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Perspective

Guidelines for communicating about bats to prevent persecution in the time of COVID-19

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ABSTRACT

While the current COVID-19 pandemic continues to wreak havoc on human health and national economies, conservationists are struggling to prevent misguided persecution of bats, which are misleadingly being blamed for spreading the disease. Although at a global level, such persecution is relatively uncommon, even a few misguided actions have the potential to cause irrevocable damage to already vulnerable species. Here, we draw on the latest findings from psychology, to explain why some conservation messaging may be reinforcing misleading negative associations. We provide guidelines to help ensure that conservation messaging is working to neutralize dangerous and unwarranted negative-associations between bats and disease-risk. We provide recommendations around three key areas of psychological science: (i) debunking misinformation; (ii) counteracting negative associations; and (iii) changing harmful social norms. We argue that only by carefully framing accurate, honest, and duly contextualized information, will we be able to best serve society and present an unbiased perspective of bats. We hope this guidance will help conservation practitioners and researchers to develop effective message framing strategies that minimize zoonotic health risks and support biodiversity and its associated ecosystem services.

1. Introduction

Zoonoses are infectious diseases — caused by bacteria, viruses, fungi, parasites or other pathogenic agents — that spread from animals to humans. Most human recurrent and emerging infectious diseases are zoonotic (Jones et al., 2008), and their origins can often be traced to specific wildlife reservoirs (Johnson et al., 2020). Emerging zoonoses have an enormous impact on global human health and are a significant burden on national economies, especially in low-income countries (Karesh et al., 2012). These impacts are particularly catastrophic when novel outbreaks spread worldwide through human-to-human transmission, such as the COVID-19 pandemic, and can lead to long-lasting consequences to the world's biodiversity and to conservation activities (Corlett et al., 2020; Evans et al., 2020).

Communicating the health risks posed by zoonoses is paramount to protecting human populations and mitigating the spread of the disease (Decker et al., 2012; Quinn et al., 2014). Yet, information (and misinformation) about zoonoses and their suspected animal hosts can potentially impact the public's perception about a given taxa (Davis et al., 2017). Ongoing news coverage, for example, repeatedly linking wildlife to a particular zoonotic disease, can fuel animosity towards a given species (or set of species), and in extreme cases, erode societal support for conservation or even fuel direct persecution of known or suspected disease reservoirs (Buttke et al., 2015; Guyton and Brook, 2015). In this context, even well-intentioned efforts by journalists, researchers, and conservationists to counteract dangerous negative associations between wildlife and zoonoses can lead to unintended consequences and further reinforce negative stereotypes (Decker et al., 2012; Buttke et al., 2015; Lu et al., 2016). This insidious outcome is particularly problematic amid the current pandemic, due to the tremendous societal and economic impacts COVID-19 is having at a global scale, combined with an overabundance of media coverage associating wildlife, and in particular bats, with the disease. Moreover, much of the ongoing media framing has been poorly crafted and inadequately contextualized, which may have inadvertently amplified public risk perceptions about bat-associated diseases, beyond the real

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proportionate risks. Such perceptions have also likely been amplified through social media, with potential counterproductive effects on public support for bat conservation.

Insights from human psychology can be used to carefully design messages that result in better outcomes for public health and conservation (Davis et al., 2017; Lu et al., 2016). Although several previous authors have already discussed some of the pitfalls and challenges associated with message framing of wildlife-disease associations (e.g. Decker et al., 2011, 2012; Buttke et al., 2015), up-to-date guidance on how to communicate about zoonoses without dampening support for conservation is currently lacking. Using COVID-19 and bat conservation as a case in point, we build on previous research and outline how psychological science can be used to address some of the complexities associated with conservation communications in the context of emerging zoonoses.

1.1. COVID-19 pandemic and bat conservation

Since first being recorded in late-2019 in China, COVID-19 has spread to > 200 countries and territories, causing over a quarter of a million human deaths and sending billions of people into lockdown as health professionals struggle to cope with rising numbers of infected patients. At an early stage in the outbreak, bats were identified as a suspected reservoir of the new disease owing to the similarity between SARS coronavirus 2 (SARS-CoV-2), the causative agent of COVID-19, and a bat-borne coronavirus (Bat CoV RATG13), previously identified in intermediate horseshoe bats (*Rhinolophus affinis*; Zhou et al., 2020). Although the World Health Organization emphasizes that "*possible animal sources of COVID-19 have not yet been confirmed*" (World Health Organization, 2020), the association between bats and perhaps the worst zoonotic outbreak in modern history, has predictably sparked negative reactions against this taxon (Zhao, 2020).

Much of the perceived disease risk associated with bats likely relates to their association with several other high-profile emerging viral zoonoses including the severe acute respiratory syndrome (SARS) coronavirus (CoV), the Ebola and Marburg filoviruses, and the Hendra and Nipah henipaviruses (Brook and Dobson, 2015; Brook et al., 2020). While bats thus present real risks as hosts for potentially dangerous diseases, several factors need to be considered to understand how this risk fits into the wider context of zoonoses. First, recent research indicates that the number of human-infecting viruses in bats is similar to other mammals, after controlling for the number of species within each order (Mollentze and Streicker, 2020; but see Olival et al., 2017). Second, ample evidence indicates that the greatest risks for virus spillover to humans comes from *human* activities that facilitate the mixing of taxonomically diverse species (e.g., intensive animal farming, live wildlife markets, keeping of wildlife as pets, in sanctuaries, and alongside domestic animals; Johnson et al., 2015) as well as activities that involve, or increase, human-animal interactions (e.g., hunting and habitat destruction and deterioration; Johnson et al., 2020). Third, bats make critical and multivariate contributions to human well-being (Kunz et al., 2011). In light of such factors, the dialogue about bat conservation and bat-associated infectious diseases thus poses a wicked problem (Waltner-Toews, 2017): namely, how to appropriately communicate about the risks between bats and zoonoses, without vilifying the former.

