Insectes Sociaux
https://doi.org/10.1007/s00040-024-00952-9

Insectes Sociaux

RESEARCH ARTICLE

# Bee-Ing positive about wasp-negative media reporting: the opinions of scientists and their influence on the media

C. A. Oi[1] · R. L. Brown[2] · S. Sumner[1]

Received: 5 November 2023 / Revised: 2 February 2024 / Accepted: 10 February 2024


**Abstract**
Insects are the most diverse group on earth, providing a vast array of essential functions for people and nature. Yet, our appreciation of their contributions is biased towards a few economically important taxa, especially pollinating insects like honeybees. Other taxa are less well appreciated despite the important roles they play, and these taxa are rarely (if ever) the focus of conservation initiatives. Here, we explore the role that scientists play through their interactions with the media in shaping our attitudes towards one of the least appreciated insects—the aculeate (stinging) wasps. Vespine wasps are an excellent taxonomic group for such a study as they are important predators in native ecosystems (e.g., the Northern Hemisphere—in Europe and North America) but ecologically devastating as invasive species in many regions of the Southern Hemisphere (e.g., New Zealand, Australia, South America). Despite this, global media coverage of wasps invariably focuses on and emotively exaggerates the negative defensive stinging behaviour of wasps, and almost entirely overlooks their beneficial positive roles (as pest controllers and pollinators). Wasp and bee scientists from around the world were surveyed about their interactions with the media and how they considered these interactions to influence public perceptions and insect conservation. Our surveys capture the negative-wasp and positive-bee biases experienced by scientists through their interactions with the media. We consider the implications of such biases on wasp populations, their conservation and management, and make recommendations for a more balanced portrayal of this important and diverse group of insects.

**Keywords** Wasp positive · Bee · Media · Scientists · Conservation

## Introduction

The evidence is clear: many insect populations are declining, worldwide. Drivers of these declines includes climate change, agricultural practices and land-use change (Outhwaite et al. 2022). Despite wide-spread concern for these organisms and their ecosystem services on which our planet depends, some groups receive more attention than others. Wasps are one of the groups that are largely overlooked and undervalued compared to, for example, bees, butterflies and flies (Sumner et al. 2018). Surveys of public opinion suggest that, generally, wasps are disliked by people, while bees are often liked (Sumner et al. 2018). One explanation for this is that the public appear to have a poorer understanding of the ecosystem services provided by wasps compared to bees. To what extent does the media fuel this wasp discontent through their 'wasp-negative' reporting? What role do scientists play in influencing this narrative? We explore these questions and ask if interactions between scientists and the media can help quell the negative portrayal of wasps. This is important because the media plays a huge role in influencing the public's understanding of science and their attitudes to nature.

Social insects contribute to ecosystem services such as seed dispersal, pollination, biological controls, pharmaceutical, medical, and food production, as well as cultural services such as biological indicators or artistic inspiration (Elizalde et al. 2020). The global value of ecosystem services such as pollination and biological control are estimated at US$117B and US$417B per year respectively (Costanza et al. 1997). Part of those services are provided by wasps, through pest control, pollination, decomposition, nutrition

✉ C. A. Oi
cintiaakemioi@gmail.com

[1] Centre for Biodiversity and Environment Research, Department of Genetics, Evolution and Environment, University College London, London, UK

[2] Manaaki Whenua-Landcare Research, P.O. Box 69040, Lincoln 7640, New Zealand

Published online: 11 March 2024

and cultural value (Brock et al. 2021). Aculeate wasps (social and solitary) prey on other arthropods, suggesting a key role for them as biological control agents (Gould and Jeanne 1984; Koide 2001; Donovan 2003; Todd et al. 2015; Prezoto et al. 2019; Southon et al. 2019). Bees contribute via pollination, products such as honey and wax, and their venom as a source of bacterial biocontrol agents for crops (Elizalde et al. 2020). Although bees are the public face of pollination, this service is also provided by wasps, as adult wasps rely on nectar for nutrition (Brock et al. 2021). Both bees and wasps are used as biological indicators for pollution and habitat conservation (Celli and Maccagnani 2003; de Souza et al. 2010; Girotti et al. 2020; Cunningham et al. 2022), and wasps are likely to be affected by climate change, land use and pollution, in the same way as bees (Dejean et al. 2011; Jönsson et al. 2021).

