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Original Contribution

Newspaper Coverage and Framing of Bats, and Their Impact on Readership Engagement

Adrià López-Baucells,[1] Natalia Revilla-Martín,[1,2] Maria Mas,[1] Pedro Alonso-Alonso,[3,4] Ivana Budinski,[1,5] Sara Fraixedas,[6,7,8] and Álvaro Fernández-Llamazares[6,9]

[1]*BiBio – Natural Sciences Museum of Granollers, Avinguda Francesc Macià 51 Baixos, 08402 Granollers, Catalonia, Spain*
[2]*Conservation Biology Group (GBiC), Landscape Dynamics and Biodiversity Program, Forest Science and Technology Centre of Catalonia (CTFC), Catalonia, Spain*
[3]*CIBIO – Research Centre in Biodiversity and Genetic Resources, Vila do Conde, Distrito do Porto, Portugal*
[4]*Desert Laboratory on Tumamoc Hill, University of Arizona, Tucson, AZ 85745*
[5]*Department of Genetic Research, Institute for Biological Research "Siniša Stanković" – National Institute of Republic of Serbia, University of Belgrade, Belgrade, Serbia*
[6]*Helsinki Institute of Sustainability Science (HELSUS), Faculty of Biological and Environmental Sciences, University of Helsinki, Helsinki, Finland*
[7]*Research Centre for Ecological Change, Organismal and Evolutionary Biology Research Programme, Faculty of Biological and Environmental Sciences, University of Helsinki, Helsinki, Finland*
[8]*Centre for Ecological Research and Forestry Applications (CREAF), Autonomous University of Barcelona, Barcelona, Spain*
[9]*Institut de Ciència i Tecnologia Ambientals (ICTA), Autonomous University of Barcelona, Barcelona, Spain*

Abstract: The media is a valuable pathway for transforming people's attitudes towards conservation issues. Understanding how bats are framed in the media is hence essential for bat conservation, particularly considering the recent fearmongering and misinformation about the risks posed by bats. We reviewed bat-related articles published online no later than 2019 (before the recent COVID19 pandemic), in 15 newspapers from the five most populated countries in Western Europe. We examined the extent to which bats were presented as a threat to human health and the assumed general attitudes towards bats that such articles supported. We quantified press coverage on bat conservation values and evaluated whether the country and political stance had any information bias. Finally, we assessed their terminology and, for the first time, modelled the active response from the readership based on the number of online comments. Out of 1095 articles sampled, 17% focused on bats and diseases, 53% on a range of ecological and conservation topics, and 30% only mention bats anecdotally. While most of the ecological articles did not present bats as a threat (97%), most articles focusing on diseases did so (80%). Ecosystem services were mentioned on very few occasions in both types ($< 30\%$), and references to the economic benefits they provide were meagre ($< 4\%$). Disease-related concepts were

Adrià López-Baucells and Natalia Revilla-Martín have shared first authorship.

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Correspondence to: Adrià López-Baucells, e-mail: adria.baucells@gmail.com

recurrent, and those articles that framed bats as a threat were the ones that garnered the highest number of comments. Therefore, we encourage the media to play a more proactive role in reinforcing positive conservation messaging by presenting the myriad ways in which bats contribute to safeguarding human well-being and ecosystem functioning.

Keywords: Chiroptera, COVID-19, Disease, Risk perception, Science communication, Social media, Virus

Introduction

There is well-established evidence that our current social–ecological crisis will by no means be addressed by an ill-informed society (Cash et al. 2003; Novacek 2008). An increasing body of research has demonstrated that the availability of credible, legitimate, and salient scientific information substantially affects the way in which people perceive environmental issues such as climate change or biodiversity loss, and how they respond to them (Spence et al. 2011). The media plays a significant role in disseminating scientific research (Allan 2002), to the point that media coverage has significantly been shown to be a valuable pathway for transforming public opinions towards environmental issues (Johns and Jacquet 2018).

The quantity and quality of scientific information disseminated on popular media largely depends on media coverage selection. According to framing theory (De Vreese 2005), any media source presents a topic through its lenses and lexical style, highlighting certain aspects but omitting others, generating significant biases and subjectivity (Shiffman et al. 2020). These choices affect how scientific information is interpreted by society, its emotions and understandings, and the confidence placed on scientific findings and guidance (Dayer et al. 2017). Personalities and researchers quoted in the media also represent a major factor shaping their credibility (Gibson et al. 2001).

