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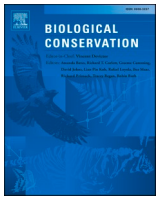

Global response of conservationists across mass media likely constrained bat persecution due to COVID-19

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ABSTRACT

Most people lack direct experience with wildlife and form their risk perception primarily on information provided by the media. The way the media frames news may substantially shape public risk perception, promoting or discouraging public tolerance towards wildlife. At the onset of the COVID-19 pandemic, bats were suggested as the most plausible reservoir of the virus, and this became a recurrent topic in media reports, potentially strengthening a negative view of this ecologically important group. We investigated how media framed bats and bat-associated diseases before and during the COVID-19 pandemic by assessing the content of 2651 online reports published across 26 countries, to understand how and how quickly worldwide media may have affected the perception of bats. We show that the overabundance of poorly contextualized reports on bat-associated diseases likely increased the persecution towards bats immediately after the COVID-19 outbreak. However, the subsequent interventions of different conservation communication initiatives allowed pro-conservation messages to resonate across the global media, likely stemming an increase in bat persecution. Our results highlight the modus operandi of the global media regarding topical biodiversity issues, which has broad implications for species conservation. Knowing how the media acts is pivotal for anticipating the propagation of (mis)information and negative feelings towards wildlife. Working together with journalists by engaging in dialogue and exchanging experiences should be central in future conservation management.

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"(Mis)information runs fast but expert replies run faster"
Carlo Maiolini

1. Introduction

Mass media represents one of the main news referring sources for people, and media framing plays a crucial role in shaping society's attitudes towards wildlife (Chong and Druckman, 2007; Gore and Knuth, 2009). In the digital era, reading news on the Web has become a regular habit for many people, and the information provided by mass media has gained the ability to reach a global audience within a very short time. Today, most newspapers produce an online version, offering unlimited coverage of breaking news worldwide. Moreover, social media has increased news visibility enormously. People share news on social media and thus act as news filters, often spreading and overemphasizing the most alarming news stories (Mammola et al., 2020; Nanni et al., 2020). Media framing may strongly shape public risk perception (Leiserowitz, 2005) and has become extremely important in promoting or discouraging public tolerance towards wildlife conservation, especially for species that ignite the human-wildlife conflict, such as large carnivores (Arbieu et al., 2021; Bombieri et al., 2018; McCagh et al., 2015; Nanni et al., 2020), spiders (Mammola et al., 2020, 2022a, 2022b), viruses (Evensen and Clarke, 2012), and bats (Cerri et al., 2021).

Bats have been identified as hosts of serious zoonotic diseases, including Nipah and Hendra virus, Rabies, and several Respiratory Syndromes (Schneeberger and Voigt, 2016). The connection with zoonotic diseases has considerable potential to negatively impact human perception of bats by evoking fear and intolerance among the public (Vaske et al., 2009; Wobeser, 2006), especially if risk communication is poorly contextualized and inadequately crafted (MacFarlane and Rocha, 2020). Negative perception of bats may be explained by an inborn fear for animals associated with the spread of diseases (Davey, 1994; Matchett and Davey, 1991; Prokop and Tunnicliffe, 2008; Ware et al., 1994; Whitaker and Douglas, 2006), as well as by the way in which information is framed by the mass media and by the scientific literature. A review conducted by López-Baucells et al. (2018) highlighted that half of the virological studies regarding bats framed them as a major concern for public health without providing evidence, while only 4% of such studies mentioned their importance for ecosystem functioning. In this sense the scientific literature acts as a possible source of (mis)information for mass media and the information shared by the scientific literature may be replaced and amplified by the mass media, which also often frame bats as a serious threat to human health (Schneeberger and Voigt, 2016). The overabundant news relating to specific topics, such as bat-associated diseases, may lead to an overestimation of the risk posed by bats and, in extreme cases, may fuel direct persecution of these suspected disease reservoirs (Buttke et al., 2015; Guyton and Brook, 2015). A balanced and accurate communication about health risk involving bats is fundamental to both mitigate the spread of diseases and render conservation efforts for bats more effective (Crockford et al., 2018; López-Baucells et al., 2018). Bats have key functional role and their conservation may improve ecosystem functioning, positively affecting economy (Boyles et al., 2011) and even human health, following the "One Health" concept (Decker et al., 2010).

A unique opportunity to globally assess the importance that communication plays for wildlife conservation was provided by the novel zoonotic coronavirus (COVID-19), that at the end of 2019 was isolated in China, and which underwent a rapid global spread between January and March 2020, with marked social and economic effects (World Health Organization, 2020). Even though the origin of COVID-19 is still debated, shortly after the onset of the COVID-19 outbreak, several studies suggested bats as the likely natural reservoir and origin of the virus (Lu et al., 2020; Wu et al., 2020; Xu et al., 2020; P. Zhou et al., 2020; Zhu et al., 2020). This information was replayed and globally spread by the mass media during the first months of the pandemic, possibly raising public anxiety and intolerance towards bats (Lu et al., 2021; Rocha et al., 2020).