Message framing of bat-associated diseases is a mammoth challenge that requires close collaboration between virologists, public health officials, conservation scientists and practitioners. Without such collaborations, poorly contextualized or overblown associations between bats and zoonotic risk can swiftly mask the intrinsic (Blackmore et al., 2013; Quinn et al., 2014), ecological (Kunz et al., 2011) and economic (e.g. Boyles et al., 2011) importance of bats. In turn, this can propagate unwarranted negative attitudes and consequently lead to both direct persecution and erosion of local support for bat conservation efforts (López-Baucells et al., 2018). For example, large flying foxes are key pollinators of durian (*Durio zibethinus*), a culturally and economically important fruit crop throughout Southeast Asia (Aziz et al., 2017). However, some durian growers are now reluctant to support flying fox conservation due to fear of backlash from the public in the aftermath of the COVID-19 outbreak (Tuttle, 2020). Worse still, reports from other parts of the world suggest a few communities have even sought to cull bats in a misplaced effort to combat the disease (CMS, 2020). Such misguided behaviours present considerable cause for concern, not least because past experience has shown such actions not only fail to eliminate disease risks (Blackwood et al., 2013) but can also *increase* the risk of zoonotic disease spreading to humans (Olival, 2016). As a case in point, a study of 20 colonies of common vampire bats (*Desmodus rotundus*) in Peru found that culling not only failed to eliminate rabies in disturbed colonies but inadvertently led to an increase in the proportion of infected bats compared to undisturbed ones (Streicker et al., 2012). Similarly, in Uganda, as a response to an outbreak of Marburg hemorrhagic fever, locals culled thousands of Egyptian fruit bats (*Rousettus aegyptiacus*) but failed to prevent a second, even larger, outbreak some 20 km from the cave where the culling took place. Worse still, the culling also increased the risk of disease spillover as the Egyptian fruit bats that subsequently recolonized the cave had higher levels of active infection (Amman et al., 2014).

Here, we draw on the latest findings from the psychology of science communication and behaviour change (Buttke et al., 2015: Decker et al., 2012; MacFarlane et al., 2020), to highlight some of the major pitfalls for bat conservationists and practitioners, especially when communicating with the public about bats and disease-risk. We do not speculate about the origin of SARS-CoV-2 or further elaborate about the relationship about bats and zoonotic viruses (see e.g., Wood et al., 2012; Brook and Dobson, 2015; Brierley et al., 2016; Brook et al., 2020; Andersen et al., 2020; Johnson et al., 2020). Instead, we aim to offer some guidance from the science of science communication (Kahan, 2015) to help ensure that conservation communications are working to neutralize dangerous and unwarranted negative-associations between bats and disease-risk. Although framed around bats and COVID-19, we believe that the advice presented here may be relevant to other taxonomic groups also linked with zoonoses (e.g. bird conservation in the context of avian influenza); and also to other situations where practitioners need to debunk harmful misinformation (e.g., false health claims about remedies made from body parts of endangered animals) or counteract unwarranted attitudes towards a given conservation issue (e.g. blaming wild carnivores for livestock attacks perpetrated by feral dogs). To improve comprehension and accessibility of our guidelines, we also provide a simplified visual depiction (Fig. 1) of the more detailed guidance we now provide below.

2. Debunking misinformation

Few would deny that the contemporary media landscape has become increasingly used to spread *dis*information—misinformation disseminated with the intent to deceive, often for political or financial motives. However, we believe that the growing tide of environmental disinformation (Cook et al., 2018) poses underappreciated threats to conservation objectives (Daly, 2020). Moreover, conservationists appear to be largely unprepared to contain disinformation when it emerges in relation to conservation issues (Kidd et al., 2019a; Thaler and Shiffman, 2015). In 2016, Oxford dictionary's word of the year was "post-truth"—defined as "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief" (Flood, 2016). Such developments suggest that, while the scientific community is pushing an evidence-based agenda, modern society may have arrived upon a new paradigm where what matters is not veracity but holding attention and social signaling (McCarthy et al., 2020). This often translates into the spread of speculative, misleading, or re-interpreted information as factual (e.g. "bats *may* be a natural reservoir of SARS-CoV-2" becomes