It is well understood in the conservation community that the dissemination of under-contextualised, over-simplified, inaccurate, and biased information can have substantial impacts on the ways in which unpopular species (e.g. wolves, sharks, or bats) are perceived by the general public, influencing the effort put towards their conservation (Jacobson et al. 2012; Muter et al. 2013; Chandelier et al. 2018). Often misunderstood and generally misrepresented, bats have traditionally been victims of fear, hostility, and cultural prejudice all over the planet (Laverty et al. 2021; Rocha et al. 2021a). Since time immemorial, in some regions, they have been maligned as blood-sucking vampires, flying blind mice, or gods of death (Kingston 2016; Eklöf and Rydell 2021). Due to their nocturnal and elusive behaviour, bats generally have little contact with humans (Voigt et al. 2016), and therefore, most of these collective beliefs on bats come from myths, legends, stories, songs, or movies (Kingston 2016; Fernández-Llamazares et al. 2018). Misconceptions frequently lead to fear, which results in direct bat persecution and deliberate destruction of important roosts and colonies, undermining their conservation (Cardiff et al. 2009). In fact, a review carried out by O'Shea et al. (2016) analysing multiple mortality events in bats reported that intentional killing is the third major threat affecting bats worldwide, only after wind turbines and white-nose syndrome. During the last years after the outbreak of the COVID-19 pandemic, the power and consequences of media messages in relation to bats and diseases have become even more visible, with a generalised spread of fear among the general public (Lu et al. 2021).

The potential association of bats with zoonotic diseases largely galvanises pre-existing negative attitudes towards these animals (López-Baucells et al. 2018; MacFarlane & Rocha 2020). Several virological studies highlight the role of bats as reservoirs and potential transmitters of zoonotic diseases and relate them with virus outbreaks such as the COVID-19 pandemic (Shereen et al. 2020), SARS in 2002 (Wang et al. 2006), or Ebola in 2014 (Marí Saéz et al. 2015). While investigating potential reservoirs of novel zoonoses is of critical importance to prevent future disease outbreaks, communication about zoonotic diseases should always consider the interconnections between human health, wildlife, and environment (MacFarlane and Rocha 2020). Sudden virus outbreaks are usually followed by sensationalist headlines that can enormously impact public opinions towards wildlife species potentially involved in the emergence of the virus. Newspaper articles linking wildlife and diseases in poorly contextualised terms (e.g. not considering the complex zoonotic disease dynamics, disregarding state-of-the-art scientific evidence on disease reservoirs, and over-simplifying zoonotic disease spill-over) could compromise the success of long-term conservation programs (Davis et al. 2019; Zhao 2020).

In response to all these conservation threats, the last years have witnessed a concerted societal effort to raise awareness of the myriad values that bats hold in our societies and the multiple ecosystem services they provide (MacFarlane and Rocha 2020; Rocha et al. 2021b). The vital role of bats in pest control is usually flagged as an illustrative example in this regard (Boyles et al. 2011), and it is reflected in several organic agriculture projects where bat boxes are employed instead of pesticides (Puig-Montserrat et al. 2015). Along these lines, the European Bat Night aims to raise awareness of the recreational and aesthetic values of bats by bringing these elusive animals closer to the public.

Newspaper content analyses have been widely used to evaluate the impact of media on perceptions and attitudes towards wildlife (Gandiwa et al. 2014; Chandelier et al. 2018). Understanding how journalists and science communicators frame bats is essential to design better communication strategies. In this paper, we scanned and evaluated the media press coverage (i.e. newspapers) of bats in Western Europe from 1956 until 2019 (i.e. before the COVID-19 pandemic). We decided to focus on the time before the COVID-19 pandemic to assess the basal society's response to different framings on bats in the media, avoiding the biases caused by bats being continuously in the spotlight. Our objectives were to (1) examine the extent to which bats were presented as a threat to human health and the reported scientific evidence underpinning such framings; (2) quantify press coverage on bat conservation values (e.g. the ecosystem services provided by them); (3) assess whether country or media-political stance had any effect upon the published information; (4) evaluate the most salient and common terms associated with bats in the articles; and (5) model the active response from the public towards different types of articles based on the number of comments written on the digital versions of such articles.