We studied the effects of information on bats delivered by the media (Fig. 1) to assess how quickly a biased negative representation of wildlife by global press may undermine conservation efforts. We gathered global media reports on bats from before and during the pandemic across 26 countries and in 7 languages. We asked the following questions:

1. What is the content of the information of each bat-related media report?
2. How has the information contained in media reports changed throughout the first months of the COVID-19 pandemic?

2. Methods

2.1. Media news retrieval

Online media reports regarding bats were collected across the globe for the period 2018–2020, using seven languages, i.e. English, Spanish, Chinese, French, Portuguese, German, and Italian. Specifically, we analyzed reports in 26 countries, i.e. China, India, Pakistan, United States of America, Canada, United Kingdom, Italy, Spain, France, Portugal, Germany, Austria, Ecuador, Peru, Argentina, Costa Rica, Brazil, Australia, New Zealand, Philippines, Democratic Republic of Congo, Namibia, Kenya, Ghana, Senegal, and South Africa, covering all six continents on which bats occur. We adapted the methodology used in Nanni et al. (2020) and Mammola et al. (2020) for retrieving online media reports on bats. The online search was conducted via the advanced Google search tool, using "bats" or the corresponding translations as a keyword, and adjusting the language and country accordingly. We specified the temporal interval of the research, i.e. one year at time (e.g. 1/01/2018 to 31/12/2018) using the 'Custom range' tool. For each year, via *Google News* we collected the first 50 bat-related news reports, as for the majority of countries no more news were available. We excluded non-pertinent reports (e.g. those related to batman, bat robots, or sport bats). Reports from online magazines were included, as well as those from blogs or YouTube videos if they represented television news from newspapers.

2.2. Data extraction

A content analysis was performed (Krippendorff, 2018). For each media report, we extracted or derived the following information: (a) title, (b) publication date, (c) newspaper name, (d) newspaper circulation ('local', 'national' or 'worldwide'), (e) topic of the news, (f) sensationalism, (g) presence of pro-conservation messages, i.e. messages promoting bats conservation and safeguard, and (h) bat species or families mentioned (if any).

We classified newspaper circulation as 'local' if their total circulation (paper + online) was below 50,000 copies, and as 'national' if it was above 50,000 copies, searching the total circulation on each newspaper webpage and cross-checking this on the Wikipedia newspaper trend page. To define newspaper circulation as 'worldwide' we used the World Press Trends 2016 News (Milosevic, 2016).

Concerning the topic of the news, we defined the following categories: (i) 'bat-associated disease', if the report was about diseases transmitted by bats to humans (articles about wet markets were included in this category); (ii) 'persecution', if the news focused on bats killing or persecution; (iii) 'dead bats', if the news main topic was about bats found dead for natural or unknown causes; (iv) 'science communication', if the news was mainly about research findings, new species discovered, or if it was an interview with a scientist; (v) 'others', for topics not fitting into the previous categories. Although that same report may encompass several of the topics above, we decided to focus on the main topic of each one which was usually expressed in the title. For reports classed as 'persecution', we created an identifier for each unique

Fig. 1. Graphic overview of recommendations to improve conservation communication by conservationists.

event (ID_ persecution) and collected the year when the event occurred to be able to recognize each unique persecution event.

To assess a media report as sensationalistic, we evaluated the title, subheading, and main text of each media report. Following the definition of 'sensationalism' by Uribe and Gunter (2007): "a characteristic of the news-packaging process that places emphasis upon those elements that could provoke an effect on the human sensory system", we considered a report as sensationalistic if it contained at least one markedly negative word as: "horror", "horrific", "nightmare", "evil", "scary", "terror", "terrifying", "terrorizes", "frightening", "alarm", "panic", "attack", "devil", "hell", "killer", "terrible", "disturbing", "creepy", "disquieting", "dreadful", "awful", "monster", "invasion", "under siege", "plague", "petrifying", "spookier", "filthy" (see Appendix S1). However, we did not classify a report as sensationalistic if such words were used ironically or rhetorically to express the opposite meaning, (e.g. "Are bats really awful creatures?", or "Is all this terror for bats necessary?"). To standardize the data mining strategy among different authors in charge of different countries and languages, we prepared a general protocol (Appendix S2) for retrieval and classification of information on reports. Moreover, the entire final database was checked for consistency by the first author to assess uniformity in the classifications.

Finally, we assessed the occurrence of pro-conservation messages by checking if each media report: (1) mentioned the importance of bats for ecosystems; (2) mentioned the extinction risk of bat species or bats in general; (3) gave motivations for safeguarding bats; (4) gave advice on how to safeguard or assist bats.

