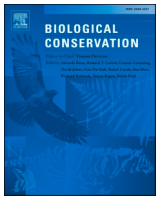
Biological Conservation 262 (2021) 109304

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon



Human dimensions of bat conservation – 10 recommendations to improve and diversify studies of human-bat interactions

Tanja M. Straka [a,*,1], Joanna Coleman [b,*,1], Ewan A. Macdonald [c,*,1], Tigga Kingston [d,*,1]

[a] Institute of Ecology, Technische Universität Berlin, Berlin, Germany
[b] Department of Biology, Queens College, City University of New York, Flushing, NY USA
[c] Saïd Business School, University of Oxford, Park End Street, Oxford, UK
[d] Department of Biological Sciences, Texas Tech University, Lubbock, TX, USA

ARTICLE INFO

Keywords:
Chiroptera
Conservation social sciences
Conservation psychology
Human-wildlife conflicts
Attitudes
Values
Beliefs

ABSTRACT

Human dimensions (HD) research is a discipline of conservation social sciences that applies social and psychological sciences to understand and influence conservation-relevant human behaviour. An understanding of the human dimensions is particularly required for bats because they are widely maligned and misunderstood and face many threats due to human behaviour. To gain a better understanding of the state of HD studies in bat conservation and address given critiques of social-science research undertaken by natural scientists, we assessed bat-related HD studies on four levels (1) authorships and the professional backgrounds of all authors, (2) conceptual foundations, including the range of contexts studied, the quality of literature reviews and conceptual framing in relation to drivers of human behaviour, (3) the extent to which authors follow social-science best practices and (4) recommendations. Our analysis of 68 papers revealed that compared to papers by natural scientists alone, those by multidisciplinary teams performed better at addressing a broader range of contexts and generating recommendations based on findings, but only slightly better on the conceptual-foundations and literature-review criteria. Our results suggest the need for more interdisciplinarity; specifically, early in the process. We also make ten recommendations for future bat-related HD research. Of these, five are intended to ground the field more firmly in conservation social science and five to prioritize future research. Collectively, our recommendations aim to solidify, accelerate and diversify bat-related HD research. Although bats are the focal animals, this paper's outcomes are potentially applicable to HD research on other taxa.

1. Introduction

1.1. Human dimensions - an established discipline of conservation social science

The global biodiversity crisis is unequivocally anthropogenic. Mitigating it clearly requires understanding people and their conservation relevant behaviours (e.g., Bennett et al., 2017a; Bennett et al., 2017b; Mascia et al., 2003). Conservation social science applies social-science constructs and practices to understand the drivers of human environmental and conservation behaviours to improve conservation policy, practice, and outcomes (Bennett et al., 2017a; Bennett et al., 2017b). It not only emphasizes that drivers of human behaviours include socio-economic and demographic factors, as long recognized in synthetic approaches to conservation biology, but also draws on wider findings from psychology, particularly behavioural psychology, to incorporate social and psychological factors (Clayton and Myers, 2009; St. John et al., 2010), or the 'human dimension' of wildlife conservation. Human dimensions (HD) research is a central discipline in conservation social science, with origins in North American wildlife and resource management. The field organizes concepts about psycho-social antecedents of behaviour – emotions, values, beliefs, norms and attitudes (Kingston, 2016; Manfredo, 2008; Manfredo and Dayer, 2004) — into conceptual frameworks, such as the Cognitive Hierarchy Theory (CHT; Fulton et al., 1996) and Reasoned Action Approach (RAA; Fishbein and Ajzen, 2011), to elucidate patterns of conservation-related cognition and behaviour

* Corresponding authors.
E-mail addresses: tanja.straka@tu-berlin.de (T.M. Straka), joanna.coleman.2000@gmail.com (J. Coleman), ewan.macdonald@sbs.ox.ac.uk (E.A. Macdonald), tigga.kingston@ttu.edu (T. Kingston).
[1] All authors contributed equally to the manuscript.

https://doi.org/10.1016/j.biocon.2021.109304
Received 10 February 2021; Received in revised form 4 June 2021; Accepted 17 August 2021
Available online 2 September 2021

(description of mentioned concepts and conceptual frameworks in Appendix SI1). Human dimensions of wildlife specifically focuses on wildlife issues to identify practical and feasible solutions for all stakeholders (human and non-human; Bennett et al., 2017a; Decker et al., 2001; Manfredo, 2008). Amid growth in wildlife-related HD literature, there is a bias toward species that are considered charismatic or in conflict with people, such as carnivores and elephants (Dressel et al., 2015; Mayberry et al., 2017); well-known ecosystem-service providers, such as insect pollinators (Hall and Martins, 2020); or that evoke ambiguous human evaluation (Frynta et al., 2019). Bats being less frequently studied, their relationships with humans remain more poorly understood than one might expect given bat diversity and near-global distribution (Kingston, 2016). Further, there is some criticism of social-science research undertaken by natural scientists (Martin, 2020) that might warrant further consideration so that human dimensions can move forward as an established discipline.

1.2. The need for human dimensions in bat conservation

Conservation biology has always been a crisis discipline (Soulé, 1985). And bats, arguably more than most other taxa, face an image crisis that is compounding challenges and retarding conservation efforts. Especially now that the human-bat interface is expanding, thereby increasing the incidence of human-bat conflict, and global media coverage creates and exacerbates the perception of bats as reservoirs of dangerous zoonoses (López-Baucells et al., 2018). In this context, bat researchers (mainly natural scientists) are increasingly drawn, and indeed are needed, to respond to the conservation crisis facing bats, particularly the human dimension.

Bats are like other species in that their conservation is enmeshed in a web of natural- and social-science concerns. There are more than 1420 described bat species (Simmons and Cirranello, 2020). However, of the 1314 species that have been assessed, more than 16% are threatened, 18% are Data Deficient (IUCN, 2020) and only 20% have stable or increasing populations. The main threats to bats, such as habitat change, human disturbance and hunting (Frick et al., 2020), are not only inherently linked (e.g., road building leads to deforestation, which increases exploitation of wildlife), but also fundamentally result from human behaviours. Moreover, bats elicit strong opinions from people – opinions that can confound conservation initiatives, so it behooves bat-conservation researchers to understand the drivers of human behaviours toward bats (Kingston, 2016).

Clearly, human behaviour toward bats, as for other wildlife, is complex. Indeed, human-bat interactions (HBIs), which we use to refer to specific and bidirectional contacts between humans and bats, are highly contextual and can range from negative (e.g., conflicts), to neutral to positive (e.g., eco-tourism; see also Frank et al., 2019). These interactions occur at a zone of contact, i.e., 'interface'. We also refer to human-bat relationships, which more broadly incorporate the affective quality of human-bat interactions (HBIs) and encompass humans' general feelings about bats. With bats among the most widely maligned and misunderstood animals (Kingston, 2016), HBIs and, consequently, human-bat relationships are likely more negative than positive. Meanwhile, conversion of natural habitats to anthropogenic land uses is rapidly expanding the human-bat interface and increasing the frequency of HBIs (Kingston, 2016).

1.3. Challenges faced by natural scientists doing social-science research

Human dimensions research draws on an established and diverse body of social-science theories, constructs, methods and language that must be clearly understood and rigorously applied for meaningful inference (Bennett et al., 2017a; Bennett et al., 2017b; Kelly et al., 2019; Manfredo, 2008; Sandbrook et al., 2013). However, many "early adopters" of conservation social sciences have natural-science backgrounds (Bennett et al., 2017a; Bennett et al., 2017b; Kelly et al., 2019; Veríssimo, 2013). This situation creates a potential challenge because if natural scientists lack relevant social-science knowledge and expertise, they may – compared to social scientists - be ill-prepared to do the type of sound conservation-social-science research whose findings benefit conservation (e.g., Mascia et al., 2003; Pooley et al., 2014; St. John et al., 2014). Despite recognition of the challenges and recommendations for overcoming them, e.g., through collaborations between social and natural scientists (Bennett et al., 2017a; Bennett et al., 2017b; Kelly et al., 2019; Kingston, 2016), Martin (2020) pointed out four problems that continue to pervade social-science research as conducted by natural scientists: (1) limited oversight of the literature and theoretical frameworks of drivers of human behaviour; (2) lack of social-science training; (3) inexperience with analytical methods; and (4) inadequate reporting of results. Even though multidisciplinary (*sensu* Stock and Burton, 2011) collaborations can improve the quality of studies, such collaboration may be stymied by the fact that researchers may have not only different epistemological backgrounds, but also different agendas (Meine et al., 2006; Sandbrook et al., 2013).

1.4. Research aims

We set out to investigate whether and to what extent recent criticisms of HD studies (i.e., about their quality) apply to the literature on human dimensions of bat conservation, focusing on four specific issues. First, we evaluated the authorships and professional backgrounds of authors conducting HD research to address generalised critiques of natural scientists doing social-science research (e.g., Martin, 2020; Mascia et al., 2003; Pooley et al., 2014; Teel et al., 2018). Second, to address the concern about ignoring an existing large body of work (e.g., theories of human behaviour, Martin, 2020), we assessed the conceptual foundations of these studies, including ranges of contexts studied, quality of literature reviews and conceptual framings. Third, we examined the extent to which authors followed social-science best practices, thereby addressing the critique about authors' lack of training (Martin, 2020). Finally, Martin (2020) raised the issue of inadequate reporting of results (Martin, 2020) – we expanded on this by characterizing the papers' outcomes, namely whether studies offered recommendations and, if so, clear ones grounded in the results (Tables 1, 2).

We were particularly interested in comparing the performance of papers by natural scientists alone, social scientists alone and multidisciplinary teams on criteria central to inference and repeatability and, additionally, in gaining an overview of the state of the literature on the human dimensions of bat conservation. Therefore, we reviewed all bat-related HD studies that sought to understand the drivers of human behaviour toward bats.