Material and Methods

Newspaper Content Analysis

Newspaper articles related to bats were compiled and reviewed from the online version of 15 newspapers from the five most populated countries in Western Europe (i.e. France, Germany, Italy, Spain, and the UK). The selection of newspapers was based on: (i) market leadership and high circulation rates in each of these countries and (ii) availability in electronic formats. The selected newspapers were: *ABC*, *Bild*, *El País*, *Il Giornale*, *La Repubblica*, *Le Figaro*, *Le Monde*, *Le Huffington Post*, *Metro*, *Süddeutsche Zeitung*, *Tagespiel*, *The Guardian*, *The Sun*, *The Telegraph*, and *20 Minutos*. In order to have a politically balanced sample across countries, we selected for each country one left-leaning newspaper, one right-leaning and one tabloid/free newspaper. The political orientation of each newspaper was determined based on reports from the scholarly literature about such newspapers (see Table S1). We decided to keep a single category for "free newspapers and tabloids" given their generally lower journalistic standards (Johansson 2007). Although the selected countries differ considerably in newspaper reading culture and market characteristics (van der Wurff et al. 2008), the spectrum of surveyed newspapers constitutes a representative sample of the national press read in each of these countries and across Western Europe.

Digital newspaper search engines were used to identify articles concerning bats. We searched for articles that contained the keywords "bat" and "bats" in the title or body text of the article. Because our review was carried out across five different countries, keywords were translated to their primary national language. To get a comparable dataset across countries and newspapers, a maximum of 100 articles published no later than 2019 (i.e. before the outbreak of the COVID-19 pandemic) per newspaper were selected. We only took the first 100 articles that were found online. Our study should be therefore understood as an essential knowledge baseline to assess if bat-related communication in the media has changed because of the COVID-19 pandemic when bats started to be increasingly associated with zoonotic disease risks in the public discourse (MacFarlane and Rocha 2020). Accordingly, our dataset is made open access so that other researchers can reassess the same research questions in the future (available in the Zenodo repository, https://zenodo.org/record/7883756), providing a unique setting to quantify the effects of the COVID-19 pandemic in media representations of bats.

Articles with no direct mention of bats or using the word "bat" in fictional contexts (e.g. film reviews about Batman, critiques of the performance of the operetta "The Bat" by Johann Strauss II) were excluded from our analysis. In addition, when possible, we retrieved the number of online comments for the selected articles. Our analysis did not consider the actual content of the online comments

(i.e. public reactions to the bat-related articles) and only used the total number of comments as a proxy for the overall social impact of each article.

To assess the content of each article, we first conducted a pilot testing to ensure consistency in the data mining process, based on a sample of 10 newspaper articles. Second, we systematically filled a questionnaire consisting of 28 questions, including a first section about the general information of the article (e.g. year of publication, topic, positive or negative depiction of bats, whether they include scientific citations or quotes from an interviewee, number of comments by readers), a second section designed to understand how bats were framed in relation to diseases, and a last section mainly focused on bat conservation and ecosystem services (see questionnaire in Table S2). Importantly, all coders were proficient in the language of the newspapers that were assigned to them.

Framing of Bats in the Media

We first classified the articles under the following topics: (1) bats and diseases, (2) a broader picture of bats, including ecology, conservation, or natural history, and (3) articles with only anecdotal mentions of bats. To decide the framing of the article and the types of assumed attitudes towards bats (positive/negative/neutral), we used information on whether they depicted bats as a threat to human health and whether they presented bat conservation issues and/or mentioned the ecosystem services that they provide (see questionnaire in Table S2). Additionally, when a conflict or a conservation issue was presented, we identified the primary diagnosis (i.e. what is the problem?), and if they presented a resulting prognostic view (i.e. how should the problem be solved?). All these characteristics extracted from the selected articles were compared between newspapers, political orientations, and countries using proportions and descriptive statistics.

We used the R software version 4.0.2. (R Core-Team 2019) to examine the most salient and common terms associated with bats. We compiled all the terms used in articles headlines for every language. To standardise terms, we first removed special characters, capital letters, numbers, punctuation, common stop words, as well as affixes and suffixes using the ''tm'' R package. To visualise the data, we used a frequency distribution table illustrated with wordclouds including the most frequent terms (minimum frequency of six), all built with the ''wordcloud'' R package.