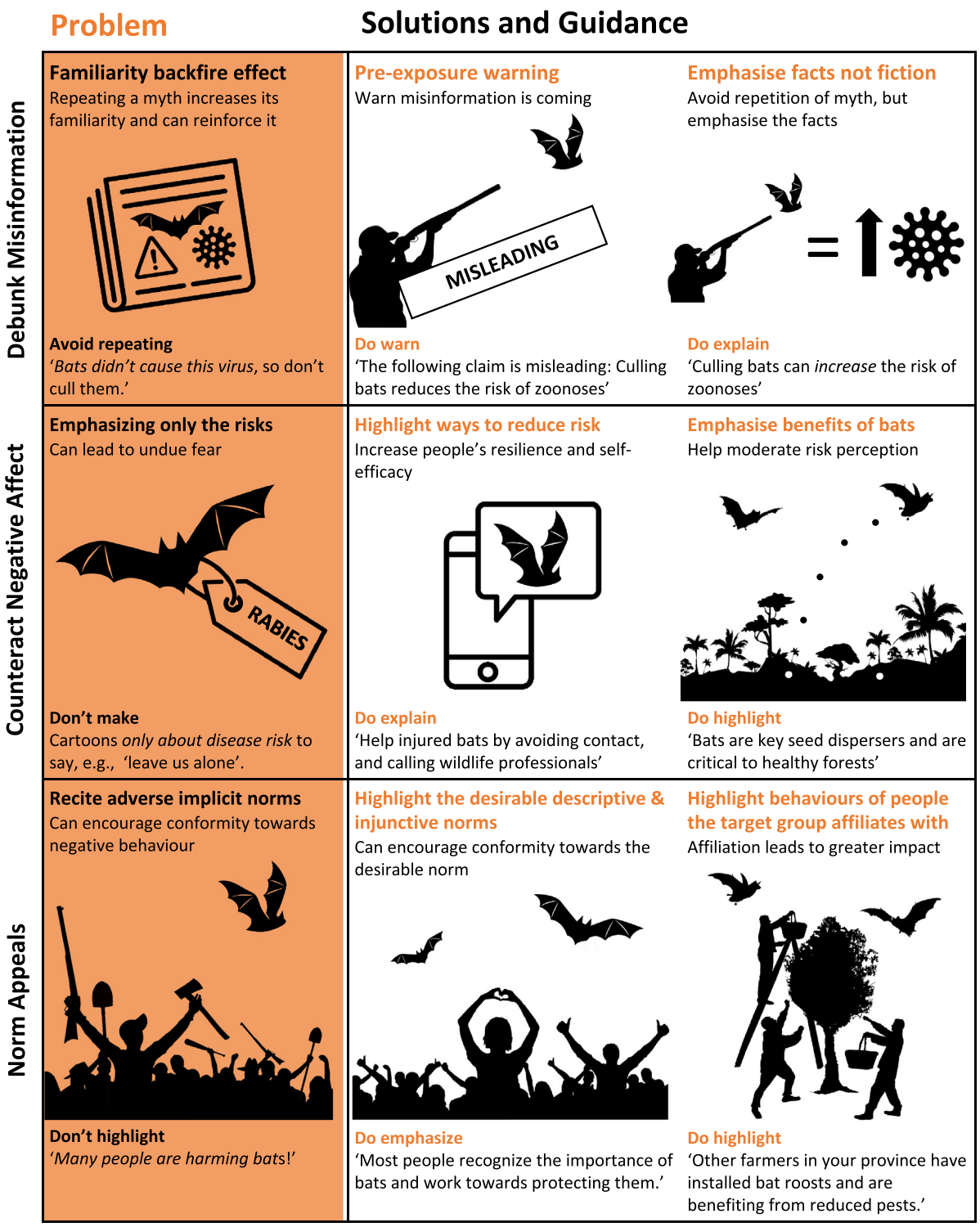

Fig. 1. A visual summary of our guidelines for communicating about bats to counteract persecution driven by fears associated with zoonotic health risks. This guide was adapted from an infographic by Lewandowsky et al. (2012) to help practitioners effectively refute misinformation.

"bats are responsible for COVID-19"). The ease and speed at which such mistruths are shared through social media expediates this spread of disinformation and greatly magnifies its real-world repercussions.

2.1. How correcting misinformation can make the problem worse

When faced with falsehoods and inaccuracies, the scientific community often reacts by directly challenging the misrepresentations (Williamson, 2016; Caulfield, 2020). However, even after credible retractions of misinformation, people's reasoning often continues to be influenced by that misinformation, a phenomenon termed the *continued influence of misinformation* (Johnson and Seifert, 1994). Several cognitive factors are responsible for this effect including that people often lack the skills to objectively evaluate information and so have a difficult time discerning between facts and familiar fictions (Bedford, 2010; Cook et al., 2018; Swire et al., 2017). Also, memory is an imperfect process, such that new information does not perfectly update old information; and recalled memories are vulnerable to outside influences

and can result in memory distortion, making it difficult to remember which information was fact and which was fiction (Lewandowsky et al., 2012).

Consequently, despite our intentions to correct misinformation, whenever we repeat it (even to refute it), our communications can strengthen the association. In other words, by stating that "bats *don't* spread COVID-19", this can strengthen the association between bats and COVID-19, and consequently many will misperceive, misremember, or simply forget the detail about bats NOT being responsible for spreading the virus. Thankfully, research from experimental psychology has demonstrated the efficacy of several tactics that can help to "debunk" misinformation in ways that counteract such problems (Lewandowsky et al., 2012). Based on this body of evidence, we now outline several key principles of effective debunking.

2.2. Guidance for evidence-based debunking of misinformation

To effectively debunk misinformation and overcome the continued misinformation effect, evidence-based refutations should:

(i) Warn recipients before confronting them with misinformation because warnings enable people to avoid the initial acceptance of misinformation, thus reducing the need for subsequent revision (Ecker et al., 2010);
(ii) Study the tactics used by those spreading misinformation (Thaler and Shiffman, 2015) and, before misleading stories gain traction, pre-emptively explain the flawed argumentation techniques used (e.g., fake experts, doctored images, oversimplified scientific concepts; Cook et al., 2017; Cook et al., 2018, van der Linden et al., 2017).
(iii) Repeat the facts, but avoid repeating the misinformation more than necessary (in order to refute it), because repetition can enhance familiarity, which ultimately can foster false beliefs (Jacoby and Kelley, 1989);
(iv) Use graphical evidence, because visual representations can make counter-arguing more difficult and help consumers comprehend data (Dixon et al., 2015);
(v) Provide alternate explanations of the debunked phenomenon to fill the mental "gap" left behind from retracting the misinformation (Ecker et al., 2010). This component of explanation should also address the potential motivation behind the initial source of misinformation (e.g., spread chaos, sell remedies, sell advertising, support an industry, support a political ideology; Nyilasy, 2019).

3. Counteracting negative associations towards bats

Throughout human history, bats have been both feared and celebrated. For instance, in Mayan mythology, bats were associated with death through the bat god *Camazotz* (Thompson, 1966). Whereas, in China, they have been traditionally regarded as symbols of good fortune (Kingston, 2016). Recently, however, negative stereotypes associated with the group (often reflected in misinformed myths, legends, and folklore) have increasingly been magnified by fear-inducing media headlines that often present bats as culprits of disease outbreaks (López-Baucells et al., 2018). Consequently, bat conservationists are increasingly faced with sensationalist fearmongering and misinformation about the risks posed by bats, and thus understandably feel compelled to counteract such beliefs in the hope of preventing public backlash against the group.

3.1. How people use feelings to make decisions

Knowledge alone is rarely the sole driver of attitudes and behaviours towards environmental issues (Fielding and Head, 2012). Instead, people's judgements and decisions are often guided by several heuristics, or mental shortcuts, that evolved to enable us to make quick decisions (Kahneman, 2012). One way we make quick decisions is by relying on "gut-feelings" rather than more deliberative rational processes. This aspect of our decision-making process is governed by *affect*— the specific quality of "goodness" or "badness" that becomes associated with an action or item (Slovic et al., 2007). Affective reasoning may explain much of the over-reactions towards bats (Kingston, 2016). Specifically, in the context of zoonoses, negative affect is being irrationally attached to bats, because of the repeated, and thus increasingly familiar, link between disease (bad) and bats (now also feels bad).