Finally, given criticisms of natural scientists delving into social science, we set out to propose tangible solutions to solidify, accelerate and diversify bat-related HD research. These are recommendations that future HD researchers (whatever their background) can use to improve their work and ultimately inform the practice of conservation. Although our focus is on bats, we believe these recommendations are also of interest to a broader audience of HD researchers and conservation social scientists.

2. Methods

2.1. Literature search and selected keywords

We searched for publications using the Web of Science (WoS) database, which we expected to yield results like those of other publication databases (Archambault et al., 2009; Norris and Oppenheim, 2007). We applied sequential searches for terms in topics, combining 'bats' with: 'attitudes', 'beliefs', 'norms', 'values', 'emotions', 'knowledge', 'perceptions', 'wildlife conflict and awareness', one by one (Appendix Fig. SI1). We selected the terms: 'attitudes', 'beliefs', 'norms' and 'values' based on their close links to conceptual frameworks for

Table 1
Parameters used to evaluate and score each publication as depicted in Table 2. Parameters marked with an asterisk are mentioned in our ten recommendations but are not part of Table 2.

Background of authors	
Author affiliations	Whether authors were likely to have received foundational training in social sciences, or be otherwise experienced with social-science methods (problem 2; Martin, 2020) and trained in the appropriate analytical methods (problem 3; Martin, 2020). Scores dichotomized as social sciences (as in Bennett et al., 2017a) or natural sciences. We used the authors' stated affiliations to categorize them and their researcher profiles (e.g., ResearchGate, personal websites, CVs) to determine whether authors had affiliations indicative of expertise with the social sciences.
Author countries*	All locations listed in the stated author affiliations.
Foundations	
Context	Placed into one of three mutually exclusive categories (pre-defined by authors): 1) Direct interactions at the human-bat interface: usually of a more applied nature, addressing existing conflicts and concerns, e.g., zoonotic disease, human-bat conflict over crops. 2) Understanding people's knowledge, attitudes or perceptions of bats in a more general context, typically as a baseline to raise awareness of a bat-conservation problem that requires public engagement (e.g., compliance with laws protecting bats). 3) Research into psychology or social science that uses bats as the subject, typically to represent an uncharismatic, scary or creepy species (e.g., studying the relative attractiveness of various wildlife species; asking whether fear and empathy can be felt at the same time). Such studies may or may not have conservation applications.
Literature overview	Review of social-science literature (problem 1, Martin, 2020). Scores were: 3: thorough review of concepts and context grounded in literature 2: basic review of concepts and context grounded in literature 1: scant or no review or overlooking relevant literature
Conceptual framing	The extent to which the study was embedded in a conceptual framework and to which the authors defined concepts. Scores were: 4: Embedded in an explicit conceptual framework grounded in literature 3: Specific concepts clearly defined and grounded in literature, implied use of framework in study 2: Specific concepts clearly defined but not grounded in literature and use of a guiding framework unclear. 1: Concepts mentioned but not defined, no framework mentioned. 0: None of the above
Specific concepts addressed by the paper	Measured concepts as defined by author(s), including attitudes, beliefs, emotions, values and other (encounters/interactions, behavioural intentions, norms, knowledge).
Implementations	
Method used	Categorized as: qualitative, quantitative, mixed*, participatory, planning and forward-thinking, evaluative, spatial, historical, meta-analytical (following Bennett et al., 2017a). *deliberately juxtaposes or combines qualitative and quantitative approaches so that one dataset informs the other (e.g., Johnson et al., 2007)
Hypothesis stated	Whether a hypothesis was explicitly stated. Scored as yes/no.
Hypothesis revisited	Whether an explicit hypothesis was revisited. Scored as yes, no or N/A.
Pre-/pilot survey	Whether the author(s) conducted a smaller-scale study involving the target group to provide the groundwork of a research project (Hassan et al., 2006). Scored as yes/no.
Reliability and validity	Whether authors mentioned reliability and validity and how they measured it.
Questionnaire provided	Whether the authors provide the instrument (e.g., questionnaire) in full, whether in-text or supplemental material. Scored as yes, no or N/A.
Results reporting	Whether the paper adequately reported results (problem 4, Martin, 2020) in terms of (1) central tendencies for questions using response scales and (2) demographic information about participants and whether (3) statistical tests were performed on the data. Scored as yes, no or N/A
Target group*	The study population, i.e., number and stakeholders
Target country*	Location of the study population
Embedded in context*	Whether participants were sampled from the target group, as opposed to, e.g., members of the public for a study on bat hunting. Scored as yes, no or N/A.
Outcomes	
Recommendations provided	We distinguished first between recommendations given (1) or not (0), and then between recommendations that were specific and grounded in the results (1) or generic (e.g., calling for more research or better outreach) (0)

behaviour change that are proving relevant for wildlife conservation (Ajzen, 1991; Fulton et al., 1996). We selected 'emotions' based on its link to wildlife and related issues (Jacobs et al., 2012) and 'knowledge' because it is a commonly identified driver of environmental attitudes and behaviours, though not one that supersedes others (Gifford and Nilsson, 2014). We did not include 'behaviour' because we were interested in behavioural antecedents, or 'culture' and 'governance' because they were out of the scope of this review, even though they may drive certain behaviours.

We accessed all articles, reviews, open access and book chapters indexed until 30 August 2020. The searches returned over 10,000 results. To restrict results to bat-related HD studies, we refined the list as follows. First, we iteratively excluded irrelevant disciplines (e.g., chemical engineering, oncology). Next, we excluded irrelevant terms that appeared in many results (e.g., 'body attitude test' and 'basic abilities test') using a "NOT" criterion, applied to the topic or title. We then repeated the process, substituting 'bats' with 'Chiroptera'. This yielded 123 records. English is the dominant language of documents published in WoS, followed by Chinese and Spanish (Vera-Baceta et al., 2019). Therefore, we repeated the searches described above in Chinese and Spanish as well as in French and German.

2.2. Applying further filters and data extraction

To narrow our search, we applied two filters (Appendix Fig. SI1). In filter 1, we assessed all abstracts and titles to determine whether each paper (1) addressed bats and (2) conducted any kind of empirical investigation to understand human-bat relationships or consisted of an opinion piece to improve these relationships. If so, we retained the publication. Filter 1 excluded 43 publications. In filter 2, any pair of this paper's authors read each paper in full and excluded nine more publications because either: (1) they did not clearly focus on any HBIs or relationships even though they passed both filter 1 criteria or (2) we could not obtain full text copies.

We thus ended up with 68 papers (hereafter, dataset), which at least two of us evaluated independently to extract information following specific guidelines (Table 1). We separated papers into those written by

Table 2
Summary of data of the evaluation and scoring as in Table 1 (foundations, implementations and outcomes) of the 68 papers. Values in "Context" do not add up to the total number of papers because some papers focused on more than one context in their study. Slashes "/" in results-reporting denote 'out of the subset of papers where expected' because questionnaires, central tendencies, demographics were not relevant in some studies. In outcomes, slashes indicate that recommendations were based on results, as opposed to general.

	BACKGROUND AUTHOR (# papers)		Natural Scientists (n = 32)	Social Scientists (n = 9)	Multidisciplinary (n = 25)	Total (n = 68)
FOUNDATIONS	Context	Specific conflict	24	2	15	41
		General attitudes	8	2	8	17
		Psychology	1	7	8	16
	Conceptual	Literature (median & mode) 1 (scant/no review) -3 (thorough review)	1 & 1	2 & 3	2 & 1	2 & 1
		Framing (median & mode) 0 (no framework) - 4 (embedded in framework)	1 & 0	3 & 4	2 & 0	1 & 0
	Concepts specified by authors	Values	1	2	2	5
		Beliefs	10	3	7	20
		Emotions	3	0	5	8
		Attitudes	16	7	19	43
		Knowledge	18	2	10	30
IMPLEMENTATION	Methods	Quantitative	26	7	19	53
		Qualitative	6	4	9	20
		Mixed Methods	2	0	0	2
		Pre-/Pilot survey	7	3	8	18
		Questionnaire provided	12/27	4/8	10/22	26/57
	Hypothesis	Stated	5	3	6	14
		Revisited	4	3	6	13
	Results reporting	Central tendencies	10/26	5/8	8/18	23/52
		Demographics	15/30	5/9	16/ 23	37/62
		Statistical analysis	22	7	17	46
	OUTCOMES	Explicit recommendations that follow from findings	9/31	2/6	10/22	21/59

natural scientists only, social scientists only and multidisciplinary teams (including at least one social scientist), as follows. One of us (JC) described the discipline of all authors by consulting their personal webpages (e.g., faculty page), Google Scholar and ResearchGate profiles and considering their degrees and stated areas of expertise. We considered 'natural sciences' to include all biological disciplines, conservation, ecology, health and veterinary sciences and resource management, and 'social sciences' to include anthropology, economics, education, sociology and psychology, among others. Following separate, independent reviews, we resolved all discrepancies in scoring or evaluation by consensus. Finally, we used Biblioshiny (Aria and Cuccurullo, 2017) to quantify international collaborations among authors, and to characterize the knowledge structure of this research field by analyzing the dynamics of the most common words that appeared in titles of references cited in all 68 papers (keyword plus; Zhang et al., 2016).

2.3. Scoring of articles

To accomplish our research aims, we assessed the background of each paper's authors and scored each paper in relation to the foundations (i.e., context, conceptual framing and concepts specified by authors), implementation (i.e., methods, hypothesis and results reporting) and outcomes (Table 1).

3. Results

Our dataset included papers by a total of 252 unique authors, published in 43 journals between 1998 and 2020. The journal with the most papers ($n = 9$) was Anthrozoos, a multidisciplinary journal with a focus on human and non-human animal relationships and interactions. Other journals with more than one paper were Zoonoses and Public Health ($n = 4$), Biological Conservation ($n = 3$), PloS Neglected Tropical Diseases ($n = 3$) and PloS One ($n = 3$).