Impact of Different Framings on Active Responses from the Readership

To understand the societal consequences of the selected articles on bat conservation, we modelled the active response of the public to the published articles by fitting generalised linear mixed models, using R software version 4.0.2. (R Core-Team 2019). The ''Number of comments'' of each article (where available) on the newspaper website was defined as the response variable. Although the number of online comments might not fully capture an article's overall impact on readers, we believe that it is the most suitable proxy available to examine public responses towards the information presented in an article. As discrete factors, we considered ''Political orientation'' (left-leaning, right-leaning, or tabloid/free newspaper), ''Topic'' (we only considered articles about bat ecology/conservation/natural history and bats and diseases but excluded from the analyses the ones where bats were hardly mentioned), ''Depiction of bats in the article'' (threat vs non-threat) and ''Country''. ''Year'' was added as a random factor to account for the interannual variation in the number of comments published. Out of the 15 newspapers analysed, only four of them did not include an online comment function (i.e. *La Repubblica*, *Le Huffington Post*, *Metro*, and *Süddeutsche Zeitung*). These four specific newspapers cut across different media types, countries, and political orientations, which means that our final sample is balanced in terms of newspaper diversity. Because our dataset showed over-dispersion, we used a negative binomial distribution with a log link function. The data distribution was also confirmed using the *descdist* function in the R ''fitdistrplus'' package. To avoid high correlations amongst the predictor variables, we used Chi-squared tests for all combinations of categorical variables. Because of this, ''Topic'' was finally removed from the models as it was strongly correlated with ''Depiction of bats in the article''. We also tested for collinearity amongst our predictors with the *vif* function in the R ''car'' package. All variables had values of variance inflation factor below five as generally expected. Then, to select the best model and the inclusion of the fixed factors, we carried out an iterative model selection process using the *dredge* function from R ''MuMIn'' package, where we compared the full model (i.e. the one including the three above mentioned covariates and the random effect) against all other model combinations. The most simplified versions of model structures included only one explanatory variable

and the random effect. Models were selected based on AICc values (AIC corrected for low sample size), considering as valid all models with ΔAICc < 2 (Burnham and Anderson 2004). The effect of each factor (estimate) was plotted using the *allEffects* function in the R "effects" package.

Results

We gathered a total of 1095 articles that included information about bats published from 1956 until 2019 (see Table S1). Out of all the articles reviewed, 17% of the articles focused on bats and diseases, with a prominent focus on virus-borne ones, 53% focused on a broader range of topics (e.g. ecology, natural history, conservation, or human–bat-related conflicts), and 30% of the articles mentioned bats anecdotally (Fig. 1). While most of the articles in the second group (i.e. ecologically-focused topics) did not present bats as a threat to human health (97% of the articles reviewed from this group), most of the disease-focused articles did so (80%) (Fig. 1). Ecosystem services were rarely mentioned in both types of articles (in 26% of the ecology and conservation-focused articles, and only in 9% of the disease related articles) and rarely quantified in terms of economic benefits (4% and 1%, respectively) (Fig. 1). Our results show that $\sim$ 50% of the articles quoted bat experts, either ecologists (55%), environmental officers and naturalists (33%) or, in lower proportions, virologists or epidemiologists (12%).

Regarding the articles about bats and diseases, the Nipah virus was the most cited (224 articles in total), followed by Ebola (66) and rabies (61). However, many other viruses were also mentioned in the articles reviewed, such as other coronaviruses, Hendra, MERS, Marburg, or SARS. While articles mentioning Nipah and rabies were relatively common throughout the study period (e.g. first articles mentioning Nipah and rabies date back to 1969 and 1981, respectively), reports about other viruses (e.g. Ebola, Marburg, SARS, Hendra) emerged only after 2007 in our dataset. Most of these articles (79%) reported cases of humans infected by the viruses mentioned above, and 48% of these specified the number of fatal cases. Among these, only 56% explained the transmission paths, and 38% the symptoms and consequences of such diseases (see questions in the second block from Table S2).

Only 26% of all the articles sampled mentioned the conservation issues threatening bats worldwide. This corresponds to 42% of the ecology-focused articles, 21% of the anecdotical mentions, and only 5% of the disease-related ones (Fig. 1). Of all articles, only 8% mentioned conservation measures to improve bat conservation (e.g. reducing hunting pressure, using bat boxes, or raising their popularity among the general public). From these, other initiatives to mitigate human–bat conflicts, such as reducing pesticides or disengaging wind turbine blades during certain wind conditions to reduce bat mortality, were also reported (see questions in Table S2). All these results were relatively evenly distributed across countries and newspapers and did not vary significantly according to the political orientation of the newspaper (see Table 1; Tables S3–S5).

Bats were described either negatively as e.g. "terrifying", "germ taxis", or "carriers of deadly viruses", or positively framed as "protected", "excellent pest controllers", or "beneficial for humans". However, we found that, considering the headlines of all reviewed articles, the most repeated concepts and words were related to virology, outbreaks, or diseases in all languages (e.g. virus, Ebola, threat, rabies or disease, among others) (Table 2 and Fig. 2).