2.3. Data on COVID-19

We recorded information on the spread of the COVID-19 pandemic from January to July 2020 across the 26 countries investigated (Dong et al., 2020). Specifically, for each country we collected: a) number of new infections every 15 days; b) number of total cases until July 31st; c) number of total deaths until July 31st; d) number of residents; and e) date of the first exponential growth of the epidemic curve, i.e. the date on which each country started to experience widespread transmission inside the community, based on the data collected by Ficetola and Rubolini (2021). We used this information to define whether each report was published before or after the first exponential growth of the epidemic curve.

2.4. Data analysis

We conducted all analyses in R (R Core Team, 2021). To assess whether the pandemic affected the media framing of bats, we built three generalized linear mixed models (GLMMs) with a binomial error distribution, and tested the significance of independent variables with a likelihood ratio test (Bolker et al., 2009). In all models, we included the country of search as random factor. In the first model, we tested whether news on bat-associated diseases became more frequent after the emergence of COVID-19 in January 2020. We used the presence/absence of news focused on bats as disease vectors as dependent variables, while the year of publication and the newspaper circulation as independent variables. We used orthogonal contrasts (Field et al., 2012) to assess if

the frequency of news describing bats as disease trasmitters differed between 2020 and the pre-covid period (i.e. 2018 + 2019), and then between 2018 and 2019. Furthermore, to assess differences associated with the newspaper circulation, we subsequently performed a Tukey post-hoc test among the levels (international, national, local), using the function *glht* of the package 'multcomp' (Hothorn et al., 2008). In the second model, we related the presence/absence of pro-conservation messages (dependent variable) to the year of publication and the newspaper circulation (independent variables). We designed the third GLMM model to verify if sensationalistic framing increased during the COVID-19 pandemic. We used the presence/absence of sensationalism as dependent variable and year and newspaper circulation as independent variables.

We then focused on what happened in the year 2020 ($N = 1160$), namely during the pandemic period, to assess how the spread of bat-related news and pro-conservation messages varied according to the diffusion of COVID-19 in each country. We built two GLMMs with a binomial error distribution, both having the logarithm of the number of cases, logarithm of incidence, newspaper circulation level and the variable "pre/post exponential" as independent variables, the latter defining whether a given report occurred before or after the first exponential date of the epidemic curve. In the first model, we used the presence/absence of a bat-associated disease in the report as the dependent variable, while in the second model we used the presence/absence of pro-conservation messages as the dependent variable.

Finally, using a Chi-squared test, we verified if the number of persecution events increased after the emergence of COVID-19. Given that for the year 2020, we only considered January/July (i.e. 7 months), we weighted the number of yearly events by the number of months for which the information was available.

We graphically explored the content of reports with barcharts using 'ggplot2' (Wickham, 2016). Using density plots, we explored the temporal distribution of bat-associated disease reports, pro-conservation messages and new COVID-19 infections, by computing a kernel density estimate with a 1.5 bandwidth adjustment (Wickham, 2016).

3. Results

We collected a total of 2651 reports regarding bats, published between January 2018 and July 2020 from 26 countries (Fig. 2a). We identified a total of 21 single events of persecution towards bats described in the news, with an increase in 2020 compared with previous years ($\chi^2_1 = 7.4$, $P = 0.006$). In African countries, the annual number of online published reports regarding bats was less than 50, especially