3.1. Authorship – professional training and geography

Most authors ($n = 157$) had natural-science backgrounds, especially medicine/public health ($n = 45$) and veterinary medicine ($n = 12$). Fewer ($n = 53$) had social-science backgrounds. There were 42 authors whose backgrounds we could not determine or were too rare to categorize (e.g., math, computer science). Most papers were authored by natural scientists only, while papers written solely by social scientists were rarest (Table 2). Two papers were written solely by authors with unknown backgrounds (which we therefore excluded from authorship-related calculations). We found a total of 25 multidisciplinary papers (by at least one social scientist and one natural scientist).

Authors were affiliated with institutions in 105 countries, but we found considerable imbalance in the geographic distribution of authors and studies and a lack of bat-related HD studies from the biodiverse Global South. About half of all studies were in North America or Europe and there were no studies from North Asia or North Africa (Fig. 1). Our Biblioshiny analysis identified 16 international collaborations, defined by the publication of at least two papers with authors from institutions in both countries (Fig. SI2). Eight collaborations were between WEIRD (Western, Educated, Industrialized, Rich and Democratic) societies (four United States (US)-Australia; two United Kingdom (UK)-Portugal; two

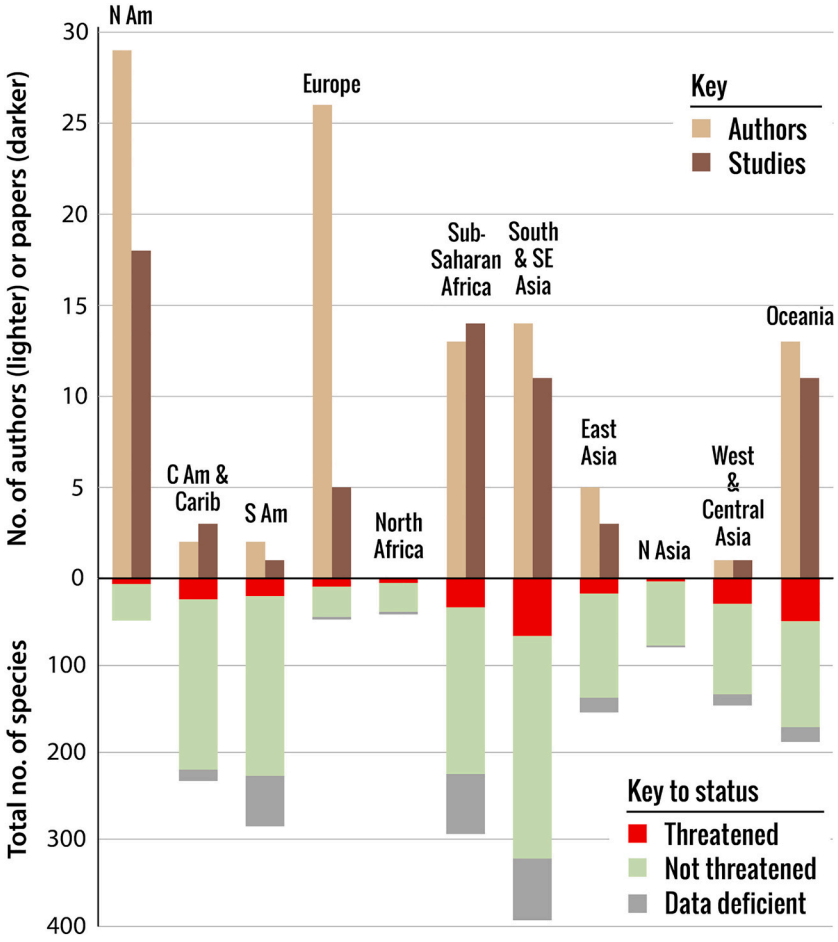


Fig. 1. The mismatch between the distribution of authors and study sites and bat diversity. Upper bar chart shows the number of papers with one or more authors from the region compared to the number of studies in each IUCN region. Lower chart shows IUCN conservation status of all bat species assessed in each region (Threatened = Vulnerable, Endangered, Critically Endangered, Extinct; Not Threatened = Least Concern and Near Threatened) (IUCN, 2020). Region names appear above bars in the upper panel - some abbreviated for simplicity, as follows: Am = America, Carib = Caribbean, C = Central, N = North, S = South, SE = Southeast.

UK-US), and eight were between the UK and non-WEIRD countries (three each with China and Ghana; two with Singapore). The most common multi-national collaborations were between researchers based in the US and Australia (n = 4), the UK and China (*n* = 3), and the UK and Ghana (n = 3; Appendix Fig. SI3).

It should be noted that our database included 22 records from journals that explicitly describe themselves as multi- or interdisciplinary or state that they welcome contributions from natural and social sciences. The most common ones in our dataset were Anthrozoos (*n* = 9), Biological Conservation (n = 3) and PLoS ONE (n = 3). We also retrieved one paper each from: Ecological Economics, Environmental Management, Forest Ecology and Management, Human Dimensions of Wildlife, Human Ecology, Human Wildlife Interactions, Journal of Environmental Psychology. As such, our review is inherently inclusive of multi- and interdisciplinary research.

3.2. *Foundations (context, conceptual and concepts)*

Our three *a priori contextual* categories that we grouped publications into were: specific conflict, general attitudes and psychology (Tables 1, 2). We observed a strong focus (*n* = 41 papers) on specific human-bat conflicts, especially zoonoses (*n* = 23). These disease-oriented papers typically aimed to document human knowledge or perception of transmission risk at the human-bat interface. Other specific conflicts addressed included hunting (n = 3), livelihood damage (n = 3) and bats in buildings (*n* = 1). General attitudes toward bats that were not motivated by a specific conflict or concern were addressed by 17 papers (e.g., different stakeholders asked about their perceptions and knowledge of seed dispersal by bats; Deshpande and Kelkar, 2015). A total of 16 papers addressed psychology or social-science questions in relation to bats, e.g., understanding children's moral and fearful affiliations toward bats (Kahn et al., 2008). Some papers fell into more than one contextual category. This was true for eight, five and five papers per contextual category ('specific conflict', 'general attitudes' and 'psychology', respectively; Table 2). Papers by natural scientists alone mainly focused on specific conflicts, whereas papers by social scientists mainly had a psychology focus (Table 2). Multidisciplinary papers tended to focus on specific conflicts as opposed to general attitudes and psychology.

Based on the Biblioshiny keywords plus analyses, the knowledge structure of these papers focused on perceptions, conservation, bushmeat, risk, attitudes, United States, management, disease, transmission and wildlife, with growing foci on perception (before 2010) and on conservation and bushmeat (2010 to 2012; Fig. 2).

In relation to the *conceptual* criteria (Tables 1, 2), only 18 papers included thorough reviews of the pertinent social-science literature (score of 3). Almost half (*n* = 35) performed scant reviews only (score of 1), and 14 performed a basic review (score of 2; one case was "not applicable"; Table 2). In this regard, multidisciplinary papers performed only slightly better than those by natural scientists alone. Papers by natural scientists alone commonly provided detailed reviews of the study's biological and conservation context, but limited coverage of the hypothesized psychological or social drivers of a relevant attitude or behaviour. Treatments of psycho-social dimensions also tended to focus on findings from other papers on bats and provide limited definitions and explanations of the constructs (e.g., attitudes, emotions) themselves.

We found similar trends for the conceptual framework criterion on our 0 (none) to 4 (explicit framework) scale (Table 1). Papers generally received low scores (median = 1, mode = 0; Table 2), but almost one third (*n* = 23) provided no framework, and so received a score of 0, while only 14 fully embedded studies in explicit frameworks (scoring a

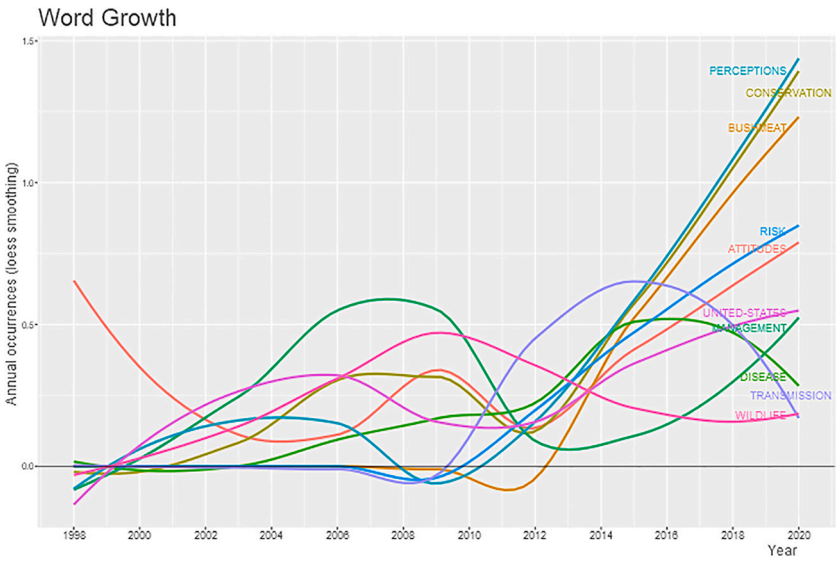


Fig. 2. Word dynamics of the ten most common words that appeared in titles of references cited by the 68 papers in our database (Keywords plus analyses in Biblioshiny).

4). Again, multidisciplinary papers performed only slightly better than those by natural scientists alone. Granted, some studies were exploratory, precluding development of *a priori* frameworks. In other cases, conceptual explanations and framing were provided post hoc in the discussion. Recurrent frameworks centred on message framing (e.g., Shreedhar and Mourato, 2019), conservation cues (Almeida et al., 2014; Gunnthorsdottir, 2001) and willingness to pay (Haefele et al., 2018). We found three examples of studies that applied the best practices of explicit framing and rigorous explanation of concepts. One (Reid, 2016) evaluated the intention to kill bats using the Theory of Planned Behaviour (TPB). The second (Haefele et al., 2018) examined the influence of country-level income on willingness to pay for the conservation of a migratory species. The third (Lu et al., 2017) explored the potential for message framing to improve communications about disease risk.