Many attributes of affective reasoning should inform public messaging about the importance of bat conservation. One key attribute is that our evaluations of risks and benefits tend to be negatively correlated—even when the nature of the risks (or benefits) is both distinctly and qualitatively different from the nature of the benefits (or risks; Alhakami and Slovic, 1994). For example, if bats are portrayed as high in risk, this will contribute to the perception that they are also low in benefit, and vice-versa. This tendency is further amplified when people have less capacity (e.g., high stress or lack of time) for analytical deliberation (Finucane et al., 2000). Evidence on the affect heuristic suggests that the perception of one attribute can be influenced by manipulating information about the other (Finucane et al., 2000; Ghanouni et al., 2017).

Another key attribute of affective decision-making is that people tend to underestimated large risks, which are mundane and under-reported (e.g., diabetes, stroke, tuberculosis) but greatly overestimate small risks, which are over-reported, sensational, or fear-inducing (e.g., shark attacks, tornadoes, and cases of rabies transmission by bats; Slovic et al., 2007). One explanation for this bias, is that such affect-laden risks, no matter how improbable, become encoded in people's memory through potent images, metaphors, and emotional narratives that trigger strong reactions and thus also greater media interest, and therefore tend to feel riskier. Unfortunately, wildlife-associated diseases tend to have many traits that can amplify the risk perceptions above the actual risk. Such traits include novelty, potential for high-consequence outcomes (illness or death), and the lack of individuals to control the threats (Buttke et al., 2015).

3.2. Guidance for counteracting harmful negative associations

To effectively alter people's irrational and/or harmful negative associations, while always being factual, communicators should aim to:

(i) Avoid using negative, especially fear-inducing, metaphors or pictures linking wild bats to diseases, as such imagery will be far more memorable than any subsequent rational appeal to conservation outcomes. However, if the messaging was specifically targeted at, and confined to, human-bat interactions, such as hunting, trading, and eating wild bats, then it may be vital to clearly communicate the real health-risks arising from such behaviours (Lu et al., 2016; Tannenbaum et al., 2015). Nevertheless, practitioners should still not use misleading imagery linking animals in the wild to zoonoses.
(ii) Emphasize the direct, and indirect, health benefits that bats provide to human populations. For example, highlight their consumption of disease carrying mosquitoes (Kemp et al., 2019) or their critical role in suppressing agricultural pests and their contribution to human food security (Wanger et al., 2014; Maas et al., 2016; Puig-Montserrat et al., 2015; Russo et al., 2018).
(iii) Provide factual, awe-inspiring, natural history information about bats, and about the benefits that they provide to natural ecosystems. For example, emphasize their role in the recovery of degraded landscapes via seed dispersal and the suppression of herbivorous insects (Farneda et al., 2018). Acknowledging the ecological benefits of bats is especially important in risk messaging (e.g., when communicating about rabies), as it can foster greater

intention to adopt recommended risk-reduction behaviours, without stigmatising bats (Lu et al., 2016).

(iv) Explain why, if most bat species are left alone, they present little, if any, risk to human health. Where some risk exists for a certain species (Quinn et al., 2014), then communicate the steps that: people can take to reduce their personal risk (Decker et al., 2012); society is taking to reduce the collective risk (Bandura, 2000); and that a given technology can help to reduce a particular risk (e.g., explain why research into bats' immune systems may hold the key to ground-breaking antiviral treatments for humans; Kachel, 2016).

(v) Risks should also be quantified using easily evaluable comparisons to relatively mundane events (e.g., "although rabies is one of the most important zoonotic viruses in bats, at a global-scale, bites from domestic dogs are responsible for over 99% of rabies-related deaths"; World Health Organization, 2013). Equally, strive to describe both the high benefits and/or low risks, using easily evaluable comparisons (e.g., "straw-coloured fruit bats (*Eidolon helvum*) benefit forests by dispersing seeds up-to four times further than other similar-sized frugivores"; Abedi-Lartey et al., 2016).

4. Changing harmful social norms

Recognising the role of social context on people's attitudes and behaviours is paramount to understanding human-bat relationships. Kingston (2016) provides a detailed account of how social norms—the rules or expectations about how members of a community should behave—can impact bat conservation. Here, we emphasize the dynamic nature of social norms and how these can be impacted by information regarding zoonoses, while providing best practice on how to use a "norm appeal" to alter damaging human behaviours towards bats.

4.1. How efforts to alter social norms can backfire

As individuals, we owe much of our success to other members within our communities. Such cooperation, and therefore our individual success, is often reliant on successfully detecting and adhering to social norms within our perceived community (Simler and Hanson, 2017). One way to alter harmful behaviours is to employ a norm appeal—messaging that aims to alter an undesirable behaviour by encouraging conformity towards more a desirable norm, usually by referring to the existing behaviour of an influential group (e.g., "most farmers in your community have installed artificial bat roosts to enhance pest-control services provided by bats"). To design effective norm appeals, we must first be able to distinguish between (i) injunctive norms— what others approve or disapprove of doing, (ii) descriptive norms—what other people typically do, and (iii) perceived norms—-what individuals believe about the real injunctive and descriptive norms (Farrow et al., 2017).

Failure to distinguish between different types of norms can result in messages that inadvertently strengthen undesirable norms. For example, stating that "people should stop harming bats" is also implicitly highlighting the descriptive norm that some people are harming bats, which could encourage others towards that undesirable behaviour (Cialdini, 2003). In contrast, stating that "most people know bats are harmless and should be protected," may be equally true, but instead it should encourage conformity in the desired direction.

4.2. Guidance for designing effective norm appeals

To effectively alter undesirable norms and encourage more desirable behaviours, communications should aim to:

(i) Avoid reciting adverse norms, such as "Stop harming bats!", as this implicitly suggests that some people are harming bats and can create perception that this behaviour is more acceptable and widespread than reality (Cialdini et al., 2006).

(ii) Emphasize descriptive norms, such as "The vast majority of countries protect bats, and millions of people live happily alongside them", as this will encourage conformity with the greater majority (Cialdini, 2003).

(iii) Where the desired behaviour is not yet established, highlight the *increasing frequency* of the desired norm, such as "more and more countries are formally recognising the importance of conserving wild bats" (Rare and The Behavioural Insights Team, 2019).