The best-fit model included the number of comments as the response variable, "Depiction of bats in the article", "Political orientation" and "Country" as predictor variables, and "Year" as the random factor. The public was significantly more engaged with articles that depicted bats as a threat to human health, having twice as many comments on average than those that did not (Table 3; Fig. 3). In terms of the political orientation, the articles from left-leaning newspapers were the ones with more comments online (231 articles, 3767 comments), followed by the right-leaning newspapers (396 articles, 546 comments) and tabloids (253 articles, 216 comments) (Fig. 3). Although less pronounced, some significant differences were also found amongst countries, being the Spanish, British, and French newspapers the ones with more public engagement (Fig. S1).

Discussion

This study assessed how 15 newspapers across five Western European countries framed bats based on a pool of 1095 articles published between 1956 and 2019. Understanding how the media portrays these animals to their readership, how people respond to these portrayals, and what kinds of articles are found to be more engaging to the general public is fundamental for bat conservation efforts to be successful.

Figure 1. Top: Proportion of newspaper articles (N = 1095) from Germany, France, Italy, Spain, and the UK classified according to whether: (1) bats and diseases were primarily targeted (e.g. outbreak articles, disease studies); (2) bats appeared in a broader picture (e.g. conservation, ecology, natural history, socio-cultural topics); and (3) bats were only anecdotally mentioned without being the main topic of the articles. The average number of comments for each category is also shown in parentheses. Bottom: Proportion of articles that: (1) identified bats as a threat or not; (2) explained conservation issues that bats are facing; (3) mentioned the ecosystem services they provide; (4) specified their economic impact; and (5) promoted positive, negative or neutral attitudes.

This information is essential to build robust strategies for efficient science communication, especially in the recent context of a global pandemic that has put bats under increasing public scrutiny. With much societal and policy discussion on what the "new normal" might eventually look like (e.g. McElwee et al. 2020), our dataset provides an essential quantitative baseline to assess if societal attitudes and behaviours towards bat conservation will come back to the levels attained before the onset of the COVID-19 pandemic. While some studies have documented media

Table 1. Proportion of different article topics and types of assumed attitudes towards bats for each political orientation.

	Bats and diseases (%)	Ecology and conservation (%)	Occasional mentions (%)	Positive (%)	Negative (%)	Neutral (%)
Left-leaning newspapers	16.1	46.1	37.7	55.1	18.1	25.4
Right-leaning newspapers	14.4	59.1	26.5	45.7	18.2	35.4
Tabloids	20.1	55.4	24.5	43.9	32.3	22.7

Table 2. Top nine most salient (observed with the highest frequency) words found in the article's headlines in each country.

France		Germany		Italy		Spain		UK	
Term	Freq	Term	Freq	Term	Freq	Term	Freq	Term	Freq
Chauve-souris (bat)	76	Fledermaus (bat)	173	Pipistrello (bat)	48	Murciélago (bat)	175	Bat	162
Rage (rabies)	17	Spur (track)	10	Ebola (ebola)	25	ébola (ebola)	28	Find	21
Coronavirus (coronavirus)	10	Tollwut (rabies)	9	Zanzare (mosquitoes)	16	Especie (species)	24	Virus	21
Nouveau (new)	10	Schutz (protection)	7	Animale (animal)	13	Nuevo (new)	15	Rabies	18
Cas (case)	8	stoppen (stop)	7	Virus (virus)	11	Animal (animal)	14	Death	17
Virus (virus)	8	Nacht (night)	6	Rischio (risk)	10	Virus (virus)	13	Ebola	17
Éolienne (wind Turbine)	8	Tier (animal)	6	Salvare (to save)	7	Refugio (roost)	11	Kill	16
France (France)	8	Gefähr (danger)	5	Specie (species)	7	Estudio (study)	11	Outbreak	13
Ebola (ebola)	7	Windrad (windmill)	5	Epidemia (epidemia)	7	Amenaza (threat)	10	New	12

Special characters, capital letters, numbers, punctuation, common stop words, affixes and suffixes were removed to standardise terms.

representations of bats during the COVID-19 pandemic (Zhao 2020; Cerri et al. 2022; Nanni et al. 2022), most of the evidence is still anecdotal, with few studies examining trends over time (but see Carandell 2023). We have, therefore, made the database underpinning this study publicly available in an open-access format for further re-assessments using a before–after experimental design (available in the Zenodo repository, https://zenodo.org/record/7883756).