As for concepts, attitudes (n = 43) were, by far and regardless of authors' backgrounds, the most frequently studied (Table 2). Beliefs (n = 20), emotions (n = 8) and values (n = 5) were more rarely studied. Although we found seven observational studies that measured knowledge and/or attitudes after some intervention (e.g., outreach), only five truly investigated changes in these attributes.

3.3. Implementation

In relation to methods, most (n = 41) studies were purely quantitative, eight were purely qualitative, and the rest used either quantitative and qualitative (n = 12) or mixed methods (n = 2). We could not attribute the predominance of quantitative surveys to authors' natural-science backgrounds, as per Martin's (2020) criticism – of the 34 studies in our dataset authored partly or fully by social scientists, 26 were purely quantitative. By mixed methods, we refer not to studies that merely incorporate quantitative and qualitative methods, as several papers in our dataset did (Tables 1, 2), but to those that emphasize purposeful integration of quantitative and qualitative sampling such that one informs the other (as in Johnson et al., 2007). This mixed-method approach was exemplified by the above-mentioned study of the conflict between livestock farmers and vampire bats in Costa Rica, where Reid (2016) used it to pinpoint the most useful foundations for effective environmental education.

As for adequate reporting, about half (n = 37) of the papers reported at least some demographics, albeit sometimes only select parameters (e.g., sex, age) that provided limited insight. Of the 53 papers that used quantitative methods, half (n = 26) provided their survey instruments (in the text or supplementary information) in sufficient detail for reproducibility. Only 18 studies in our dataset reportedly included pilot studies (Table 2), e.g., testing questionnaire items with professors, biology-education experts and students (Prokop et al., 2009).

Finally, in relation to reliability and validity, only eight papers reported or discussed these measures (not reported in Table 2 given the low numbers). The vast majority (n = 63) of papers were embedded in context, meaning they worked with an affected or influential stakeholder group rather than peripheral or unaffected actors. However, most (n = 57) investigated only one target group, only eight studied more diverse stakeholders. One paper (Deshpande and Kelkar, 2015) stood out for the diversity of stakeholders (farmers, plantation workers, horticulturists, orchard owners and forest management staff) consulted to better understand perceptions of ecosystem services by fruit bats in Kerala, India.

3.4. Recommendations

Regardless of authors' backgrounds, the recommendations by most of the 59 papers that proposed any (we scored nine papers as NA for this criterion) were generic, e.g., calls for "more research" or to "raise public awareness of bats". Only 21 papers provided clear recommendations that were grounded in the results – most written by multidisciplinary teams (Table 2). One exemplary study (Shreedhar and Mourato, 2019) made specific fundraising recommendations and stated the benefit of emphasizing the link between anthropogenic activities and species endangerment. Another (Sheherazade and Tsang, 2015), generated explicit recommendations to address the bat-bushmeat trade in Sulawesi, Indonesia – these ranged from engaging churches in environmental education, to providing sustainable alternatives to bat meat, to involving local students in campaigning.

4. Discussion

Human dimensions studies are gaining importance in the conservation literature amid rising concerns about natural scientists conducting social science. To investigate the validity of criticisms leveled at such research, we reviewed 68 bat-related HD studies authored by natural scientists alone, social scientists alone and multidisciplinary teams. We scored them papers based on their foundations, implementations and outcomes.

Key criticisms (by Martin, 2020) of social-science research done by

natural scientists include limited oversight of the literature, lack of relevant training, inexperience with analytical methods and inadequate reporting of results, leading to the inference that multidisciplinarity might solve these problems (Stock and Burton, 2011). We agree that natural scientists likely lack social-science training and experience. Nevertheless, our review detected no evidence that these problems are unique to papers written by natural scientists alone (see e.g., predominant use of quantitative methods). We hope our recommendations help future HD studies, whether by multidisciplinary teams or not, avoid these pitfalls.

Even though the fact that researchers from different disciplines have different research agendas could hinder effective collaborations (Meine et al., 2006; Sandbrook et al., 2013), our review does reveal some clear benefits of multidisciplinarity. First, multidisciplinary teams achieved broader coverage of all three contexts (specific conflicts, general attitudes and psychology) compared to teams composed solely of natural scientists (mainly conflict-focused) or social scientists (mainly psychology-focused). Of course, it must be noted that we selected these three contexts *a priori* and future studies may include others. Next, when it came to generating explicit recommendations grounded in findings, multidisciplinary teams performed better than uni-disciplinary teams – a possible indication of uncertainty about how to interpret findings (natural scientists) and how to make them relevant to (bat) conservation (social scientists).

Otherwise, the benefits of multidisciplinarity were less evident. First, we detected minimal disciplinal effect on paper quality, in that scores for the literature-review and conceptual-framework criteria were only slightly higher for papers by multidisciplinary teams than for those by natural scientists alone. That multidisciplinary teams did not perform considerably better in this regard could signal a failure to integrate social scientists from the start or some drowning out of their perspectives by their natural-scientist collaborators. As such, it may be indicative not of a failure of multidisciplinarity *per se* but a sign of a greater need for *inter*disciplinarity, which more fully integrates knowledge domains and objectives to address a problem (Stock and Burton, 2011). Of course, it is also possible for natural scientists in multidisciplinary teams to be outnumbered by social scientists and their perspectives. Second, the problematic practices of mostly studying attitudes and using quantitative methods were not unique to papers by natural scientists alone but were pervasive in the bat-related HD literature. Interestingly, the knowledge structure focused on overall on perceptions and did not involve any specific concept such as attitude, emotion or value. Third, social scientists working alone did only slightly better than natural scientists alone or multidisciplinary teams at reporting central tendencies and demographics. Fourth, the likelihood that studies deploying questionnaires made these instruments available appeared unrelated to discipline.

We must acknowledge certain caveats. First, there are obvious limitations to using internet presence to classify authors' disciplines – however, we believe our broad categories (natural vs. social sciences) limited misassignments. Second, because we only searched the WoS database for papers in its three most common languages, plus French and German, we may have missed some papers written in other languages or not indexed in WoS.

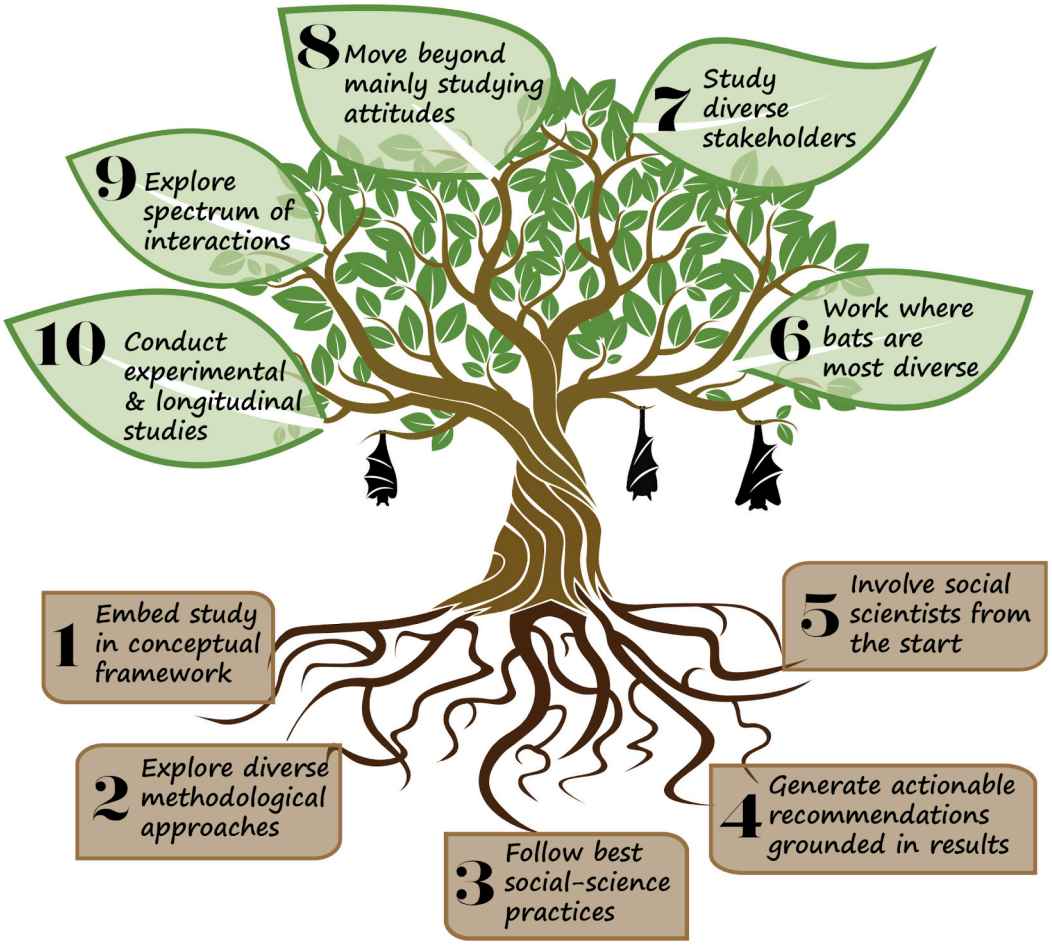


Fig. 3. Ten recommendations for future research in human dimensions of bat conservation separated in two groups (roots and branches). Roots represent recommendations to root the field more firmly in best practices in conservation social sciences and branches represent the direction intended to prioritize future research in this field.

4.1. Ten recommendations to root and grow human dimensions of bat conservation

Based on our findings, we make ten recommendations to improve and diversify interdisciplinary (sensu Stock and Burton, 2011) and multidisciplinary bat-related HD studies (Fig. 3). The first five aim to root the field more firmly in the best practices of conservation social science, thereby promoting the strength of inference needed to guide conservation (Bennett et al., 2017a; Bennett et al., 2017b; Martin, 2020). The latter five focus on directions where we see immediate need for bat-related HD research, supported by the strong roots of best practice. Most of these ten recommendations are derived from our findings, but we also provide generic recommendations to increase their applicability and utility across taxa and conservation issues.