(iv) Highlight norms that are specific to the target populations, as the more a target community identifies with, respects, or aspires to the referent group, the greater the impact of the norm appeal (e.g., "People in your specific community are protecting bats, and benefiting from their role in nature"; White et al., 2009).

(v) Combine descriptive norms with injunctive norms. Combining both what people are doing, and what people approve of others doing (Axelrod, 1986), can create the strongest form of a norm appeal (e.g., "Most people are now rejecting evicting bats from their roosts and instead are now in favour of greater protection of bats"; Cialdini, 2003).

5. Discussion

The COVID-19 pandemic, with its associated loss of life, severe human suffering and economic impacts, is due to profoundly re-shape the perceived risks for wildlife-associated diseases. The fact that—the most similar virus to SARS-CoV-2, identified to-date, is a bat-borne coronavirus—has engulfed bats in a maelstrom of virus-related news coverage and a related growing tide of misinformation. The reverberations will likely carve long-lasting negative impact on perceptions, attitudes, and behaviours towards bats. As the pandemic continues to unfold, bat-researchers across the world are facing unprecedented pressure to directly engage with the public to contextualize the risks of bat-borne zoonoses and minimize potential backlash against the group. This task is likely pushing many researchers, especially ecologists and conservationists, into unfamiliar territory. While valuable lessons from different sub-fields of conservation science are available to help design conservation messages, such guidance has yet been collated and placed in the context of zoonotic risk.

In this article, we outlined some key points that bat conservationists should consider when devising conservation messaging aimed at neutralizing unwarranted negative-associations between bats and disease-risk. Our advice focuses on three areas of psychological science that we perceived as particularly relevant in the current context. We stress that our advice is not exhaustive, and should be considered within the growing body of literature devoted to zoonotic risk communication (Decker et al., 2010, 2012, 2016), conservation message framing (Kidd et al., 2019a; Kusmanoff et al., 2020) and conservation focused social-marketing, particularly in the context of human-wildlife conflict (Veríssimo et al., 2019).

In addition to the points highlighted here, communicators should also consider many other factors that influence public reactions to conservation messages. These include, but are not limited to, hyper-saliency, social/cultural context, psychological distance, message framing, message channel, and messenger effects (Veríssimo et al., 2019; Kidd et al., 2019b; Kusmanoff et al., 2020). Such factors should not be regarded in isolation, as their interaction can influence the receiver's attitudes and/or behaviours. Furthermore, zoonotic risk often represents a single dimension of the human-bat conflict and acknowledged or latent drivers of animosity towards bats (e.g. reactions to fruit damage by bats or to the noise and smells of rooting colonies) may also affect people's perception of bats and their reaction to conservation communications.

Conservation messages are often intuitively designed (i.e., not informed by evidence; Kidd et al., 2019b) and their impact on people's

behaviour is rarely robustly evaluated (Veríssimo and Wan, 2019). Such shortcomings will be especially prevalent during an unprecedented pandemic, and thus we acknowledge that many conservation communications must often, and unavoidably, be more reactive than proactive. Despite this impediment, communicators should consider that even messages based on the best available evidence can have unintended effects (Kusmanoff et al., 2020). Messages should thus be, wherever feasible, pilot tested with a representative sample of the target population. Testing should adopt appropriate experimental designs (to enable robust causal inference; MacFarlane, 2020) and not only evaluate message effectiveness but also record unforeseen outcomes. Critically, messages should align with best available advice from heath authorities, who, along with other relevant stakeholders (e.g., local communicates, government departments etc.), should be consulted as key actors in the communication strategy.

6. Concluding remarks

Bats represent nearly one fifth of all described mammal species and rival only humans as the most widely distributed mammals on Earth (Conenna et al., 2017; Burgin et al., 2018; Frick et al., 2019). Owing to scarce research and the cumulative effects of anthropogenic pressures such as habitat loss and degradation, overharvesting, invasive species, and climate change, around one third of the > 1400 recognised bat species are classified as data deficient or threatened by the IUCN Red List (Frick et al., 2019). Despite the critical ecological importance of bats, their hyper-saliency as reservoirs of dangerous zoonoses is likely to negatively affect support for their conservation. In the aftermath of the current pandemic, bat biologists will need to carefully navigate the human-dimensions of bat conservation and be exceedingly cautious about how they communicate about bats and zoonoses. To this end, we argue that the psychology of science communication provides the best guidance available.

In a world where humans and the natural hosts of emerging infectious diseases are increasingly connected, an integrated and interdisciplinary approach to articulate wildlife-related science communication in the context of human health is paramount. Only by carefully framing accurate, honest, and duly contextualized information will we be able to best serve society with a comprehensive and unbiased perception of wildlife that minimizes zoonotic health risks and allows wild species, their vital ecosystem services and human societies to co-exist.

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.

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References

Abedi-Lartey, M., Dechmann, D.K., Wikelski, M., Scharf, A.K., Fahr, J., 2016. Long-distance seed dispersal by straw-coloured fruit bats varies by season and landscape. Glob. Ecol. Conserv. 7, 12–24.

Alhakami, A.S., Slovic, P., 1994. A psychological study of the inverse relationship between perceived risk and perceived benefit. Risk Anal. 14 (6), 1085–1096.

Amman, B.R., Nyakarahuka, L., McElroy, A.K., Dodd, K.A., Sealy, T.K., Schuh, A.J., Shoemaker, T.R., Balinandi, S., Atimnedi, P., Kaboyo, W., Nichol, S.T., 2014. Marburgvirus resurgence in Kitaka Mine bat population after extermination attempts, Uganda. Emerg. Infect. Dis. 20, 1761.

Andersen, K.G., Rambaut, A., Lipkin, W.I., Holmes, E.C., Garry, R.F., 2020. The proximal origin of SARS-CoV-2. Nat. Med. 26, 450–452.

Axelrod, R., 1986. An evolutionary approach to norms. Am. Polit. Sci. Rev. 80, 1095–1111.

Aziz, S.A., Clements, G.R., McConkey, K.R., Sritongchuay, T., Pathil, S., Abu Yazid, M.N.H., Campos-Arceiz, A., Forget, P.M., Bumrungsri, S., 2017. Pollination by the locally endangered island flying fox (*Pteropus hypomelanus*) enhances fruit production of the economically important durian (*Durio zibethinus*). Ecol. Evol. 7, 8670–8684.