Global media coverage of wasps invariably focuses on, and emotively exaggerates, the negative side of wasps. They are regarded as dangerous pests; this is partly due to their stings being responsible for deaths around the world; for instance, over a 23 year period in Europe alone 1691 deaths were recorded (Feás et al. 2022). But their rocky reputation can also be attributed to the negative ecological impacts of wasps when they are in new regions as non-native species, where invasive populations compete with local biodiversity and cause economic damage (Beggs et al. 2011; Lester and Beggs 2019). As a consequence, media coverage of wasps is predominantly negative. Typical newspaper headlines include: *Are there more wasps around than usual this year?* (https://www.bbc.co.uk/newsround/58666791); *Single 'murder hornet' queen may have led insect's aggressive invasion of Europe* (https://www.independent.co.uk/news/science/murder-hornet-europe-invasion-origin-b2240449.html); *Yellow jackets, wasps and hornets are more aggressive this time of year. Here's why.* (https://eu.usatoday.com/story/news/nation/2021/10/06/yellow-jackets-wasps-hornets-why-now-worse-time/6017885001/); *Waging war on wasps with revolutionary bait* (https://www.nzherald.co.nz/rotorua-daily-post/news/waging-war-on-wasps-with-revolutionary-bait/7Z2BNHWXLGO3DIBUNMU7EADKR4/). These types of headlines are likely to be fuelling the public's negative perception of wasps. Interestingly, when the media reports the good side of wasps, it is usually related to a peculiar behaviour, rather than anything about their importance in ecosystems; for example, a recent study published in Current Biology (Sugiura and Tsujii 2022) reported how male wasps use their genitals as "pseudo-stings" for defence, as they do not possess a real sting. This paper received media coverage worldwide, including main journals as The New York Times, The Guardian, Le Monde and Folha de São Paulo. Media coverage of wasps and their role in ecosystems is entirely shaped by a late summer peak in the northern hemisphere (Google Trends), when social vespine wasps become a little troublesome for the public as their colonies peak in size and worker wasps have less brood-feeding duties and less larvae-based nutrition via trophallaxis.

Public opinion matters, especially when it impacts conservation efforts. Conservation initiatives require people to value or care about a particular organism(s) and thus have a desire to take positive action to improve its situation. If people do not care about or value wasps because they do not understand what they do, then there will be little incentive for conservation efforts (Hart and Sumner 2020). The media plays an important role in shaping public awareness: it can shift attitudes and encourage conservation actions; e.g., positive reporting by the media has had a positive impact on conservation of amphibians (Loyau and Schmeller 2017) and cougars (Lassiter et al. 1997). How the media portrays an organism can also change over time, representing shifts in how people perceive them; e.g., in the case of the hellbender salamander in the USA, media coverage from 1863 to 2016 saw a shift to positive reporting from 1980, coinciding with the Conservation Biology Era (Unger and Hickman 2020). Furthermore, misinformation by mainstream media can also lead to public confusion of conservation initiatives; e.g., conservation of sharks—banning fin trade was not enough to conserve them (Shiffman et al. 2020). Currently, the negative, sensationalist media coverage of wasps is likely to fuel public fear and misunderstanding of wasps; conversely, a future media that amplifies the important services provided by wasps (as it has done for bees) would help to increase appreciation of these insects. Media may promote more research into their ecological roles and even instigate support for wasp conservation programmes, benefiting wider ecosystems (Sumner et al. 2018). In Guiyang City (China), for example, vespine wasps and their products were attributed a high economical value, and this information helped to change public perceptions towards positive view of wasps (Dai et al. 2021).

Journalists will often seek the opinions of scientists when covering a story about a new discovery, or some unexpected event that requires an expert to help explain it (Jerome 1990; Yeo and Brossard 2017). These interviews have the potential to shape the tone and direction of the story, or result in an erroneous story being corrected or dropped (e.g., if the whole premise is wrong); a good example of this is the sensationalist media coverage on a paper on climate change and conservation, in which suggested catastrophic scenarios using headlines as "*Climate change threatens a million species with extinction*", as opposed to critically accessing it (Ladle et al. 2005). Because media has power over public opinion, it is important to comprehend the nature of interactions between scientists and the media (Peters 2013); the degree to which scientists feel that they have influence over how science is reported, is underappreciated. A swathe of

studies indicate how public attitudes towards conservation can be improved if the ecological and economic value of biodiversity is communicated effectively (Novacek 2008; Lewandowski and Oberhauser 2017; Loyau and Schmeller 2017).

We conducted a survey on the opinions and experiences of wasp and bee scientists and their interactions with the media to determine their perceptions on whether the media is fuelling the wasp-negative/bee-positive agenda, whether they felt they had any influence over this narrative, their opinions on the need for conservation or control of wasps and bees, and how the media influences this. First, we were interested to find out to what extent they perceive the media to be biased in its reporting of bees and wasps; specifically, we test the hypothesis that wasps are typically presented in a negative light and bees in a positive light (Aim 1). Second, we explored the extent to which wasp scientists might be contributing to these biases through their interactions with the media; we test the hypothesis that scientists may be reinforcing biases, because they too are victims of cultural norms (Aim 2). We then investigated the extent to which researchers feel they can influence how these insects are reported through their interactions with the media; specifically, we were interested to learn whether the scientists felt they could steer a story to be more positive (Aim 3). Next, we wanted to find out how the scientists felt about the need to control or conserve wasps or bees and learn about existing conservation efforts (Aim 4). Finally, we assessed the interests of the public in wasps and bees using Google Trends to gather data on internet searches (Aim 5).