4.1.1. Embed study in a conceptual framework, supported by a rigorous review of pertinent literature to explain constructs

Papers by natural scientists alone and multidisciplinary teams generally scored poorly on oversight of the literature and the use of conceptual frameworks. Here, we emphasize that when conducting research to understand the genesis of conservation-relevant attitudes and behaviours, the measured constructs (e.g., values, attitudes) must be clearly defined and embedded in a framework that defines their interrelationships and supports assessment of their relative contributions to a behaviour. A conceptual framework is, in essence, a set of causal hypotheses about how a behaviour (or behavioural intention) or attitude comes about. The positioning of constructs and frameworks in the relevant conservation theory and application should also be reviewed. This "gold standard" further supports appropriate development of study design, including selection of target groups, methods of inquiry and, in quantitative studies, sample sizes, development of survey items and others.

We further suggest that any study first and foremost understand the conservation problem of concern and identify the behaviours to be changed, discouraged (e.g., hunting) or promoted (e.g., protecting crops with netting). Then, the study can be designed to address the key issues and embedded in an appropriate framework (e.g., TPB, CHT, RAA). Such a clear, behaviour-focused approach (who must do what by when) informed by a valid conceptual framework allows researchers to critically assess the top research priorities. Specifying which conservation-relevant behaviours to address also ensures the correct questions are asked at the human-bat interface. Most papers in our review focused on attitudes, i.e., whether people like or dislike bats. Providing information or asking whether community members like bats is fine, but if the underlying conservation objective is to influence an undesirable or desirable behaviour (e.g., uptake of fruit-tree netting by local farmers to mitigate conflict over fruit crops), then research effort might be better invested in understanding underlying drivers of this behaviour or identifying perceived barriers to behaviour uptake. Understanding the conservation problem of concern not only guides which conceptual framework to use and how to collect and analyse the data, but also increases the likelihood of generating sound findings and informed recommendations.

4.1.2. Explore the diversity of available methodological approaches

Regardless of authors' background, we detected an imbalance in methodologies and strong preponderance of quantitative surveys. Here, we emphasize that human-nature relationships, being inherently nuanced and complex, may resist description when the only language is numbers, as opposed to words (see also Drury et al., 2011; Moon et al., 2019). We recognize that quantitative surveys have clear benefits, such as facilitating large sample sizes and clear response data that support statistical comparisons of explanatory factors and allow broad generalization (Choy, 2014). They feature prominently in positivist studies that aim to establish causality, operationalize definitions of concepts and address hypotheses about social phenomena (Masue et al., 2013). That said, their limitations must be acknowledged. Quantitative surveys do not always promote an in-depth understanding of social phenomena, are not very powerful when sample sizes are small (Choy, 2014) and poorly elucidate the "how" and "why", i.e., the genesis of attitudes, norms and behaviours (Drury et al., 2011). Here, qualitative approaches might be a better starting point. To obtain a holistic picture of human dimensions of bat conservation, we suggest future HD researchers explore the wide range of approaches in the social science 'toolbox', some of which are likely more suited to key questions in this field and more contextually appropriate (e.g., Drury et al., 2011).

To start, researchers could explore basic qualitative practices, such as focus group discussions, interviews and participant observation (see also Drury et al., 2011). Next, we highlight the need for more mixed-methods research - an approach that, as Pluye and Hong (2014) put it, "combines the power of stories and the power of numbers". Finally, we note the rarity or absence of certain useful approaches to complex issues. For instance, no studies used participatory techniques, such as Delphi method (e.g., Marchini et al., 2019) - this despite the importance of equity and participation to environmental decision-making (e.g., Law et al., 2018). Spatial techniques (see also Bennett et al., 2017a) were also largely absent (but see Lawson et al., 2017) even though they can allow meaningful combination of social and ecological data (see also Carter et al., 2019). One final, overlooked tool is Q-method, a purposeful sampling technique that generates qualitative and quantitative data to describe the gamut of views on a topic (Watts and Stenner, 2005). Because bat conservation tends to be a fraught topic and because Q-method promotes consideration of diverse stakeholders (see recommendation 4.1.7 below) and can lead to rapprochement, we see much value in it. Indeed, it has been used (Mattson et al., 2006; e.g., Rastogi et al., 2013) to explore very thorny issues elsewhere.

4.1.3. Follow social-science best practice

We evaluated uptake of some of the most common social-science research practices, with an emphasis on quantitative, explanatory approaches. One is the use of pilot studies – despite being crucial first steps to lay the groundwork for an intended study (Hassan et al., 2006), we encountered them rarely. Here, we emphasize that pilot studies help elucidate the correct approach (e.g., self-administered questionnaire vs. interview), the length of an interview or questionnaire and whether the language is understandable and suited to the target population (Hassan et al., 2006; Sutherland et al., 2018). Centrally, pilot studies let researchers test the validity of their overall models and whether individual or subsets of questions are appropriate measures of constructs.

We echo Martin's (2020) call for more comprehensive reporting. For instance, validity and reliability are essential evaluations of whether an instrument, such as a survey, truly measures the intended concept (validity) and does so repeatedly (reliability) (Bryman, 2008). Although these evaluations should be carried out and reported, few papers in our dataset did so (but see, e.g., Prokop et al., 2009). Researchers should also include demographic data to support interpretation and validation.

Finally, we emphasize that providing a questionnaire facilitates replication and cross-cultural comparisons (particularly of a validated instrument) and supports transparency. This transparency is important because most conservation-social-science studies are published in conservation journals that may lack the capacity to sufficiently review social-science research (Martin, 2020; St. John et al., 2014; Teel et al., 2018). Generally, despite the vast literature on social-research methods (e.g., Bryman, 2008; Walliman, 2016) and their application to conservation issues (e.g., Newing, 2010), inexperience with social-science methods, lack of training in analytical methods and inadequate reporting of results remain core criticisms of social-science research by natural scientists (Martin, 2020). These are significant criticisms because they suggest absence of the practices that are needed for robust implementation of studies, meaningful inference and replication. Of course, what constitutes best practice is often context-specific and we recommend becoming familiar with these practices to yield high quality data

that can inform conservation efforts.

4.1.4. Generate actionable recommendations grounded in the results

Few papers in our dataset made recommendations that were explicit and results-based. If bat-related HD research aims to elucidate human-bat relationships and interactions and, ultimately, benefit bat conservation, then describing the state of affairs is insufficient. Instead, authors must provide actionable recommendations arising from their findings as an essential step in a progression that can lead to design, implementation and evaluation of interventions to effect attitudinal or behavioural change (Williams et al., 2020). Generic recommendations, such as "more outreach is needed", miss an important opportunity to link the research and potential (conservation) interventions or to identify remaining research gaps. Furthermore, clear recommendations illustrate the utility of applying social-science theories and potentially convince "skeptics" of the value of holistic, interdisciplinary approaches (Sandbrook et al., 2013). Recommendations such as those made by Shreedhar and Mourato (2019) or Sheherazade and Tsang (2015) not only are specific and useful for on-site conservation actions, but also can inspire application and research to similar issues elsewhere. We suggest, especially in multidisciplinary research projects, that team members discuss research results and derivative recommendations before lessons are lost and projects or experienced individuals move on (see also Pooley et al., 2014).

4.1.5. Involve social scientists meaningfully from the design phase

In contrast to our expectation that multidisciplinary teams would yield the best outcomes for all disciplines involved (e.g., applying or advancing social science concepts while answering important questions for bat conservation), the multidisciplinary papers in our dataset only scored marginally higher than those by natural scientists alone on the literature review and conceptual framework criteria.

Interdisciplinary research is inherently challenging (Stock and Burton, 2011) and subject to disciplinal language barriers, conflicting agendas, power imbalances and epistemiological differences, among other obstacles (Mascia et al., 2003; Meine et al., 2006; Moon and Blackman, 2014; Pooley et al., 2014; Sandbrook et al., 2013). Although certain principles (e.g., open mindedness, embracing complexity and patience; as suggested by Kelly et al., 2019) could improve the quality of multidisciplinary research, we emphasize that researchers should consciously integrate and align their objectives early in a collaborative study to support the development of a conceptual framework and appropriate methods. Studying human-wildlife (bat) relationships is a space for interdisciplinary research in which social scientists identify adequate frameworks while natural scientists identify and emphasize a study's relevance to (bat) conservation. This might also be an opportunity for social scientists to advance psychological concepts and theories using conservation contexts. Interdisciplinary research is likely to be particularly effective if collaborators are motivated by shared interests (Kading and Kingston, 2020), rather than one discipline being "in service" of the other.

Given the need for patience and mutual respect in equitable and productive collaborations, we suggest training workshops for natural and social scientists as a starting point to introduce both disciplines to each other's approaches. To that end, within the Bat Specialist Group of the IUCN Species Survival Commission, we have created a "Human Dimensions of Bat Conservation" working group as part of the Global Union of Bat Diversity Networks (GBatNet). Networks accessible to all taxa include for instance the Social Science Working Group of the Society for Conservation Biology and the International Association for Society and Natural Resources.

4.1.6. Work where bats are most diverse

We found few studies from the biodiverse Global South (Fig. 1). Of course, our search parameters might not have returned all existing studies, especially those published in databases besides WoS or in less common languages. The underrepresentation of studies from the Global South is nothing new (Maas et al., 2021), but we reiterate that it can hinder the development of conservation solutions where they are most needed. Like other taxa, bats are most diverse in the tropics. However, in many high-diversity tropical regions, legal protection for bats is absent or limited, while rapid human population growth and development threaten bat species and fast expand the human-bat interface (Kingston, 2016). In this context, not only is the potential for negative interactions and human-bat conflict elevated, but so is the need for public awareness campaigns to highlight the sensitivity of bats to human disturbance and counter misconceptions that may hamper bat conservation.