According to our results, approximately half of all the articles focused on bat ecology, conservation, or natural history, while only 17% focused on virology and epidemiology. This pattern was evenly distributed across countries and newspapers. The relatively low proportion of disease-related articles stands in stark contrast to an emerging body of literature arguing that disease-related speculation in the media is a pervasive problem fuelling negative attitudes towards this taxonomic group (López-Baucells et al. 2018; MacFarlane and Rocha 2020). However, across all the reviewed articles, terminology evocative of diseases, outbreaks and viruses was prominently used, usually with negative connotations towards bats. In terms of public engagement, we found that, on average, those articles framing bats as a threat to human health were twice more engaging to the public than those not presenting bats as dangerous animals. Further research could help to cross-check the reliability of our proxy for public engagement (e.g. based on interviews, content analysis and/or experimental design).

Our results suggest that a handful of articles framing bats as a threat to human health, recurrently using disease-related and fear-inducing terminology, might have a broader reach and might catch the attention of the general readership more efficiently than dozens of articles focused

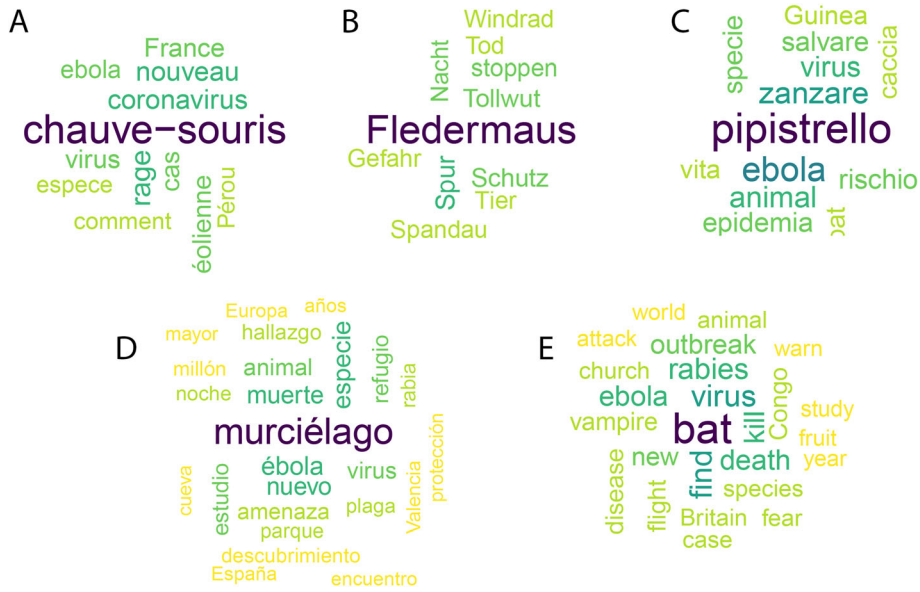

Figure 2. Wordclouds with the most salient words used in the titles of the reviewed articles (words with a frequency of appearance ≥ 6) for each country (**A**: France, **B**: Germany, **C**: Italy, **D**: Spain and **E**: UK).

Table 3. Results of the best-fit negative binomial generalised linear mixed model explaining readership engagement.

Selected model: glmer.nb (Number of comments ~ Depiction of bats in the article + Political orientation + Country + (1|Year))				
AIC	BIC	logLik	Deviance	df.resid
1590.7	1631.9	−785.3	1570.7	447
Scaled residuals:				
Min	1Q	Median	3Q	Max
−0.4293	−0.4083	−0.3597	−0.1728	7.5924
Random effects:				
Groups name	Variance	Std.Dev		
Year (Intercept)	1.911	1.382		
Number of obs:	457	groups: Year	29	
Fixed effects				
	Estimate	SE	*z* value	Pr($>\|z\|$)
(Intercept)	1.41	0.733	1.925	0.054
Framing of the article: threat vs non-threat	**1.209**	**0.306**	**3.950**	**< 0.0001**
Political orientation: right-leaning vs left-leaning	**−1.618**	**0.414**	**−3.911**	**< 0.0001**
Political orientation: tabloid vs left-leaning	**−1.335**	**0.399**	**−3.344**	**0.0008**
Country: Germany vs France	−1.162	0.486	−2.391	0.0168
Country: Italy vs France	**−1.329**	**0.449**	**−2.959**	**0.003**
Country: Spain vs France	−0.138	0.740	−0.187	0.852
Country: UK vs France	−0.087	0.531	−0.163	0.870

Significant results with $p < 0.01$ are bolded.

on natural history and bat conservation (Shapiro et al. 2021a). We discuss the relevance and implications of these findings in the following sections.