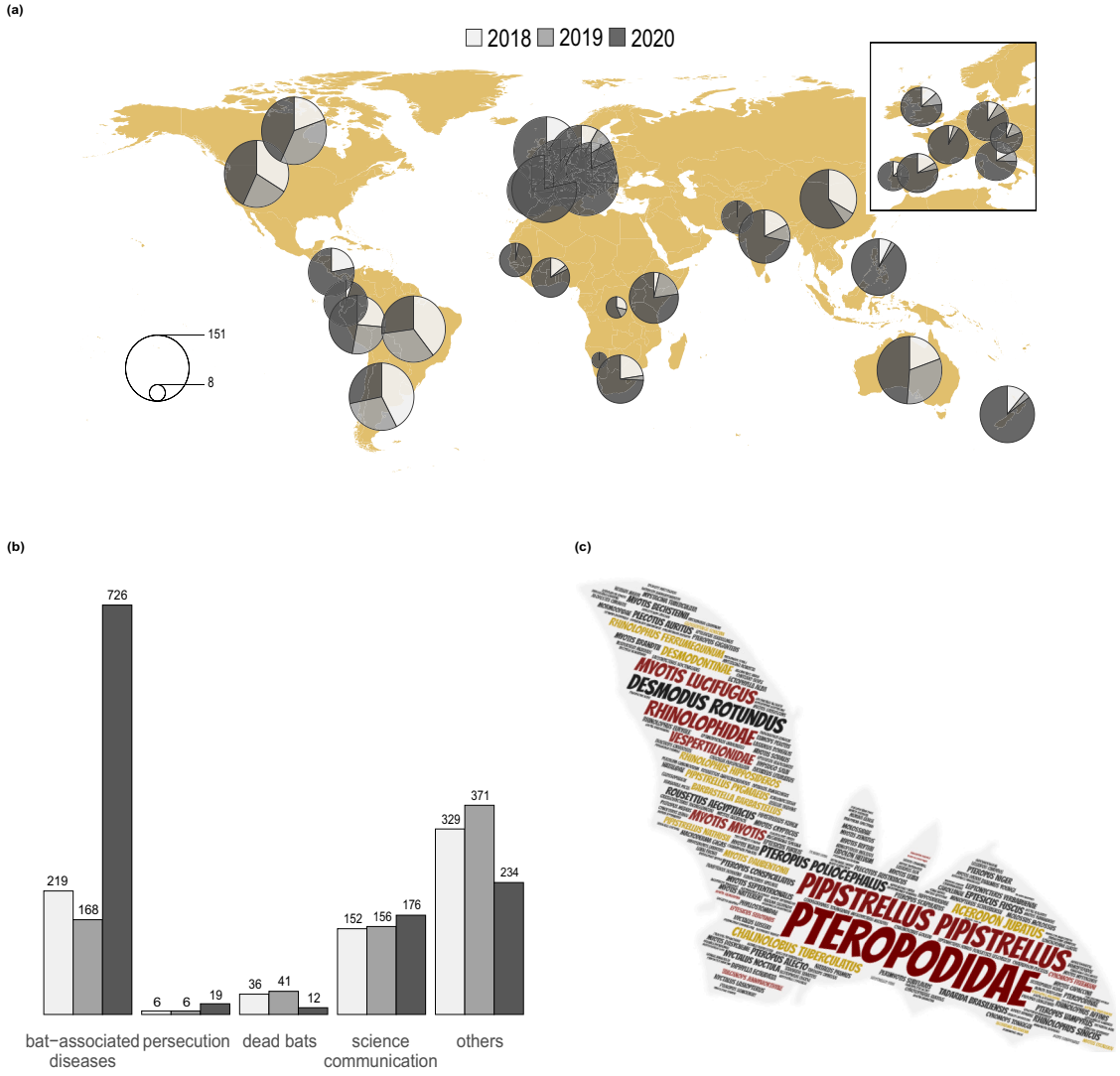

Fig. 2. (a) Yearly proportion of reports on bat-associated diseases by country. (b) Total number of media reports regarding each topic in 2018, 2019 and 2020. Reports regarding disease transmission by bats increased significantly in 2020 ($p = 2.2\ e^{-16}$). (c) Word cloud of media coverage of bats families and species as mentioned in the news (when only the genus was mentioned it was grouped into the corresponding family).

before 2020. Reports were published in 1104 different online newspapers, mainly at the national level (71.1%, $n = 1885$), followed by local (22.7%, $n = 601$), and worldwide levels (6.2%, $n = 165$). The majority of reports focused on pathogenic elements of potential zoonotic risk identified in bats (42%, $n = 1113$), 'others' (35,2%, $n = 934$) and science communications (18.3%, $n = 484$), while few reports focused on dead bats or persecution (3.4%, $n = 89$, and 1.2%, $n = 31$ respectively). The category 'others' included, for example, news regarding events organized for the public, bat-focused projects, white-nose syndrome, bats found in dwellings, bat tourism and eating bats, as well as summary reports on the general status of bats and their ecosystems, and impacts of infrastructures. Considering the total number of reports in each country, reports regarding bat-associated disease were higher in Africa (between 46.7% and 81.1%), Asia (between 43.4% and 71.4%) and Central-South America (between 55.9% and 66.7%), compared with North America (between 43.4% and 71.4%), Oceania (between 25.5% and 27.3%), and Europe (between 15.9% and 40.7%).

The frequency of reports describing bats as disease transmitters was significantly different across years (GLMM: $\chi^2_2 = 301.7$, $P < 0.001$). Orthogonal contrasts showed that reports describing bats as disease transmitters were much more frequent in 2020, the global outbreak year, than in 2018 and 2019 ($\chi^2_1 = 295.1$, $P < 0.001$). Furthermore, in 2019 we found slightly fewer reports on this topic compared with 2018 ($\chi^2_1 = 8.3$, $P = 0.004$; Fig. 2b). Differences between newspaper circulation levels were detected ($\chi^2_2 = 10.7$, $P = 0.005$), with fewer reports describing bats as disease vectors in international newspapers compared with both national and local newspapers (Tukey's post hoc: both $P \leq 0.01$), while we did not detect differences between national and local newspapers ($P = 0.956$). The variance of the random effect for country of search was 0.52 (SE = ±0.72). The majority of news had no sensationalistic components (95.6%, $n = 2534$), and rate of sensationalism was constant over the years ($\chi^2_2 = 2$, $P = 0.36$).