About half the authors were affiliated with institutions in North America or Europe. These two regions are where most knowledge of human psychology and behaviour, particularly in the conservation domain, have been developed. However, cognitive and motivational processes can vary across cultures (Henrich et al., 2010), so great caution is needed in applying concepts and instruments developed and tested in WEIRD societies, which account for just ~12% of the world's population (Henrich et al., 2010), to other cultures and regions. Consequently, we emphasize that there is a clear need not only for more studies in biodiverse countries, but also to actively engage in-country social and cultural expertise to flag conceptual misalignments and to test, adjust and validate approaches developed elsewhere. Research projects should ideally be led by in-country social scientists or, failing that, at least integrate them as empowered collaborators in culturally representative research teams.

4.1.7. Study diverse stakeholders

Most papers focused on single target groups. This is problematic because HBIs generally involve diverse human stakeholders from the private, corporate, governmental and non-governmental sectors. Agricultural producers, animal-rights advocates, guano collectors, conservation managers, people for whom bats hold spiritual value and future generations —these are just some of the affected agents.

Given that conservation social science fundamentally recognizes that effective conservation is only attainable by understanding the human dimension, researchers should seek to understand the diversity of human viewpoints and behaviours and their relative influence on a given conservation behaviour or issue. Indeed, this principle is the cornerstone of stakeholder mapping, i.e., the first step in systematic conservation planning (Redpath et al., 2013), and without adequate participation, bridging the research-action gap is difficult, if not impossible (Cook et al., 2013). It appears vital to target more vulnerable and or marginalized groups, i.e., individuals and communities who hold little power in decision-making and/or are likely to be strongly impacted by said decisions (Rastogi et al., 2010; Reed et al., 2019). We therefore urge future researchers to proceed with due consideration for the gamut of people involved. The first step may be some form of mapping or network-analysis exercise to identify stakeholders and determine their respective rights, risks and responsibilities (e.g., Vogler et al., 2017).

4.1.8. Move beyond mainly studying attitudes

Most studies (regardless of author backgrounds) investigated bat-related attitudes. Attitudes are worth studying. Indeed, many conceptual frameworks relevant to conservation social-science (e.g., RAA; Fishbein and Ajzen, 2011) identify attitudes as key antecedents of human behaviours. However, these frameworks also recognize the roles of other drivers, which we therefore recommend be explored (and situated in supported conceptual framework; see also recommendation 4.1.1).

One driver is emotion. Emotions can: affect almost all areas of cognition (Jacobs et al., 2012); mediate the relationship between conservation-related values and behaviours (e.g., Lute et al., 2016); and be better predictors than cognitive concepts (e.g., value orientations) of the palatability of wildlife management strategies (Jacobs et al., 2014). Another antecedent is social norms, which can influence the perceived

appropriateness of conservation related behaviours (Perry et al., 2021). Finally, values, which are at the base of the CHT (Fulton et al., 1996), often resist change, so effective conservation strategies must work within existing value structures (Manfredo et al., 2017; Young et al., 2016).

Beliefs about and emotions toward bats might be particularly relevant to study given the prominent role of bats in many cultures. For instance, beliefs that eating bats improves libido and power (Suwannarong et al., 2020) or can heal asthma (Sinha and Sinha, 2001) can lead to increased hunting of bats. Further, most bat-related emotions studied thus far have been negative, such as fear (Kahn et al., 2008; Kaninsky et al., 2018). We suggest that bat-related HD research explore emotions that are conducive to conservation, such as compassion, which can be evoked, e.g., through photo stimuli (Straka et al., 2020), and motivate people to get involved (Greving and Kimmerle, 2020).

4.1.9. Explore the spectrum of human-bat interactions

We observed a strong focus on conflicts in our review. However, like interactions with other wildlife (Frank et al., 2019), HBIs fall on a spectrum. Although negative HBIs are often the most pressing conservation concern, more comprehensive research that also includes positive interactions aligns better with the growing interest in management practices that emphasize human coexistence, rather than conflict with, wildlife (Buijs and Jacobs, 2021).

We recommend at least three areas for future research. First, managing perceptions of disease risk. The disease-related papers we reviewed largely focused on the misperception of no risk, when in fact, one exists, a problem that raises vulnerability to exposure. However, the opposite misperception (that risk is high when it is really non-existent) is also a conservation concern, as observed in recently increased persecution and killing of bats linked to COVID-19 (e.g., Zhao, 2020). A few papers we reviewed (e.g., Lu et al., 2016; Lu et al., 2017) explored risk framing and messaging, but there is an urgent need to understand how to accurately portray risk without instilling negative attitudes and emotions toward bats. Second, expand studies of human-bat conflicts beyond disease-oriented studies. With increasing habitat change, the human-bat interface is expanding, bringing more species into conflict with people over crops (Aziz et al., 2016), dwelling spaces (Voigt et al., 2016) and loss of amenity (Lentini and Welbergen, 2019). Such conflicts can quickly escalate and drive persecution (e.g., Kingston et al., 2018), which is currently listed as a direct threat to 38 bat species (IUCN, 2020) although this is likely the tip of the iceberg. Finally, derive more insights into the (behavioural) drivers that enhance positive HBIs, e.g., bat-related ecotourism; public participation in bat-oriented citizen-science projects (Newson et al., 2017); and volunteer engagement in bat rescue and rehabilitation (Markus and Blackshaw, 1998).

Understanding concepts from positive psychology, such as 'pleasure', 'engagement' or 'meaning', as they relate to bats could point to strategies that inspire and strengthen environmental stewardship and public support for conservation (Buijs and Jacobs, 2021). New situations or research might begin with qualitative approaches such as grounded theory or ethnographic investigations to get a thorough understanding of the context to generate hypotheses.

4.1.10. Conduct experimental and longitudinal studies

Changes of attitudes or other concepts through interventions were rarely truly investigated. Because HD research seeks to understand human behaviours and, ultimately, inform useful interventions to benefit biodiversity, the field must investigate the effectiveness of planned interventions. Such studies are rare not only in the bat-related HD literature, but also in that on wildlife conservation in general (see also Dayer et al., 2020).

To assess the potential for interventions to effect change via statistical inference, we specifically highlight the need for two types of studies. The first type is experimentation, here defined as rigorous studies involving treatment groups who receive the intervention in question and controls who do not (see also Newing, 2010). A classic design is the randomized-control trial, used by four papers we reviewed (Lu et al., 2016; Lu et al., 2017; Shreedhar and Mourato, 2019; Rule and Zhbanova, 2012). One useful approach may be a modification of the Before-After/Control-Impact (BACI) design familiar to many ecologists. Although not used by any papers we reviewed, the BACI design has been used in analogous contexts, e.g., to determine that economic incentives do not get Brazilians in the Amazon to cut their consumption of wild meat, but that social marketing does (Chaves et al., 2018).

The second type of study is longitudinal. This involves following the same participants over time, which none of the papers in our database did, although two (Mehal et al., 2014; George et al., 2016) did revisit questions asked by earlier studies. This longitudinal approach seems especially powerful when it comes to assessing the durability of behavioural changes instigated by conservation interventions (see also Newing, 2010). For instance, several studies (e.g., Hughes, 2013 and others cited therein) have shown that even where pre- and post-visit surveys suggest that ecotourism raises awareness of and appreciation for nature and promotes the intent to conserve, rarely does it elicit persistent behavioural change.

5. Conclusions

The need for HD bat research is urgent, and (bat) conservation biology is a crisis discipline (Soulé, 1985). Therefore, one often must act before knowing all the facts. Still, to advance the HD research field, now might be a crucial juncture to learn from each others' disciplines to be most effective for (bat) conservation with high quality information from all the disciplines involved. We found a mere 68 research studies conducted in just over 20 years. However, now is a time when bat populations are embroiled in anthropogenic crises around the world. These crises are especially prevalent in the Global South, where land use and land cover change and the potential for human-bat conflicts are highest while legal protection for bats is lowest and financial support for conservation research is often limited. Globally, the need to increase research and research capacity is intensified by the influence of the COVID-19 pandemic on emotions, attitudes and behaviours toward bats. Increased persecution is already documented (e.g., Zhao, 2020). As such, those who conduct bat-related HD research must act swiftly to understand and mitigate shifting behaviours and their drivers that might exacerbate existing conservation issues, ignite new ones and change the landscape of bat conservation for decades to come.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. E.A. Macdonald was supported by Chester Zoo's Scholar and Fellow Programme.

CRediT authorship contribution statement

Tanja Straka: Conceptualization, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review and editing. **Joanna Coleman**: Conceptualization, Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review and editing., **Ewan Macdonald**: Conceptualization, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review and editing.

Tigga Kingston: Conceptualization, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We want to thank S. Boonman-Berson, and D. Kendal and two anonymous reviewers, for their helpful suggestions and comments on our manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2021.109304.