Framing Bats in the News

In general, bats were not presented as a threat to public health in those articles specifically focused on bat ecology,

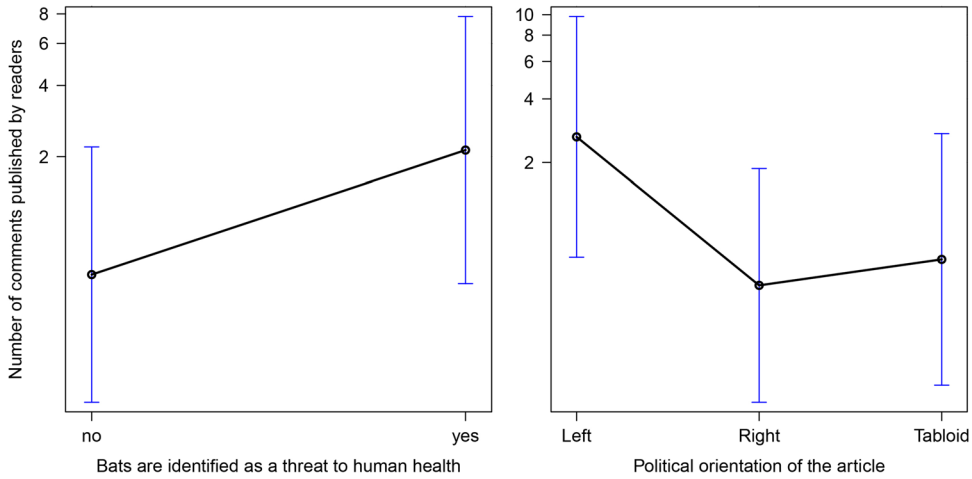

Figure 3. Effects of the fixed predictors ("Depiction of bats in the article" and "Political orientation") on the active response and engagement by the readership in terms of public comments.

conservation, and natural history, with more than half of the attitudes supported by these articles being positive. However, only less than half of these articles mentioned the conservation problems that bats face or the ecosystem services that they provide. Also, almost none of the articles presented their positive economic contributions in relation to pest control, seed dispersal or pollination (Boyles et al. 2011; Kunz et al. 2011). Our results suggest that the conservation threats that bats face might not efficiently reach the general public in Western Europe. Providing some quantitative estimates of the economic benefits accrued by bats could help to promote bat conservation efforts in the media. However, to do so, it is paramount to frame and describe such conservation issues in a didactic and appealing way (Hoffmaster et al. 2016). Some notable examples could be the economic benefits of guano harvesting in Madagascar (Rocha et al. 2021a), pest insect suppression in Spain (Puig-Montserrat et al. 2015) or the pollination of the tequila plant in South America (Trejo-Salazar et al. 2016). Highlighting examples in this vein could motivate people to protect bats from human activities that threaten their populations and habitats (López-Hoffman et al. 2010).

On the other hand, disease-related articles showed an opposite trend, most of them presenting bats as a threat to human health, largely overlooking their ecosystem services, and generally not highlighting any conservation issue. Even though research on zoonotic diseases is crucial, biased framings pointing bats only as potentially harmful virus reservoirs can jeopardise bat conservation worldwide. Although bats have been consistently referred to as reservoirs of several viruses and deadly diseases, the complex interconnections between bats, viruses and disease outbreaks are still not fully understood (Moratelli and Calisher 2015). In fact, the capacity of bats to transmit viruses or diseases compared to similar taxa and their role as virus reservoirs is still highly debated (Streicker and Gilbert 2020). Zoonotic infections often occur when human beings get in direct contact with a pathogen reservoir (e.g. bushmeat; Marí Saéz et al. 2015; Anti et al. 2015). This has rarely been reported in bats (i.e. insofar, only four zoonotic viruses have successfully been traced back to direct bat-human transmission worldwide; Smith et al. 2013, Moratelli and Calisher 2015) especially in Europe, where close human–bat contacts are minimal.

In general, all the results about the topics of the articles and their framing were relatively similar between countries and newspapers, suggesting that these kinds of journalistic routines and framing approaches are relatively common across most written media in Western Europe. However, these patterns might change either regionally or geographically. For instance, many Asia–Pacific cultures feature far more positive associations with bats than most Western societies, probably linked to the influences of Christianity on the latter (Forth 2021; Low et al. 2021). Disdain and fear of bats are largely embroiled in the Christian doctrine, where bats symbolise the Devil (see Eklöf and Rydell 2021 for further details).

