaluations of interventions' effectiveness are usually limited to specific wildlife species, taxonomic groups, or geographical regions and meta-analyses are rare. Although the effect of interventions can be species or situation specific, it is also possible that management practices for one species or situation can draw learnings from other contexts. Furthermore, stakeholders and wildlife managers may face situations where multiple species cause damage, requiring multi-species assessment and a toolbox to handle complex situations. Literature review and synthesis focusing on intervention effectiveness across taxonomic groups and geographical regions would thereby provide a useful overview of the current scientific knowledge, and guide future research towards current knowledge gaps.

Theory of change or causal model
The implementation of interventions (e.g., physical and psychological barriers, deterrents, scaring actions, or removal) will lead to less damage on agricultural crops caused by herbivorous wild birds and mammals.

Stakeholder engagement

The review is commissioned by the Swedish Wildlife Damage Centre on behalf of their funders, to update the website EviWild with syntheses of scientific evidence. The SWDC works closely with wildlife managers and practitioners, from whom they collate and receive feedback about the EviWild website, to ensure it develops as a useful tool for these practitioners. The SWDC representatives have been involved in the formulation of the research questions and setting the scope and focus of the review. They have been actively involved in the initial development of the search strategy and search string. Additionally, they provide input and set the direction for the review, to meet their output needs as defined by their funders. These stakeholders are, and will continue to be, engaged as co-authors on the project. Through written communication alongside multiple workgroup meetings, they will be able to provide feedback on all parts of the review process.

Objectives and review question

The review, described in this protocol and in Eklund et al. (in press), seeks to answer the following question: How effective are evaluated interventions in reducing damage from herbivorous wild birds and mammals on agricultural crops?

Definitions of the question components

Population: Agricultural crops, i.e., any plants or plant parts intentionally grown by people for food consumption of people or domestic animals, under threat from terrestrial herbivorous wildlife. In the review context, terrestrial herbivorous wildlife is defined as wild (not domesticated) birds and mammals of regionally or migratory native species (not introduced, feral, or invasive), that are free-living in the wild (not captive or tamed). Intervention: Any method, action, or technology implemented to reduce the negative impact (e.g., damage, depredation, destruction) of terrestrial herbivorous wildlife on growing agricultural crops. Comparator: Treatment (exposure to evaluated intervention) setting compared to a control (no exposure to evaluated intervention) setting. Apart from the exposure to the evaluated intervention in the treatment setting, all else should be equal. Outcome: Quantitative measures and comparisons of the occurrence or severity of wildlife damage on agricultural crops in the treatment and control settings, i.e., evaluations of intervention effectiveness.

Search strategy

Zoological Records (WoS): TS= Scopus: TITLE-ABS-KEY ((lark* OR mallard* OR goose OR geese OR swan* OR waxwing* OR hornbill* OR * bananaquit* OR crow* OR raven* OR crane* OR blackbird* OR “black bird*” OR cowbird* OR grackle* OR bee-eater* OR guineafowl OR francolin* OR turkey* OR flamingo* OR woodpecker* OR parrot* OR parakeet* OR ringneck* OR cockatoo* OR corella* OR galah* OR bonnet* OR rosella* OR bulbul* OR starling* OR robin* OR impala* OR blackbuck* OR bison* OR gaur* OR nilgai* OR buffalo* OR ibex OR duiker* OR wildebeest OR topi* OR gazelle* OR antelope* OR waterbuck* OR “buffon’s kob” OR dik-dik* OR bushbuck* OR sitatunga* OR kudu* OR racoon* OR capuchin* OR monkey* OR mangabey* OR guenon* OR colobus* OR macaque* OR baboon* OR langur* OR moose* OR chital* OR deer OR elk OR muntjac* OR vole* OR agouti* OR elephant* OR zebra* OR giraffe* OR mongoose* OR hippopotamus OR gorilla* OR chimpanzee* OR orangutan* OR porcupine* OR hare* OR rabbit* OR rodent* OR mouse OR mice OR marten* OR badger* OR civet* OR hyrax OR “fruit bat*” OR squirrel* OR warthog* OR bushpig* OR “buch pig*” OR “warty pig*” OR “wild boar*” OR peccaries OR “cane rat*”) AND (crop* OR fruit* OR vegetable* OR orchard* OR lettuce OR plant* OR cultivar* OR grain* OR seed* OR pasture* OR field* OR farmland* OR cropland* OR grassland* OR ley OR “arable land”) AND (damage* OR strike* OR raid* OR depredat* OR destroy OR destruction OR impact* OR loss) AND (protect* OR prevent* OR mitigat* OR intervention* OR action* OR repel* OR deter* OR scare OR scaring OR displace OR displacing OR divert* OR “supplementary feeding” OR barrier* OR hunt* OR fence* OR spray*) AND (trial* OR experiment* OR evaluat* OR effect*))