References

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211.
Almeida, A., Vasconcelos, C., Strecht-Ribeiro, O., 2014. Attitudes toward animals: a study of Portuguese children. Anthrozoös 27, 173–190.
Archambault, É., Campbell, D., Gingras, Y., Larivière, V., 2009. Comparing bibliometric statistics obtained from the web of science and Scopus. J. Am. Soc. Inf. Sci. Technol. 60, 1320–1326.
Aria, M., Cuccurullo, C., 2017. Bibliometrix: an R-tool for comprehensive science mapping analysis. J. Informet. 11, 959–975.
Aziz, S.A., Olival, K.J., Bumrungsri, S., Richards, G.C., Racey, P.A., 2016. The conflict between pteropodid bats and fruit growers: species, legislation and mitigation. In: Voigt, C.C., Kingston, T. (Eds.), Bats in the Anthropocene: Conservation of Bats in a Changing World. Springer International Publishing, Cham, pp. 377–426.
Bennett, N.J., Roth, R., Klain, S.C., Chan, K., Christie, P., Clark, D.A., Cullman, G., Curran, D., Durbin, T.J., Epstein, G., Greenberg, A., Nelson, M.P., Sandlos, J., Stedman, R., Teel, T.L., Thomas, R., Veríssimo, D., Wyborn, C., 2017a. Conservation social science: understanding and integrating human dimensions to improve conservation. Biol. Conserv. 205, 93–108.
Bennett, N.J., Roth, R., Klain, S.C., Chan, K.M.A., Clark, D.A., Cullman, G., Epstein, G., Nelson, M.P., Stedman, R., Teel, T.L., Thomas, R.E.W., Wyborn, C., Curran, D., Greenberg, A., Sandlos, J., Veríssimo, D., 2017b. Mainstreaming the social sciences in conservation. Conserv. Biol. 31, 56–66.
Bryman, A., 2008. Social Research Methods. Oxford University Press, New York, USA.
Buijs, A., Jacobs, M., 2021. Avoiding negativity bias: towards a positive psychology of human–wildlife relationships. Ambio. 50 (2), 281–288.
Carter, N.H., Bruskotter, J.T., Vucetich, J., Crabtree, R., Jaicks, H., Karns, G., Nelson, M. P., Smith, D., Linnell, J.D.C., 2019. Towards human–wildlife coexistence through the integration of human and natural systems: the case of grey wolves in the Rocky Mountains, USA. In: Frank, B., Glikman, J.A., Marchini, S. (Eds.), Human–Wildlife Interactions: Turning Conflict into Coexistence. Cambridge University Press, Cambridge, pp. 384–413.
Chaves, W.A., Valle, D.R., Monroe, M.C., Wilkie, D.S., Sieving, K.E., Sadowsky, B., 2018. Changing wild meat consumption: an experiment in the Central Amazon, Brazil. Conserv. Lett. 11, e12391.
Choy, L.T., 2014. The strengths and weaknesses of research methodology: comparison and complimentary between qualitative and quantitative approaches. IOSR J. Humanit. Soc. Sci. 19, 99–104.
Clayton, S., Myers, G., 2009. Conservation Psychology: Understanding and Promoting Human Care for Nature. Wiley-Blackwell, Chichester, UK.
Cook, C.N., Mascia, M.B., Schwartz, M.W., Possingham, H.P., Fuller, R.A., 2013. Achieving conservation science that bridges the knowledge-action boundary. Conserv. Biol. 27, 669–678.
Dayer, A.A., Silva-Rodríguez, E.A., Albert, S., Chapman, M., Zukowski, B., Ibarra, J.T., Gifford, G., Echeverri, A., Martínez-Salinas, A., Sepúlveda-Luque, C., 2020. Applying conservation social science to study the human dimensions of Neotropical bird conservation. Condor 122.
Decker, D.J., Brown, T.L., Siemer, W.F., 2001. Human Dimensions of Wildlife Management in North America. The Wildlife Society.
Deshpande, K., Kelkar, N., 2015. How do fruit bat seed shadows benefit agroforestry? Insights from local perceptions in Kerala, India. Biotropica 47, 654–659.
Dressel, S., Sandström, C., Ericsson, G., 2015. A meta-analysis of studies on attitudes toward bears and wolves across Europe 1976–2012. Conserv. Biol. 29, 565–574.
Drury, R., Homewood, K., Randall, S., 2011. Less is more: the potential of qualitative approaches in conservation research. Anim. Conserv. 14, 18–24.
Fishbein, M., Ajzen, I., 2011. Predicting and Changing Behavior: The Reasoned Action Approach. Psychology Press, New York, NY, USA.
Frank, B., Glikman, J.A., Marchini, S., 2019. Human-Wildlife Interactions: Turning Conflict into Coexistence. Cambridge University Press, Cambridge.
Frick, W.F., Kingston, T., Flanders, J., 2020. A review of the major threats and challenges to global bat conservation. Ann. N. Y. Acad. Sci. 1469, 5–25.
Frynta, D., Peléšková, Š., Rádlová, S., Janovcová, M., Landová, E., 2019. Human evaluation of amphibian species: a comparison of disgust and beauty. Sci. Nat. 106 (7), 1–19.
Fulton, D.C., Manfredo, M.J., Lipscomb, J., 1996. Wildlife value orientations: a conceptual and measurement approach. Hum. Dimens. Wildl. 1, 24–47.
George, K.A., Slagle, K.M., Wilson, R.S., Moeller, S.J., Bruskotter, J.T., 2016. Changes in attitudes toward animals in the United States from 1978 to 2014. Biol. Conserv. 201, 237–242.
Gifford, R., Nilsson, A., 2014. Personal and social factors that influence pro-environmental concern and behaviour: a review. Int. J. Psychol. 49, 141–157.
Greving, H., Kimmerle, J., 2020. You poor little thing! The role of compassion for wildlife conservation. Hum. Dimens. Wildl. 1–17.
Gunnthorsdottir, A., 2001. Physical attractiveness of an animal species as a decision factor for its preservation. Anthrozoös 14, 204–215.
Haefele, M.A., Loomis, J.B., Merideth, R., Lien, A., Semmens, D.J., Dubovsky, J., Wiederholt, R., Thogmartin, W.E., Huang, T.-K., McCracken, G., Medellin, R.A., Diffendorfer, J.E., López-Hoffman, L., 2018. Willingness to pay for conservation of transborder migratory species: a case study of the Mexican free-tailed bat in the United States and Mexico. Environ. Manag. 62, 229–240.
Hall, D.M., Martins, D.J., 2020. Human dimensions of insect pollinator conservation. Curr. Opin. Insect Sci. 38, 107–114.
Hassan, Z.A., Schattner, P., Mazza, D., 2006. Doing a pilot study: why is it essential. Malays. Fam. Physician 1, 70–73.
Henrich, J., Heine, S.J., Norenzayan, A., 2010. Most people are not WEIRD. Nature 466, 29.
Hughes, K., 2013. Measuring the impact of viewing wildlife: do positive intentions equate to long-term changes in conservation behaviour? J. Sustain. Tour. 21, 42–59.
IUCN, 2020. The IUCN red list of threatened species. Version 2020-3. https://www.iucnredlist.org.
Jacobs, M.H., Vaske, J.J., Roemer, J.M., 2012. Toward a mental systems approach to human relationships with wildlife: the role of emotional dispositions. Hum. Dimens. Wildl. 17, 4–15.
Jacobs, M.H., Vaske, J.J., Dubois, S., Fehres, P., 2014. More than fear: role of emotions in acceptability of lethal control of wolves. Eur. J. Wildl. Res. 60 (4), 589–598.
Johnson, R.B., Onwuegbuzie, A.J., Turner, L.A., 2007. Toward a definition of mixed methods research. J. Mixed Methods Res. 1, 112–133.
Kading, R.C., Kingston, T., 2020. Common ground: the foundation of interdisciplinary research on bat disease emergence. PLoS Biol. 18, e3000947.
Kahn, P.H., Saunders, C.D., Severson, R.L., Myers, O.E., Gill, B.T., 2008. Moral and fearful affiliations with the animal world: children's conceptions of bats. Anthrozoös 21, 375–386.
Kaninsky, M., Gallacher, S., Rogers, Y., 2018. Confronting people's fears about bats: Combining multi-modal and environmentally sensed data to promote curiosity and discovery. In: Proceedings of the 2018 Designing Interactive Systems Conference. Association for Computing Machinery, Hong Kong, China, pp. 931–943.
Kelly, R., Mackay, M., Nash, K.L., Cvitanovic, C., Allison, E.H., Armitage, D., Bonn, A., Cooke, S.J., Frusher, S., Fulton, E.A., Halpern, B.S., Lopes, P.F.M., Milner-Gulland, E. J., Peck, M.A., Pecl, G.T., Stephenson, R.L., Werner, F., 2019. Ten tips for developing interdisciplinary socio-ecological researchers. Socio-Ecol. Pract. Res. 1, 149–161.
Kingston, T., 2016. Cute, creepy, or crispy—How values, attitudes, and norms shape human behavior toward bats. In: Voigt, C.C., Kingston, T. (Eds.), Bats in the Anthropocene: Conservation of Bats in a Changing World. Springer International Publishing, Cham, pp. 571–595.
Kingston, T., Florens, V., Oleksy, R., Ruhomaun, K., Tatayah, V., 2018. Pteropus niger. In: The IUCN Red List of Threatened Species 2018.
Law, E.A., Bennett, N.J., Ives, C.D., Friedman, R., Davis, K.J., Archibald, C., Wilson, K.A., 2018. Equity trade-offs in conservation decision making. Conserv. Biol. 32, 294–303.
Lawson T., Elaine, Ohemeng, F., Ayivor, J., Leach, M., Waldman, L., Ntiamoa-Baidu, Y., 2017. Understanding framings and perceptions of spillover: preventing future outbreaks of bat-borne zoonoses. Disaster Prev. Manag. 26, 396–411.
Lentini, P., Welbergen, J., 2019. Managing tensions around urban flying-fox roosts. Austral Ecol. 44, 380–385.
López-Baucells, A., Rocha, R., Fernández-Llamazares, Á., 2018. When bats go viral: negative framings in virological research imperil bat conservation. Mammal Rev. 48 (1), 62–66.
Lu, H., McComas, K.A., Buttke, D.E., Roh, S., Wild, M.A., 2016. A one health message about bats increases intentions to follow public health guidance on bat rabies. PLoS One 11, e0156205.
Lu, H., McComas, K.A., Buttke, D.E., Roh, S., Wild, M.A., Decker, D.J., 2017. One health messaging about bats and rabies: how framing of risks, benefits and attributions can support public health and wildlife conservation goals. Wildl. Res. 44, 200–206 (207.).
Lute, M.L., Navarrete, C.D., Nelson, M.P., Gore, M.L., 2016. Moral dimensions of human–wildlife conflict. Conserv. Biol. 30, 1200–1211.
Maas, B., Pakeman, R.J., Godet, L., Smith, L., Devictor, V., Primack, R., 2021. Women and Global South strikingly underrepresented among top-publishing ecologists. Conserv. Lett. 14, 1–9.
Manfredo, M.J., 2008. In: Manfredo, M.J. (Ed.), Who Cares About Wildlife?, in Who Cares About Wildlife? Social Science Concepts for Exploring Human-wildlife Relationships and Conservation Issues. Springer US, New York, NY, pp. 1–27.
Manfredo, M.J., Dayer, A.A., 2004. Concepts for exploring the social aspects of human–wildlife conflict in a global context. Hum. Dimens. Wildl. 9, 1–20.
Manfredo, M.J., Bruskotter, J.T., Teel, T.L., Fulton, D., Schwartz, S.H., Arlinghaus, R., Oishi, S., Uskul, A.K., Redford, K., Kitayama, S., Sullivan, L., 2017. Why social values cannot be changed for the sake of conservation. Conserv. Biol. 31, 772–780.
Marchini, S., Ferraz, K.M.P.M.B., Zimmermann, A., Guimarães-Luiz, T., Morato, R., Correa, P.L.P., Macdonald, D.W., Frank, B., Glikman, J.A., Marchini, S., 2019. Planning for coexistence in a complex human-dominated world. In: Human–Wildlife Interactions: Turning Conflict into Coexistence. Cambridge University Press, Cambridge, pp. 414–438.
Markus, N., Blackshaw, J.K., 1998. Motivations and characteristics of volunteer flying-fox rehabilitators in Australia. Anthrozoös 11, 203–209.
Martin, V.Y., 2020. Four common problems in environmental social research undertaken by natural scientists. BioScience 70, 13–16.