Bandura, A., 2000. Exercise of human agency through collective efficacy. Curr. Dir. Psychol. Sci. 9, 75–78.

Bedford, D., 2010. Agnotology as a teaching tool: learning climate science by studying misinformation. J. Geogr. 109, 159–165.

Blackmore, E., Underhill, R., McQuilkin, J., Leach, R., Holmes, T., 2013. Common Cause for Nature: A Practical Guide to Values and Frames in Conservation. Public Interest Research Centre, Wales, United Kingdom.

Blackwood, J.C., Streicker, D.G., Altizer, S., Rohani, P., 2013. Resolving the roles of immunity, pathogenesis, and immigration for rabies persistence in vampire bats. Proc. Natl. Acad. Sci. 110, 20837–20842.

Boyles, J.G., Cryan, P.M., McCracken, G.F., Kunz, T.H., 2011. Economic importance of bats in agriculture. Science 332, 41–42.

Brierley, L., Vonhof, M.J., Olival, K.J., Daszak, P., Jones, K.E., 2016. Quantifying global drivers of zoonotic bat viruses: a process-based perspective. Am. Nat. 187, 53–64.

Brook, C.E., Dobson, A.P., 2015. Bats as 'special' reservoirs for emerging zoonotic pathogens. Trends Microbiol. 23, 172–180.

Brook, C.E., Boots, M., Chandran, K., Dobson, A.P., Drosten, C., Graham, A.L., Grenfell, B.T., Müller, M.A., Ng, M., Wang, L.F., van Leeuwen, A., 2020. Accelerated viral dynamics in bat cell lines, with implications for zoonotic emergence. Elife 9, e48401.

Burgin, C.J., Colella, J.P., Kahn, P.L., Upham, N.S., 2018. How many species of mammals are there? J. Mammal. 99, 1–14.

Buttke, D.E., Decker, D.J., Wild, M.A., 2015. The role of one health in wildlife conservation: a challenge and opportunity. J. Wildl. Dis. 51, 1–8.

Caulfield, T., 2020. Pseudoscience and COVID-19-we've had enough already. Nature. https://doi.org/10.1038/d41586-020-01266-z.

Cialdini, R.B., 2003. Crafting normative messages to protect the environment. Curr. Dir. Psychol. Sci. 12, 105–109.

Cialdini, R.B., Demaine, L.J., Sagarin, B.J., Barrett, D.W., Rhoads, K., Winter, P.L., 2006. Managing social norms for persuasive impact. Soc. Influ. 1, 3–15.

Conenna, I., Rocha, R., Russo, D., Cabeza, M., 2017. Insular bats and research effort: a review of global patterns and priorities. Mammal Rev. 47, 169–182.

Convention on the Conservation of Migratory Species of Wild Animals (CMS), 2020. Facts about Bats and COVID-19 [press release]. https://www.cms.int/en/news/2020005-facts-about-bats-and-covid-19, Accessed date: 10 April 2020.

Cook, J., Lewandowsky, S., Ecker, U.K.H., 2017. Neutralizing misinformation through inoculation: exposing misleading argumentation techniques reduces their influence. PLoS One 12 (5), e0175799.

Cook, J., Ellerton, P., Kinkead, D., 2018. Deconstructing climate misinformation to identify reasoning errors. Environ. Res. Lett. 13, 024018.

Corlett, R.T., Primack, R.B., Devictor, V., Maas, B., Goswami, V.R., Bates, A.E., Koh, L.P., Regan, T.J., Loyola, R., Pakeman, R.J., Cumming, G.S., Pidgeon, A., Johns, D., Roth, R., 2020. Impacts of the coronavirus pandemic on biodiversity conservation. Biol. Conserv. 108571.

Daly, N., 2020. This 'hand-washing' orangutan went viral—but the story isn't true. https://www.nationalgeographic.com/animals/2020/04/coronavirus-fake-animal-news-part-two/, Accessed date: 7 April 2020.

Davis, T., Goldwater, M.B., Ireland, M.E., Gaylord, N., Van Allen, J., 2017. Can you catch Ebola from a stork bite? Inductive reasoning influences generalization of perceived zoonosis risk. PLoS One 11, e0186969.

Decker, D.J., Evensen, D.T., Siemer, W.F., Leong, K.M., Riley, S.J., Wild, M.A., Castle, K.T., Higgins, C.L., 2010. Understanding risk perceptions to enhance communication about human-wildlife interactions and the impacts of zoonotic disease. ILAR J. 51, 255–261.

Decker, D.J., Siemer, W.F., Wild, M.A., Castle, K.T., Wong, D., Leong, K.M., Evensen, D.T., 2011. Communicating about zoonotic disease: strategic considerations for wildlife professionals. Wildl. Soc. Bull. 35, 112–119.

Decker, D.J., Siemer, W.F., Evensen, D.T., Stedman, R.C., McComas, K.A., Wild, M.A., Castle, K.T., Leong, K.M., 2012. Public perceptions of wildlife-associated disease: risk communication matters. Hum. Wildl. Interacti. 6, 112–122.

Decker, D.J., Schuler, K., Forstchen, A.B., Wild, M.A., Siemer, W.F., 2016. Wildlife health and public trust responsibilities for wildlife resources. J. Wildl. Dis. 52, 775–784.

Dixon, G.N., McKeever, B.W., Holton, A.E., Clarke, C., Eosco, G., 2015. The power of a picture: overcoming scientific misinformation by communicating weight-of-evidence information with visual exemplars. J. Commun. 65, 639–659.

Ecker, U.K., Lewandowsky, S., Tang, D.T., 2010. Explicit warnings reduce but do not eliminate the continued influence of misinformation. Mem. Cogn. 38, 1087–1100.

Evans, K.L., Ewen, J.G., Guillera-Arroita, G., Johnson, J.A., Penteriani, V., Ryan, S.J., Sollmann, R., Gordon, I.J., 2020. Conservation in the Maelstrom of Covid-19 – A Call to Action to Solve the Challenges, Exploit Opportunities and Prepare for the Next Pandemic. https://doi.org/10.1111/acv.12601.