Jargon and Lexical System in Bat-Related Articles

Our study shows that disease- and virus-related terminology is prominent in newspaper articles about bats, often with negative connotations and fear-inducing associations (Shapiro et al. 2021a). As discussed in several studies (MacFarlane & Rocha 2020; Shapiro et al. 2021a), the recurrence of conceptual associations between bats and zoonotic infections contributes to the creation of mental shortcuts guided by irrational processes that frame bats as "bad creatures" (Slovic et al. 2007). The rapid diffusion of digitised information usually reinforces negative framings, with short and often uncontrasted messages that can easily go viral (López-Baucells et al. 2018). However, articles focused on ecology, conservation, and natural history topics tended to use less frequently such repetitive terminology, as they cover a broader spectrum of topics.

Articles' Engagement and Public Response

To our best knowledge, this is the first study showing that articles framing bats as a threat to human health attract a higher number of reader comments than those framing bats in neutral or positive terms. Wildlife perceptions are shaped by culture and personal experiences. In a world where people are becoming increasingly disconnected from nature (Fernández-Llamazares et al. 2020), perceptions on wildlife are largely shaped by mass media and their communication of wildlife-related risks (Riley et al. 2003). While wildlife specialists can have a broader perspective of the risk and can evaluate it under professional judgement (Decker et al. 2012), public perception of risk is highly influenced by factors such as community history and culture, the closeness of the hazard and risk communication (Decker et al. 2011). Zoonotic diseases are a matter of increasing interest to the general public, as their outbreaks are becoming increasingly common in the last decades (Jones et al. 2008), often with global socio-economic impacts, as exemplified by the COVID-19 pandemic. Human health-related news significantly impacts the public, and the association of wildlife with a disease can result in social amplification of risks, most likely affecting public attitudes towards certain wildlife species. Fear of disease can decrease the values that society places on wildlife and its ecosystem services. For example, Hudenko et al. (2008) found that, when asked about coyotes, suburban residents of Westchester Country (New York, US) reported that disease transmission could potentially become an issue of major concern. Interestingly, only one case of rabies had been recorded in the state of New York in the previous 15 years. While interviewees mentioned both positive and negative effects of coyote presence in their area (e.g. feral cat and rodent control and ecosystem balance as positive), many agreed that media coverage tended to have a negative bias, influencing the communities' opinions. This example highlights the extent to which disease-related speculation shapes public attitudes towards wildlife. Positive perceptions of wildlife are essential for wildlife conservation, but they can rapidly erode by amplified risk and fear perceptions. Preventing the spread of misleading and speculative information magnifying the association of wildlife zoonotic risks is of utmost importance (Buttke et al. 2015). When negative associations between wildlife and zoonoses are deeply rooted in collective social imaginaries, simply communicating facts may not be enough to face previous negative associations, and a careful communication strategy is necessary. As exposed in MacFarlane & Rocha 2020, to oppose misinformation, refutations should avoid repeating myths. Instead of emphasising the risks of zoonosis, prevention messages should present practices that minimise risks of exposure while reinforcing positive ideas, such as the ecosystem services provided by wildlife. Along the same lines, giving visibility to positive bat–human interrelationships should be prioritised over negative or aggressive behaviours towards bats (Low et al. 2021, Shapiro et al. 2021b).

Implications and Recommendations for Conservation

To counteract the ubiquitous negative perceptions that persist in the general public (Pennisi et al. 2004; Kingston 2016), it is essential to highlight the vital roles of bats in safeguarding global public interests (e.g. ecosystem integrity, human well-being). Moreover, the media can also take a more active role in amplifying existing information as well as the best practices guidelines about human–bat coexistence in order to make bats more accessible to the public (e.g. Brittingham et al. 2000; Bruckermann et al. 2022). There are already several initiatives and resources that can pave the way for improving bat–human interactions in both rural and urban areas (e.g. Racey et al. 2013; Sutherland et al. 2018). However, just a handful of articles with negative framings towards bats can easily jeopardise the influence of many articles with positive framings. Therefore, an international strategy to communicate bat-

related discoveries and events accurately is required to avoid misinformation and biased perceptions. Scientists and international conservation groups can provide guidance, but only the interdisciplinary work between journalists, scientists and policy and decision makers at multiple scales will ensure effective conservation strategies (Kingston 2016), accounting for different local contexts (Kamins et al. 2015). The magnitude of the world's social–ecological crisis calls for innovative ways to connect global audiences to conservation challenges (Novacek 2008; Balmford 2017). We believe that the mass media in general, and journalists in particular, should be considered key partners in the arduous endeavour of educating people to take informed conservation action. In the current context of the COVID-19 pandemic, the need to tell positive stories about bats, their myriad values, and all the ecosystem services they provide has perhaps never been more critical.

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