The frequency of pro-conservation reports was significantly different across years and newspaper circulation categories (GLMM: $\chi^2_2 = 40.7$, $P < 0.001$ and $\chi^2_2 = 9.3$, $P = 0.01$, respectively). Orthogonal contrasts showed fewer pro-conservation messages in the media in 2020 compared with previous years ($\chi^2_1 = 40.4$, $P < 0.001$). Tukey's post hoc test showed that reports containing pro-conservation messages were more frequent in local newspapers compared with national ones ($P = 0.005$), while no differences were detected between national and international or local and international newspapers ($P = 0.994$ and $P = 0.157$, respectively). The countries where more than half of the total news published contained pro-conservation messages were Germany (78%, $n = 117$), Canada (64.7%, $n = 97$), United Kingdom (62.9%, $n = 95$), Spain (59.3%, $n = 89$), New Zealand (55.7%, $n = 59$), Australia (55.3%, $n = 83$), and France (52.4%, $n = 76$).

Focusing on 2020, the frequency of disease transmission reports did not follow the epidemic course of each country (Fig. 3). Indeed, we found no correlation between the date of the first exponential growth and the probability of disease transmission reports occurring ($\chi^2_1 = 0.3$, $P = 0.6$). Conversely, almost all countries registered a first peak in the number of disease-related news at the beginning of 2020, during the diffusion of the epidemic in China ($\chi^2_1 = 0.3$, $P = 0.6$; Fig. 3). We observed an increase in pro-conservation news during 2020, which occurred consistently after the onset of the exponential growth of the epidemic curve in each country ($\chi^2_1 = 10.2$, $P = 0.001$; Fig. 4). The onset of the exponential growth was the only variable showing a significant relationship with the probability of finding pro-conservation reports.

Bat species had different popularity in the media (Fig. 2c). The species with more than 25 citations were: *Desmodus rotundus*, *Myotis lucifugus*, *Pipistrellus pipistrellus*, *Chalinolobus tuberculatus*, *Acerodon jubatus*, *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros*, and *Pipistrellus pygmaeus*. The common vampire bat (*D. rotundus*) and the giant golden-crowned flying fox (*A. jubatus*) where cited by newspapers all around the world despite their limited geographical occurrence (Central-South America and Philippines, respectively). The other species were mainly cited by newspapers of countries in which those species normally occur. In the case of the two *Rhinolophus* species, which were found to host the closest - known - relative of SARs-CoV-2, they gained visibility outside their geographic range after the emergence of the pandemic. However, most of the time media news just mentioned the genus or family, without giving the exact species name. The most cited families were Pteropodidae ($n = 156$), Rhinolophidae ($n = 54$), and Vespertilionidae ($n = 34$) (Fig. 2c).

4. Discussion

News plays a major role in the human perception of wildlife and biodiversity. Most people have little direct experience with wildlife, and the mass media often becomes the means by which people connect with nature, thus their importance on transmitting reliable information to help species conservation. Our interest was to identify how mass media around the world shaped the risk perception on bats by humans. We found that events of persecution towards bats increased after the COVID-19 outbreak, possibly driven by the raise in the media representation of bat-associated diseases. As demonstrated in other studies, news exposure provokes a social amplification of risk associated with wildlife (Gore et al., 2005; Gore and Knuth, 2009). However, the action of conservationists in disseminating pro-conservation messages immediately after the surge in reports on bats as disease transmitters, may have helped to reduce the public's negative perception of bats due to COVID-19. According Harcup and O'Neill (2017) news delivery satisfy the 'surprise' and the 'follow-up' requirements (among others), stories having an element of surprise and/or contrast, as well as stories that introduce new elements on subjects already in the news, were preferred in the media dialogue. Thus, journalists likely received messages delivered by conservationists as an opportunity to fuel the media dialogue and include them into the news. Our results provide guidance for responding and contributing effectively to media coverage, a fundamental component of efforts for wildlife conservation (Fig. 1, Appendix S3).