Bibliographic databases
The literature searches will be made according to the subscriptions of the Swedish University of Agricultural Sciences in Scopus and Zoological Record. Searches will be made in titles, abstracts, and keywords of publications in Scopus (TITLE-ABS-KEY). In Zoological Record publications are searched using topic terms (field tag: TS=) which include titles and abstracts alongside for instance descriptors and organism details. Searches in Zoological Record are undertaken with the Web of Science search engine, using the exact search option. No date or language restrictions will be applied during the search, although inclusion of studies in the analysis will be restricted to English and Swedish language due to the language limitations of the review team. Searches in Scopus will be limited to the two subject areas “Agricultural and Biological Sciences” and “Environmental Science”.

Web-based search engines
N/A

Organisational websites
In addition to searching the two databases using the complete search string, manual searches will be undertaken to capture grey literature. Agricultural organizations are expected to evaluate interventions to prevent damage to crops, and searches for research will therefore be undertaken on main organizational websites. This involves screening research on the Environment topic, and sub-topic Wildlife, animals, biodiversity and ecosystems on the website of the UK government (https://www.gov.uk/search/research-and-statistics), and using population terms from the search string to search for relevant titles in the catalogue of the Foods and Agriculture Organization of the United Nations (FAO, https://www.fao.org/library/libraryhome/en/), the USDA Economics, Statistics and Market Information System (ESMIS) developed and maintained by Mann Library at Cornell University on behalf of the United States Department of Agriculture (USDA, https://usda.library.cornell.edu/?locale=en), and the online Joint Research Centre Publications Repository of the European Commission (https://publications.jrc.ec.europa.eu/repository/).

Comprehensiveness of the search
Scoping searches indicate an expected return of approximately 10,700 titles from Scopus and 8,700 titles from Zoological Record. A set of 19 benchmark articles were used to estimate the ability of the search string to return the relevant publications. Five of these benchmark articles were added by the work group. An additional 14 benchmark articles were identified through the online library collated by the IUCN work group on Human-Wildlife Conflict and Coexistence (HWC). Initial scoping searches based on the original search terms returned 42 and 53 percent of the benchmark articles in Scopus and Zoological Record. Fewer benchmark articles were returned, and no benchmark articles were exclusively returned, from scoping searches in Web of Science Core Collection, BIOSIS Citation Index, and CABI: CAB Abstracts ®. Therefore, Scopus and Zoological Record were determined the most relevant databases for this review. Informed by the missing benchmark articles additional search terms were added, and amendments were made to the string so that finally 100 % of the benchmark articles were returned by the two databases.

Search update
A search update may be undertaken before the study is finalized but is subject to time and budget limitations.

Screening strategy
Manual screening of the returned literature will be undertaken in two steps. In the first step all titles and abstracts will be imported to an online Rayyan (https://www.rayyan.ai/) account, where duplicates are removed before titles and abstracts are manually screened for inclusion of an eligible

population and intervention according to the review eligibility criteria. Relevant publications and publications for which relevance cannot be determined by screening of titles and abstracts, will be retained for the second screening step. In this second step, publications will be subject to a full-text reading and assessed according to all eligibility criteria of the review. The eligibility screening will be recorded in an Excel spreadsheet where publications are provided with a study ID number, and bibliographic information (title, author, publication year, journal) will be extracted. Eligibility for each criterion (population, intervention, comparator, outcome) is coded: yes/no/unclear. Publications which meet all eligibility criteria (coded: yes) will be included in the analysis and synthesis, while publications that fail to meet one or several of the eligibility criteria (coded: no) will not. In cases where insufficient information to assess eligibility is available from the full-text reading, more information will be sought from the authors of the publication. Eligibility screening from full-text reads is undertaken by one reviewer, with a random sample of five percent that is screened by two reviewers. Cohen's Kappa coefficient will be calculated to evaluate consistency between reviewers. Review team members will not evaluate the eligibility of their own papers.