Mascia, M.B., Brosius, J.P., Dobson, T.A., Forbes, B.C., Horowitz, L., McKean, M.A., Turner, N.J., 2003. Conservation and the social sciences. Conserv. Biol. 17, 649–650.
Masue, O.S., Swai, I.L., Anasel, M.G., 2013. The qualitative-quantitative 'disparities' in social science research: what does qualitative comparative analysis (qca) brings in to bridge the gap? Asian Soc. Sci. 9, 211–221.
Mattson, D.J., Byrd, K.L., Rutherford, M.B., Brown, S.R., Clark, T.W., 2006. Finding common ground in large carnivore conservation: mapping contending perspectives. Environ. Sci. Pol. 9, 392–405.
Mayberry, A., Hovorka, A., Evans, K., 2017. Well-being impacts of human-elephant conflict in Khumaga, Botswana: exploring visible and hidden dimensions. Conserv. Soc. 15, 280–291.
Mehal, J.M., Holman, R.C., Brass, D.A., Blanton, J.D., Petersen, B.W., 2014. Changes in knowledge of bat rabies and human exposure among United States cavers. Am. J. Trop. Med. Hyg. 90, 263–264.
Meine, C., Soulé, M., Noss, R.F., 2006. "A mission-driven discipline": the growth of conservation biology. Conserv. Biol. 20, 631–651.
Moon, K., Blackman, D.A., 2014. A guide to understanding social science research for natural scientists. Conserv. Biol. 28, 1167–1177.
Moon, K., Blackman, D.A., Adams, V.M., Colvin, R.M., Davila, F., Evans, M.C., Januchowski-Hartley, S.R., Bennett, N.J., Dickinson, H., Sandbrook, C., Sherren, K., St. John, F.A.V., van Kerkhoff, L., Wyborn, C., 2019. Expanding the role of social science in conservation through an engagement with philosophy, methodology, and methods. Methods Ecol. Evol. 10, 294–302.
Newing, H., 2010. Conducting Research in Conservation - Social Science Methods and Practice. Routledge, London, UK.
Newson, S.E., Evans, H.E., Gillings, S., Jarrett, D., Raynor, R., Wilson, M.W., 2017. Large-scale citizen science improves assessment of risk posed by wind farms to bats in southern Scotland. Biol. Conserv. 215, 61–71.
Norris, M., Oppenheim, C., 2007. Comparing alternatives to the Web of Science for coverage of the social sciences' literature. J. Informet. 1, 161–169.
Perry, L.R., Macdonald, E.A., Moorhouse, T., Johnson, P., Loveridge, A., Macdonald, D., 2021. Social referents and normative standards affect perceptions of livestock management behaviors. Human Dimensions of Wildlife.
Pluye, P., Hong, Q.N., 2014. Combining the power of stories and the power of numbers: mixed methods research and mixed studies reviews. Annu. Rev. Public Health 35, 29–45.
Pooley, S.P., Mendelsohn, J.A., Milner-Gulland, E.J., 2014. Hunting down the chimera of multiple disciplinarity in conservation science. Conserv. Biol. 28, 22–32.
Prokop, P., Fančovičová, J., Kubiatko, M., 2009. Vampires are still alive: Slovakian students' attitudes toward bats. Anthrozoös 22, 19–30.
Rastogi, A., Badola, R., Hussain, S.A., Hickey, G.M., 2010. Assessing the utility of stakeholder analysis to protected areas management: the case of Corbett National Park, India. Biol. Conserv. 143, 2956–2964.
Rastogi, A., Hickey, G.M., Badola, R., Hussain, S.A., 2013. Diverging viewpoints on tiger conservation: a Q-method study and survey of conservation professionals in India. Biol. Conserv. 161, 182–192.
Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., Whitehouse, A., Amar, A., Lambert, R.A., Linnell, J.D.C., Watt, A., Gutiérrez, R.J., 2013. Understanding and managing conservation conflicts. Trends Ecol. Evol. 28, 100–109.
Reed, J., Barlow, J., Carmenta, R., van Vianen, J., Sunderland, T., 2019. Engaging multiple stakeholders to reconcile climate, conservation and development objectives in tropical landscapes. Biol. Conserv. 238, 108229.
Reid, J.L., 2016. Knowledge and experience predict indiscriminate bat-killing intentions among Costa Rican men. Biotropica 48, 394–404.
Rule, A.C., Zhbanova, K.S., 2012. Changing perceptions of unpopular animals through facts, poetry, crafts, and puppet plays. Early Childhood Educ. J. 40, 223–230.
Sandbrook, C., Adams, W.M., BÜScher, B., Vira, B., 2013. Social research and biodiversity conservation. Conserv. Biol. 27, 1487–1490.
Sheherazade, Tsang, S.M., 2015. Quantifying the bat bushmeat trade in North Sulawesi, Indonesia, with suggestions for conservation action. Glob. Ecol. Conserv. 3, 324–330.
Shreedhar, G., Mourato, S., 2019. Experimental evidence on the impact of biodiversity conservation videos on charitable donations. Ecol. Econ. 158, 180–193.
Simmons, N.B., Cirranello, A.L., 2020. Bat species of the world: a taxonomic and geographic database. https://batnames.org/.
Sinha, R.K., Sinha, S., 2001. Ethnobiology: Role of Indigenous and Ethnic Societies in Biodiversity Conservation, Human Health Protection, and Sustainable Development. Surabhi Publications, Jaipur, India.
Soulé, M.E., 1985. What is conservation biology? BioScience 35 (11), 727–734.
Straka, T.M., Greving, H., Voigt, C.C., 2020. The effects of bat photographs on emotions, attitudes, intentions, and wildlife value orientations. Human Dimensions of Wildlife 1–8.
St. John, F.A.V., Edwards-Jones, G., Jones, J.P.G., 2010. Conservation and human behaviour: lessons from social psychology. Wildl. Res. 37, 658–667.
St. John, F.A.V., Keane, A.M., Jones, J.P.G., Milner-Gulland, E.J., 2014. FORUM: robust study design is as important on the social as it is on the ecological side of applied ecological research. J. Appl. Ecol. 51, 1479–1485.
Stock, P., Burton, R.J., 2011. Defining terms for integrated (multi-inter-trans-disciplinary) sustainability research. Sustainability 3, 1090–1113.
Sutherland, W.J., Dicks, L.V., Everard, M., Geneletti, D., 2018. Qualitative methods for ecologists and conservation scientists. Methods Ecol. Evol. 9, 7–9.
Suwannarong, K., Balthip, K., Kanthawee, P., Suwannarong, K., Khiewkhern, S., Lantican, C., Ponlap, T., Bupha, N., Amonsin, A., 2020. Bats and belief: a sequential qualitative study in Thailand. Heliyon 6, e04208.
Teel, T.L., Anderson, C.B., Burgman, M.A., Cinner, J., Clark, D., Estévez, R.A., Jones, J.P. G., McClanahan, T.R., Reed, M.S., Sandbrook, C., St. John, F.A.V., 2018. Publishing social science research in conservation biology to move beyond biology. Conserv. Biol. 32, 6–8.
Vera-Baceta, M.A., Thelwall, M., Kousha, K., 2019. Web of science and Scopus language coverage. Scientometrics 121 (3), 1803–1813.
Veríssimo, D., 2013. Influencing human behaviour: an underutilised tool for biodiversity management. Conserv. Evid. 10, 29–31.
Vogler, D., Macey, S., Sigouin, A., 2017. Stakeholder analysis in environmental and conservation planning. Lessons Conserv. 7, 5–16.
Voigt, C.C., Phelps, K.L., Aguirre, L.F., Corrie Schoeman, M., Vanitharani, J., Zubaid, A., 2016. Bats and buildings: the conservation of synanthropic bats. In: Voigt, C.C., Kingston, T. (Eds.), Bats in the Anthropocene: Conservation of Bats in a Changing World. Springer International Publishing, Cham, pp. 427–462.
Walliman, N., 2016. Social Research Methods: The Essentials. Sage Publications, London, UK.
Watts, S., Stenner, P., 2005. Doing Q methodology: theory, method and interpretation. Qual. Res. Psychol. 2, 67–91.
Williams, D.R., Balmford, A., Wilcove, D.S., 2020. The past and future role of conservation science in saving biodiversity. Conserv. Lett. 13, e12720.
Young, J.C., Searle, K., Butler, A., Simmons, P., Watt, A.D., Jordan, A., 2016. The role of trust in the resolution of conservation conflicts. Biol. Conserv. 195, 196–202.
Zhang, J., Yu, Q., Zheng, F., Long, C., Lu, Z., Duan, Z., 2016. Comparing keywords plus of WOS and author keywords: a case study of patient adherence research. J. Assoc. Inf. Sci. Technol. 67, 967–972.
Zhao, H., 2020. COVID-19 drives new threat to bats in China. Science 367, 1436.