4.1. Increase in bat-associated diseases news and bat persecution

A large proportion of the collected reports focused on bat-associated diseases, with a significant increase in 2020 compared with the previous years (Fig. 2a, b). However, the number of reports regarding bat-associated diseases was not correlated with the spread of the epidemic curve in each country. Instead, in most of countries, a first peak in the amount of news on bat-associated diseases was registered during the spread of COVID-19 in China, even if in those countries the epidemic had not yet arrived (Fig. 3). This result suggests that the first COVID-19 outbreak in China was the main driving force for the worldwide media. Certainly, following the spread of the virus in China, news linking bats to COVID-19 were frequently in the spotlight of the global press. Many news denounced an increase in human intolerance for bats following the COVID-19 pandemic (e.g. in India https://cutt.ly/OxfOU9W; or in Singapore https://www.tnp.sg/news/singapore/more-calls-acres-feb-COVID-fear-led-bat-publicity; see also Manenti et al., 2020) and, according to our results, news may have contributed to increase persecution events in 2020. Even if it is possible that prior to the pandemic bat persecution events did not gain mass media attention, this apparent rise in fear and intolerance towards bats, which in extreme cases ended with direct persecution, was likely related to the media overrepresentation of bat-associated diseases and the spread of misinformation in the media during the first months of the COVID-19 pandemic. Similarly, Lunney and Moon (2011) found that media attention on zoonoses without supporting evidence on disease transmission risks increased animosity towards bats in Australia. Undoubtedly, much of the public understanding of infectious diseases comes from information released by the mass media (Evensen and Clarke, 2012).