Eligibility criteria

Does the study population comply with the eligibility criteria: Agricultural crops, i.e., any plants or plant parts intentionally grown by people for food consumption of people or domestic animals, under threat from terrestrial herbivorous wildlife? In the review context, terrestrial herbivorous wildlife is defined as wild (not domesticated) birds and mammals of regionally or migratory native species (not introduced, feral, or invasive), that are free-living in the wild (not captive or tamed). Does the study intervention comply with the eligibility criteria: Any method, action, or technology implemented to reduce the negative impact (e.g., damage, depredation, destruction) of terrestrial herbivorous wildlife on growing agricultural crops? Does the study comparator comply with the eligibility criteria: Treatment (exposure to intervention) setting compared to a control (no exposure to intervention) setting? Does the study outcome comply with the eligibility criteria: Quantitative measures and comparisons of the occurrence or severity of wildlife damage on agricultural crops in the treatment and control settings, i.e., evaluations of intervention effectiveness?

Consistency checking

One reviewer will screen all the titles/abstracts (except any publications authored by the reviewer her/himself) and a random sample comprised of a minimum of five percent of the titles/abstracts will be manually screened by two reviewers. Cohen's Kappa will be calculated to estimate consistency between reviewers. Eligibility screening from full-text reads is undertaken by one reviewer, with a random sample of five percent that is screened by two reviewers. Cohen's Kappa coefficient will be calculated to evaluate consistency between reviewers. Where reviewers disagree on their decisions, they will meet to discuss the decisions until consensus is reached. If the discrepancy cannot be solved by the reviewers themselves, other members of the review team will be consulted. Different members of the review team will be included as "double reviewers" to detect any potential systematic error of the main reviewer.

Reporting screening outcomes

ROSES flow diagram, list of eligible articles and full text articles excluded with reasons for exclusion.

Study validity assessment

Critical appraisal will be undertaken using the Collaboration for Environmental Evidence Critical Appraisal Tool prototype, version 0.3 (Konno et al. 2021). The tool is developed for critical appraisal of studies within the field of environmental research, including applied ecology. Following the tool, risk of studies' internal validity will be appraised according to 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).

Consistency checking
In the critical appraisal of study validity, at least two reviewers will assess and judge each included article for its associated risk of bias. In uncertain cases the work group will be consulted.

Data extraction strategy
Data extraction and coding will be undertaken in the purposely designed review data sheet (Additional file 1). The data sheet was developed in a pilot test of benchmark articles 1 – 10, and two reviewers. We will extract and code data to map the study context (e.g., geographic location, wildlife species, intervention category etc.), descriptives of the experiment (e.g., duration of study, statistical unit etc.), and data for effect estimates (e.g., sample size, effect measures). Detail of data coding and extraction is provided for each variable in the review data sheet. In studies where effect measures are reported in figures rather than text or tables, the estimates will be back transformed to numerical values using the online tool PlotDigitzer (https://plotdigitizer.com/app). Values will be extracted by two reviewers, and considering the potential challenges of using the software to ensure the estimations are valid and reliable. In cases where data is missing in the original articles, the corresponding author of the study will be contacted via email, with a request to provide or confirm missing data. This will also be done in cases where we are unable to extract values from figures in the original article. All author communications are recorded. If authors do not respond, studies will be excluded from further analysis and the reason will be stated in the data extraction sheet. Extracted data records will be made available as additional files in the final review publication.

Meta-data extraction and coding strategy
Data extraction and coding will be undertaken in the purposely designed review data sheet. The data sheet was developed in a pilot test of benchmark articles 1 – 10, and two reviewers. Detail of data coding and extraction is provided for each variable in the review data sheet. Meta data such as the number of study periods or from where values for effect measures are extracted from, will be included in the data sheet together with extracted data.

Consistency checking
Data coding and extraction undertaken for studies eligible for the review analysis will mainly be undertaken by one reviewer, with a minimum of 5 % of the studies subjected to double review for consistency checking. Where disagreements occur, these will be discussed between the reviewers until consensus is reached, or if the disagreement is not resolved then the work group will be consulted to reach consensus.