Farneda, F.Z., Rocha, R., López-Baucells, A., Sampaio, E.M., Palmeirim, J.M., Bobrowiec, P.E., Grelle, C.E., Meyer, C.F., 2018. The road to functional recovery: temporal effects

of matrix regeneration on Amazonian bats. Trop. Conserv. Sci. 11, 1–4.
Farrow, K., Grolleau, G., Ibanez, L., 2017. Social norms and pro-environmental behaviour: a review of the evidence. Ecol. Econ. 140, 1–13.
Fielding, K.S., Head, B.W., 2012. Determinants of young Australians' environmental actions: the role of responsibility attributions, locus of control, knowledge and attitudes. Environ. Educ. Res. 18, 171–186.
Finucane, M.L., Alhakami, A., Slovic, P., Johnson, S.M., 2000. The affect heuristic in judgements of risks and benefits. J. Behav. Decis. Mak. 13, 1–17.
Flood, A., 2016. 'Post-truth' Named Word of the Year by Oxford Dictionaries. The Guardian. https://www.theguardian.com/books/2016/nov/15/post-truth-named-word-of-the-year-by-oxford-dictionaries, Accessed date: 12 May 2020.
Frick, W.F., Kingston, T., Flanders, J., 2019. A review of the major threats and challenges to global bat conservation. Ann. N. Y. Acad. Sci. https://doi.org/10.1111/nyas.14045.
Ghanouni, A., Nuttall, E., Wardle, J., Von Wagner, C., 2017. Testing whether barriers to a hypothetical screening test affect unrelated perceived benefits and vice versa: a randomised, experimental study. Patient Educ. Couns. 100, e1–e24.
Guyton, J.A., Brook, C.E., 2015. African bats: conservation in the time of Ebola. Therya 6, 69–88.
Jacoby, L.L., Kelley, C., 1989. Becoming famous overnight: limits on the ability to avoid unconscious influences of the past. J. Pers. Soc. Psychol. 56, 326–338.
Johnson, H.M., Seifert, C.M., 1994. Sources of the continued influence effect: when misinformation in memory affects later inferences. J. Exp. Psychol. Learn. Mem. Cogn. 20, 1420–1436.
Johnson, C.K., Hitchens, P.L., Evans, T.S., Goldstein, T., Thomas, K., Clements, A., Joly, D.O., Wolfe, N.D., Daszak, P., Karesh, W.B., Mazet, J.K., 2015. Spillover and pandemic properties of zoonotic viruses with high host plasticity. Sci. Rep. 5, 14830.
Johnson, C.K., Hitchens, P.L., Pandit, P.S., Rushmore, J., Evans, T.S., Young, C.C.W., Doyle, M.M., 2020. Global shifts in mammalian population trends reveal key predictors of virus spillover risk. Proc. R. Soc. B Biol. Sci. 287, 20192736.
Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk, D., Gittleman, J.L., Daszak, P., 2008. Global trends in emerging infectious diseases. Nature 451, 990–993.
Kachel, N., 2016. 24/7 immunity from lethal diseases? It's in the bat, man! CSIROscope [Press release]. https://blog.csiro.au/bat-disease-immunity/, Accessed date: 12 May 2020.
Kahan, D.M., 2015. What is the "science of science communication"? J. Sci. Commun. 14, 1–12.
Kahneman, D., 2012. Thinking, Fast and Slow. Penguin, London, United Kingdom.
Karesh, W.B.D., Dobson, A.P., Lloyd-Smith, J.O.P., Lubroth, J.D.V.M., Dixon, M.A.M., Bennett, M.P., et al., 2012. Ecology of zoonoses: natural and unnatural histories. Lancet 380, 1936–1945.
Kemp, J., López-Baucells, A., Rocha, R., Wangensteen, O.S., Andriatafika, Z., Nair, A., Cabeza, M., 2019. Bats as potential suppressors of multiple agricultural pests: a case study from Madagascar. Agric. Ecosyst. Environ. 269, 88–96.
Kidd, L.R., Garrard, G.E., Bekessy, S.A., Mills, M., Camilleri, A.R., Fidler, F., et al., 2019a. Messaging matters: a systematic review of the conservation messaging literature. Biol. Conserv. 236, 92–99.
Kidd, L.R., Bekessy, S.A., Garrard, G.E., 2019b. Evidence is key for effective biodiversity communication. Trends Ecol. Evol. 34, 693–694.
Kingston, T., 2016. Cute, creepy, or crispy—how values, attitudes, and norms shape human behaviour toward bats. In: Voigt, C.C., Kingston, T. (Eds.), Bats in the Anthropocene: Conservation of Bats in a Changing World. Springer, pp. 571–588.
Kunz, T.H., de Torrez, E.B., Bauer, D., Lobova, T., Fleming, T.H., 2011. Ecosystem services provided by bats. Ann. N. Y. Acad. Sci. 1223, 1–38.
Kusmanoff, A.M., Fidler, F., Gordon, A., Garrard, G.E., Bekessy, S.A., 2020. Five lessons to guide more effective biodiversity conservation message framing. Conserv. Biol. https://doi.org/10.1111/cobi.13482.
Lewandowsky, S., Ecker, U.K., Seifert, C.M., Schwarz, N., Cook, J., 2012. Misinformation and its correction: continued influence and successful debiasing. Psychol. Sci. Public Interest 13, 106–131.
López-Baucells, A., Rocha, R., Fernández-Llamazares, Á., 2018. When bats go viral: negative framings in virological research imperil bat conservation. Mammal Rev. 48, 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.
Maas, B., Karp, D.S., Bumrungsri, S., Darras, K., Gonthier, D., Huang, J.C.C., Lindell, C.A., Maine, J.J., Mestre, L., Michel, N.L., Morrison, E.B., 2016. Bird and bat predation services in tropical forests and agroforestry landscapes. Biol. Rev. 91, 1081–1101.
MacFarlane, D., 2020. Towards Robust Evaluations of Demand-Reduction Interventions: Deep Dive Technical Briefing Paper on Social Science Surveys. The Wildlife Trade Monitoring Network under CITES & MIKE, TRAFFIC. https://www.changewildlifeconsumers.org/site/assets/files/1550/technical_briefing_paper_deep_dive_social_science_surveys-1.pdf, Accessed date: 12 May 2020.