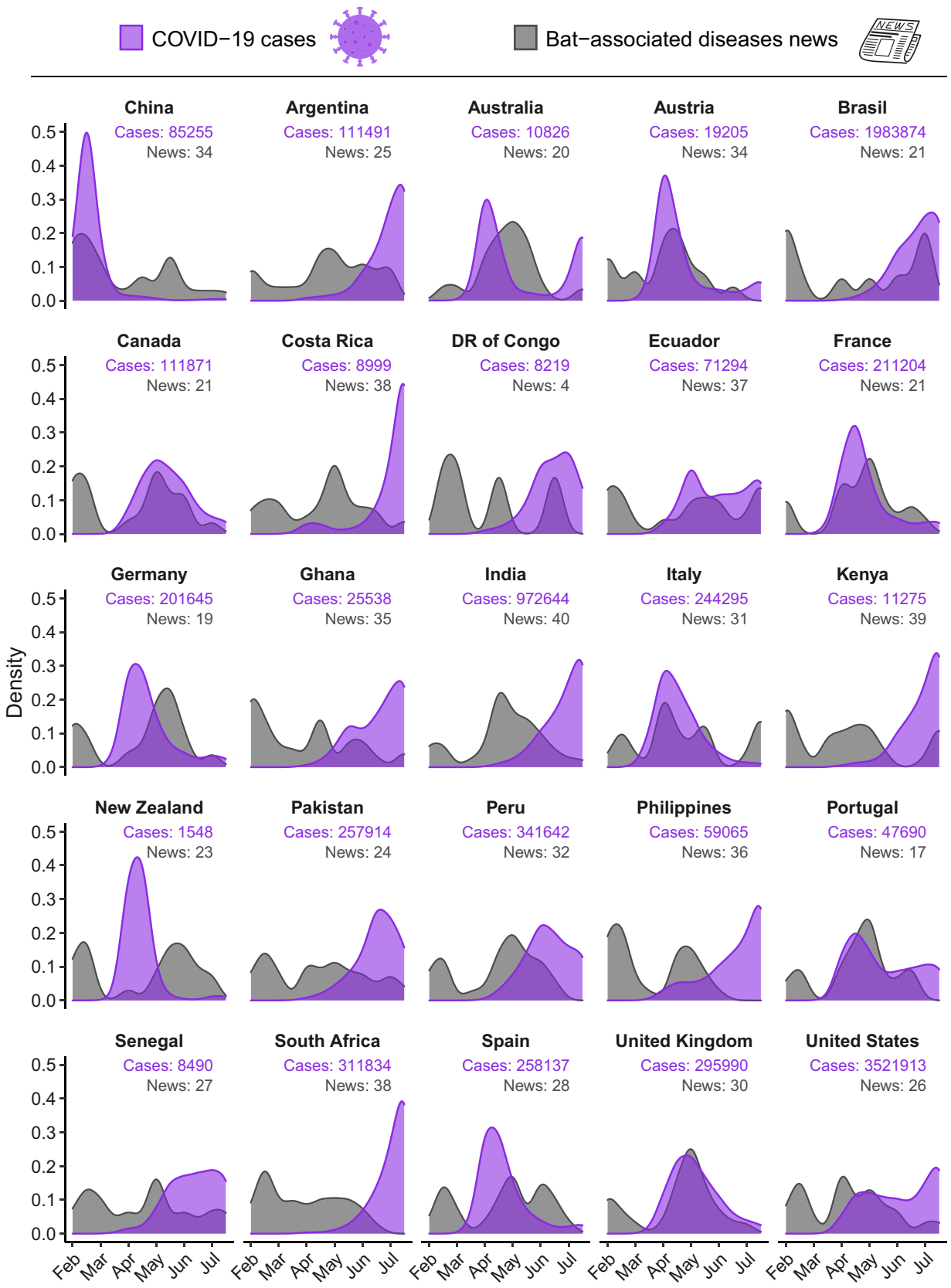

Fig. 3. Comparison between the spread of both news reports on bat-associated diseases (grey) and the COVID-19 pandemic (purple) in each country in 2020. Namibia was excluded because no reports on bat-associated diseases were located. We considered the temporal trend of both news on bat-associated disease and emerging cases of COVID-19, every 15 days. The cumulative curves for the media news and COVID-19 cases were estimated with a kernel density estimation. In the majority of countries, the first peak of news on bat-associated diseases news coincided with the first peak of the epidemic in China, regardless of whether the epidemic had arrived ($\chi^2_1 = 0.3$, $P = 0.6$). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 4. Comparison between the spread of news reports containing pro-conservation messages (grey), and the COVID-19 pandemic (purple) in each country in 2020. Namibia was excluded because no pro-conservation reports were located. We considered the temporal distribution of both pro-conservation media reports, and emerging cases of COVID-19, every 15 days. The cumulative curves for pro-conservation news and COVID-19 cases were estimated with a kernel density estimation. Pro-conservation reports were significantly more frequent after the first exponential growth of the epidemic curve in each country ($\chi^2_1 = 10.2$, $P = 0.001$). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4.2. Diffusion of pro-conservation messages

News with pro-conservation messages decreased in 2020 compared with previous years, possibly because the COVID-19 topic monopolized the press, leaving less space for other bat-related topics, such as educational events organized for the public, white-nose syndrome or bat tourism. Nevertheless, focusing only on 2020, pro-conservation messages in the news increased, especially after the first exponential growth of the epidemic in each country (Fig. 4), and reports became more balanced towards the positive role bats play in ecosystems, economy and human health. This was likely associated with swift reactions of bat conservationists to the initial surge of negative reports, which happened likewise in different countries. For example, in Italy, the Institute for the Environmental Protection and Research (ISPRA) released an official communication on March 31st 2020 to clarify the relationship between bats and COVID-19 (https://bit.ly/3rrf6iA). At the end of April 2020, a group of 64 scientists from six Asian nations released a statement to clarify that bats do not pose a direct risk to human health (https://theprint.in/science/dont-demonise-bats-we-need-them-researchers-explain-why-mass-hysteria-is-uncalled-for/408485/). In June, MacFarlane and Rocha (2020) published guidelines for communication about bats to prevent persecution following the COVID-19 outbreak. Such responses by conservationists were excellent examples of the importance of a rapid and massive communication strategy to amplify pro-conservation messages to the global media. In just a few months, the way the media represented bats changed, with a likely very positive effect in stemming bat persecution due to COVID-19. Conservationists were rapid and efficient at utilizing public and media interest in the topic to bring them closer to a more balanced view on bats. Certainly, a vital aid in spreading the message so quickly and widely was having the eyes of the world on the pandemic.

4.3. Differences between countries

In Africa, Asia and Central-South America, media attention largely focused on bat-associated diseases, while the proportion of pro-conservation reports was lower compared with Europe, North America, and Oceania. This trend may be partially explained by the high number of human cases affected by severe zoonotic diseases in those continents (World Health Organization, 2006), that are mainly linked to some ebolaviruses (Shapiro et al., 2020) and rabies (Velasco-Villa et al., 2005). In most parts of the world, bats frequently arouse negative emotions among the public, such as fear and disgust (Davey et al., 1998; Deshpande and Kelkar, 2015; Fagan et al., 2018; Kubiatko, 2012; Lim and Wilson, 2019; Polák et al., 2020; Prokop et al., 2009; Prokop and Tunnicliffe, 2008; Shapiro et al., 2021; Todd, 2016). In many cultures, they have been associated with aspects of death (Fernández-Llamazares et al., 2018), witchcraft (Agbanusi, 2016; Lunney and Moon, 2011; Musila et al., 2018; Tuttle, 2017), evil (Charro, 1999; Voigt and Kingston, 2016), malevolent creatures such as vampires (Prokop et al., 2009) and omens of bad luck, disease, and lack of fundamental resources (Eklöf and Rydell, 2021; Laverty et al., 2021).