Potential effect modifiers/reasons for heterogeneity
Heterogeneity is expected among studies in the research designs as well as contextual effect modifiers. Wildlife species may be an effect modifier due to species specific behavioral patterns or physical adaptations, corresponding to “clinical diversity” in medical trials. For example, barriers such as fences may hinder mammals but not flying birds from entering an area. Care will be taken if studies evaluate intervention effectiveness in relation to different or mixed species or different crop types. Analyses and syntheses may be performed separately if species are observed effect modifiers. Other potential effect modifiers may relate to the biological factors (e.g., gender, age, or reproductive status) and behavior of individual animals but such effects may be difficult to identify in our analysis. The potential influence of individual trait effect modifiers may be discussed. Effect modifiers may also relate to the physical context in which interventions are implemented or maintained. In prior studies we have identified discrepancies in the practical implementation and

maintenance of interventions, and within intervention categories there may be different types of applications of an intervention, e.g., different types of fencing or scaring approaches. The interventions specifics are extracted in the data sheet, and discrepancies between models or designs may be observed. Implementation and maintenance needs will possibly vary in different settings and ecosystems, and care will be taken to observe potential effect modifiers related to intervention material and implementation.

Type of synthesis
Narrative and quantitative

Narrative synthesis methods
The narrative synthesis will be based on data extracted, and for each included study provide the article reference and describe in text the subject population (e.g., focal wildlife species, location of data collection), context (e.g., crop type, intervention material), methodological design and reported results of the study. Studies will be grouped and narratively presented according to the intervention type under investigation. The narrative synthesis will include a diagram and/or a table to visualize the results of each study and intervention type as well as provide a map of the geographic distribution of studies linked to intervention type. A diagram that illustrates the focal species for which the effectiveness of each intervention type has been evaluated, will also be included.

Quantitative synthesis methods
In the quantitative synthesis, a summary statistic (preferably logarithmic risk ratio) will be calculated based on the data of each study. The risk ratio is calculated as the ratio between the probability of yield loss (alternatively, proxies of the same e.g., wildlife abundance) in the treatment and the control setting. As some studies are expected to report dichotomous outcomes while others report continuous outcomes, recalculating outcomes as risk ratios allows comparison between individual studies. Where the outcome is reported as count data, the data will be dichotomised prior to the calculation of risk ratio. Where effect estimates in the original studies are reported as continuous outcomes the conversion to a relative measure implies a loss of information (Deeks et al. 2022). Therefore, for studies reporting continuous outcomes, a standardized mean difference will be calculated for comparisons. Meta-regression analysis will be undertaken in IBM SPSS software provided that the assumptions of meta-regression are met. If meta-regression is not possible, then summary statistics for individual studies will be presented jointly (e.g., in tables and/or figures) based on their similarities (e.g., taxonomic, or physiological, traits of the wildlife involved and/or based on intervention sub-types) that provides some homogeneity of the data. Sensitivity analysis will be undertaken to identify potential variation in the overall effects when studies judged as having a high risk of bias are included or excluded from the analyses. The quantitative outcomes will be graphically presented in a forest plot, together with judgements of critical appraisals (Deeks et al. 2022).

Qualitative synthesis methods
N/A

Other synthesis methods
N/A

Assessment of risk of publication bias
Many included articles are expected to be peer-reviewed, and thus an overall publication bias of the included studies may be suspected. Research protocols for the returned studies are expected to be missing, so to detect signs of publication bias, we seek to employ a funnel plot of the effect measure against the standard error of the effect measure for each study. If asymmetry is detected using the

Egger test (Egger et al. 1997), then the review will discuss the possible underlying causes of the asymmetry, of which publication bias may be one cause (Page et al. 2022). Provided that grey literature is returned from the database search, or searches of organizational websites, the outcomes of these studies in relation to scientifically published papers, can inform the understanding of potential publication bias.

Knowledge gap identification strategy
N/A

Demonstrating procedural independence
To ensure independence of the reviews, any member of the review team who appears as an author on an included study will not be involved in evaluating the eligibility of the paper or in judging its validity.

Competing interests
J.M. has previously published relevant research articles within the field, and in situations where associated publications are returned in the literature search, other members of the review team will 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.M. and J.F. directed the scope of the review, contributed to development of the search string, and contributed to the final version of the manuscript.

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