MacFarlane, D., Hurlstone, M.J., Ecker, U.K.H., 2020. Protecting consumers from fraudulent health claims: a taxonomy of psychological drivers, interventions, barriers, and treatments. Soc. Sci. Med. 112790.
McCarthy, I.P., Hannah, D., Pitt, L.F., McCarthy, J.M., 2020. Confronting indifference toward truth: dealing with workplace bullshit. Bus. Horiz. 63, 253–263.
Mollentze, N., Streicker, D.G., 2020. Viral zoonotic risk is homogenous among taxonomic orders of mammalian and avian reservoir hosts. Proc. Natl. Acad. Sci. 117, 9423–9430.
Nyilasy, G., 2019. Fake news: when the dark side of persuasion takes over. Int. J. Advert. 38, 336–342.
Olival, K.J., 2016. To cull, or not to cull, bat is the question. EcoHealth 13, 6–8.
Olival, K.J., Hosseini, P.R., Zambrana-Torrelio, C., Ross, N., Bogich, T.L., Daszak, P., 2017. Host and viral traits predict zoonotic spillover from mammals. Nature 546 (7660), 646–650.
Puig-Montserrat, X., Torre, I., López-Baucells, A., Guerrieri, E., Monti, M.M., Ràfols-García, R., Ferrer, X., Gisbert, D., Flaquer, C., 2015. Pest control service provided by bats in Mediterranean rice paddies: linking agroecosystems structure to ecological functions. Mamm. Biol. 80, 237–245.
Quinn, E.K., Massey, P.D., Cox-Witton, K., Paterson, B.J., Eastwood, K., Durrheim, D.N., 2014. Understanding human–bat interactions in NSW, Australia: improving risk communication for prevention of Australian bat lyssavirus. BMC Vet. Res. 10 (1), 144.
Rare and The Behavioural Insights Team, 2019. Behavior Change for Nature: A Behavioral Science Toolkit for Practitioners. Arlington, VA, USA.
Russo, D., Bosso, L., Ancillotto, L., 2018. Novel perspectives on bat insectivory highlight the value of this ecosystem service in farmland: research frontiers and management implications. Agric. Ecosyst. Environ. 266, 31–38.
Simler, K., Hanson, R., 2017. The Elephant in the Brain: Hidden Motives in Everyday Life. Oxford University Press, Oxford, United Kingdom.
Slovic, P., Finucane, M.L., Peters, E., MacGregor, D.G., 2007. The affect heuristic. Eur. J. Oper. Res. 177, 1333–1352.
Streicker, D.G., Recuenco, S., Valderrama, W., Gomez Benavides, J., Vargas, I., Pacheco, V., Condori Condori, R.E., Montgomery, J., Rupprecht, C.E., Rohani, P., Altizer, S., 2012. Ecological and anthropogenic drivers of rabies exposure in vampire bats: implications for transmission and control. Proc. R. Soc. B Biol. Sci. 279, 3384–3392.
Swire, B., Ecker, U.K.H., Lewandowsky, S., 2017. The role of familiarity in correcting inaccurate information. J. Exp. Psychol. Learn. Mem. Cogn. 43, 1948–1961.
Tannenbaum, M.B., Hepler, J., Zimmerman, R.S., Saul, L., Jacobs, S., Wilson, K., Albarracin, D., 2015. Appealing to fear: a meta-analysis of fear appeal effectiveness and theories. Psychol. Bull. 141, 1178–1204.
Thaler, A.D., Shiffman, D., 2015. Fish tales: combating fake science in popular media. Ocean Coast. Manag. 115, 88–91.
Thompson, J.E.S., 1966. Maya hieroglyphs of the bat as metaphorgrams. Man 176–184.
Tuttle, M.D., 2020. A viral witch hunt. https://issues.org/a-viral-witch-hunt-bats/, Accessed date: 12 May 2020.
van der Linden, S., Leiserowitz, A., Rosenthal, S., Maibach, E., 2017. Inoculating the public against misinformation about climate change. Global Chall. 1, 1600008.
Veríssimo, D., Wan, A.K.Y., 2019. Characterizing efforts to reduce consumer demand for wildlife products. Conserv. Biol. 33, 623–633.
Veríssimo, D., Sadowsky, B., Douglas, L., 2019. Conservation marketing as a tool to promote human-wildlife coexistence. In: Frank, C., Glikman, J.A., Marchini, S. (Eds.), Human-wildlife interactions: Turning conflict into coexistence. Cambridge University Press, pp. 335–354.
Waltner-Toews, D., 2017. Zoonoses, one health and complexity: wicked problems and constructive conflict. Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci. 372, 20160171.
Wanger, T.C., Darras, K., Bumrungsri, S., Tscharntke, T., Klein, A.M., 2014. Bat pest control contributes to food security in Thailand. Biol. Conserv. 171, 220–223.
White, K.M., Smith, J.R., Terry, D.J., Greenslade, J.H., McKimmie, B.M., 2009. Social influence in the theory of planned behaviour: the role of descriptive, injunctive, and in-group norms. Br. J. Soc. Psychol. 48, 135–158.
Williamson, P., 2016. Take the time and effort to correct misinformation. Nature 540, 171.
Wood, J.L., Leach, M., Waldman, L., MacGregor, H., Fooks, A.R., Jones, K.E., Restif, O., Dechmann, D., Hayman, D.T., Baker, K.S., Peel, A.J., 2012. A framework for the study of zoonotic disease emergence and its drivers: spillover of bat pathogens as a case study. Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci. 367, 2881–2892.
World Health Organization, 2013. WHO Expert Consultation on Rabies: second report. https://apps.who.int/iris/handle/10665/85346, Accessed date: 3 May 2020.
World Health Organization, 2020. Q&A on coronaviruses (COVID-19). https://www.who.int/news-room/q-a-detail/q-a-coronaviruses, Accessed date: 7 April 2020.
Zhao, H., 2020. COVID-19 drives new threat to bats in China. Science 367, 1436.
Zhou, P., Yang, X.L., Wang, X.G., Hu, B., Zhang, L., Zhang, W., Si, H.R., Zhu, Y., Li, B., Huang, C.L., Chen, H.D., 2020. A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 579, 270–273.