4.4. Sensationalism

Sensationalistic news on bats constitutes a relatively small proportion of all news when compared with similar studies about other feared animals (Mammola et al., 2020; Nanni et al., 2020), likely because here, we took a more comprehensive view of all topics related to bats, and not only on extreme human-wildlife conflict events as large carnivore attacks on humans (Bombieri et al., 2018) or bite of venomous animals (Mammola et al., 2020). Moreover, species which arouse negative emotions such as bats, spiders, snakes, sharks, and alligators tend to receive peoples' attention regardless of the media framing. In Nanni et al. (2020), reports on sharks and alligators were shared by the public on social media regardless of the framing (i.e. negative or neutral). In contrast, reports on more charismatic species, such as brown bear, wolf or lion, were shared more frequently if negatively framed. Such species arouse polarized feelings in the public, ranging from fear to fascination and respect (Gittleman, 2013). This could imply that to attract public attention journalists do not need to add fearful components to news if they focus on widely feared species.

4.5. Media coverage of bat families and species

The media frequently referred to bats in a general way, or mentioned only their genus or family. The most cited families were Pteropodidae, followed by Rhinolophidae and Vespertilionidae (Fig. 2c). Pteropodidae, commonly called flying foxes, are a very charismatic family of bats (Newsome et al., 2017) that easily attract the attention of the public and, consequently, of the media. Rhinolophidae gained visibility worldwide after the emergence of the pandemic, because two species, *Rhinolophus affinis* and *R. malayanus*, were, apparently and at a relatively early stage of the pandemic, identified as the reservoirs of the most proximal COVID-19 ancestor (H. Zhou et al., 2020; P. Zhou et al., 2020). Finally, Vespertilionidae were often cited by the media, probably because they represent the most diverse and widely distributed bat family (Wilson and Mittermeier, 2011), and they are subject of extensive research. Besides the *Rhinolophus* species, other frequently cited bats species were the common vampire bat *D. rotundus*, the common pipistrelle *P. pipistrellus* and the little brown bat *M. lucifugus* (Fig. 2c). Vampire bats are very popular all over the world because they arise the collective imagination, involving fantasy stories about vampires, thereby easily gaining media visibility. Another reason why they attract media attention is the fact that these species, by feeding on animal blood are the main cause of human and domestic animals rabies infections in Central-South America (Schneeberger and Voigt, 2016). Finally, *P. pipistrellus* is a common species that can be easily observed in human settlements and *M. lucifugus* is one of the species most affected by the White-nose syndrome (Frick et al., 2015), a current topic in the media.

5. Conclusions

The COVID-19 pandemic generated global media attention on bats as disease reservoirs, possibly jeopardizing efforts for bat conservation. The increased public concerns and amplified fear of bats during the beginning of the pandemic likely led to an enhancement in persecution events. However, a significant increase in conservation messages appeared in the news a few months after the spread of the pandemic. This study highlights the effectiveness of a prompt response by conservationists who – with choral messages from different parts of the world – were able to reach the global media with a potentially positive impact on the public perception of bats. Such pro-conservation messages likely stemmed the social amplification of risk associated with bats due to COVID-19. A study conduct by Slagle et al. (2013) highlighted the importance of including into communication campaigns messages regarding benefits associated with the presence of bears to build public tolerance. Further research will be needed to better understand the short- and long-term effects of widespread conservation messages among the public. Interestingly, the frequency of reports regarding bat-associated diseases was not correlated with the spread of the epidemic curve in the respective countries, but it was closely related with the beginning of the pandemic in China. We suggest that conservationists should react quickly in terms of getting their message out to the media, even if events seem far away and localized.

5.1. Recommendations for a good conservation communication

Attractive topics spread rapidly across the globe in the media, and effective conservation messages should be equally fast to anticipate the diffusion of misconceptions and negative feelings among the public to avoid direct persecution of wildlife. Working together with journalists

by engaging in dialogue and exchanging experiences should be central in any conservation program as well as advise the public on how to handle the information ecosystem, for example checking the correctness of reports and avoiding to share dis- or mis-information on social media. The new information ecosystem poses a real challenge to conservation, funds for communication campaigns should be implemented given the wide scale impact they may have, as highlighted by our work. We provide some hints on how communication messages should be designed and promoted by conservationists and journalists and how public should navigate through the information ecosystem (Fig. 1, Appendix S3). Future studies should test the effectiveness of efforts undertaken by conservation project to promote the public outreach and mass media coverage of wildlife. Foster multidisciplinarity by including sociologists, anthropologists and communicators in conservation planning is pivotal to achieve conservation goals.

Data availability statement

The database supporting the study is available in Figshare (https://figshare.com/articles/dataset/db_bats_news_xlsx/19778812).

CRediT authorship contribution statement

Conceptualization: VN
Data collection: AC, NM-H, ALS, EL, CM, RA, MS, SH, ZZ, JZ, RM, VN
Data management: VN
Data analysis: GFF, VN, RM
Data visualization: VN, SM
Writing (first draft): VN
Writing contributions: NM-H, RM, GFF, EM-dM, ALS
English revision: DC
All authors read the text, provided comments, suggestions and corrections, and approved the final version.

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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2022.109591.

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