The survey targeted both wasp and bee scientists to make comparisons between these two groups. Since the lay public often confuse wasps and bees for each other, we considered bees as the obvious comparative group as they are close relatives of wasps, and resemble them in appearance; they also sting but are widely reported in a positive light by the media (with exception of invasive species [e.g., *Apis mellifera* in South America (Jernelöv 2017)], and there are many bee conservation initiatives (e.g., the Bumblebee Conservation Trust, https://www.bumblebeeconservation.org; Women for bees—Unesco https://en.unesco.org/themes/biodiversity/women-for-bees). We discuss our results within the context of the role of both scientists and media in influencing cultural attitudes towards wasps and implications of this for conservation.

## Materials and methods

### Data collection and general data handling

We conducted an online survey with scientists using Google Forms between 8 and 26th November 2022. Our survey was distributed widely on social media (Facebook, Twitter, Instagram), sent out to specialist learned societies groups (e.g., International Union of Study of Social Insects IUSSI mailing lists in different countries) (Table S4); we also emailed directly to as many wasp and bee laboratories around the world as we could, inviting participation and further dissemination. All surveys were anonymous; participants chose to complete the wasp or bee survey, depending on their expertise; they could also opt to complete both surveys, although there were no identifiers linking the two surveys meaning that the data in two surveys completed by the same person could not be compared. Quantitative data was recorded and analysed using a Likert Scale from the package *likert* (Bryer and Speerdschneider 2016). The replies were transformed to an ordinal scale for analysis using a cumulative linked model from the package *ordinal* (Christensen 2022). Each response was analysed separately by survey type, and pairwise comparisons were used to check the differences between bee and wasp surveys were done using the package *emmeans* (Russel 2020). Specific analyses are described below, with their corresponding section. Full questionnaire and raw data are provided in the Supplemental Material; the survey was approved by UCL Ethics Committee under project ID 19589.001. All statistical analyses were conducted in R version 4.2.0 (R Development Core Team 2012).

### Demography of respondents

We first describe the demographics of our respondents, and test whether there was a bias towards working with bees or wasps with respect to research demographic traits. We then used a generalised linear model with binomial distribution (response variable: bee or wasp survey respondent) with explanatory variables as academic position, gender, the location of institution where the research was based and how long they had been working in the field. Models were run using the package *stats* in R (R Development Core Team 2012). We also asked scientists what they understood by the term 'media', and visualised these data using package *wordcloud* (Fellows 2018) in R, the size of the word depicted the frequency of words used.

### Testing the aims and hypotheses

**Aim 1: Attitudes to bees and wasps by media and the public.** We asked the scientists' opinion on how media portray their study organisms (question a: "*In your opinion, how does media portray wasps/bees?*"). We were also interested in the scientists' opinions about how the general public perceive wasps in their institution's country and the countries that they study wasps in (if different). To do this we asked the scientists to imagine stopping a member of the public on the street in the town of their home institution, asking how

that person felt about their study organism (either bees or wasps), and to score their result on a Likert Scale (from 1 (strongly negative) to 10 (strongly positive), with 5 indicating neutral (i.e., neither like nor dislike) (question b: "*This question is about the country in which your study institution is based. If you stopped a random member of the public in the street in your institution's town, and asked them how they feel about wasps/bees, what do you think they would say?*").

**Aim 2: Scientists' attitudes towards their study organism.** We asked respondents how they felt about their study organism (question c: "*How do you feel about wasps/bees?*"), and how they thought media portrayed those organisms (question d). Respondents rated the organisms on a linear scale from 1 (strongly negative) to 10 (strongly positive), with 5 indicating neutral (i.e., neither like nor dislike).

**Aim 3: Influence of scientists on media.** We sought to understand when a scientist was approached by the media, whether there was already a specific bias in their approach (question d: "*We are interested in the nature of the questions that the media initially asked you about wasps/bees. Did these initial inquiries have a positive, negative or neutral angle with respect to wasps/bees?*") and whether the outcome had changed by the end of the interview (question e: "*We are now interested in the nature of the final article/news story that was written/broadcast, after your interaction with the media. To what extent did it present wasps/bees in a positive, negative or neutral light?*"). Respondents rated the replies on a linear scale being 1 (strongly negative) to 10 (strongly positive), with 5 indicating neutral (i.e., neither like nor dislike).

We were interested to hear how much influence the scientists felt they had over the direction of the story (question f: "*To what extent do you think your interaction with the media influenced the nature of article/broadcast, regarding the portrayal of wasps/bees?*"). Respondents rated their replies on a linear scale from 1 ("my interaction had no impact at all on the story/the media ignored what I had to say") to 10 ("my interaction had an enormous impact on the story/my interaction completely changed the angle of the article").

Questions d and e were analysed separately, by adding a factor for time (initial interaction *vs* post-interview): the original interest by the media *before* the scientist gave the interview or opinion and *after* the interview/article was broadcast/published, whether the final outcome changed the angle from the first interaction with the media. For these analyses we used the Likert score as an ordered factor as the response variable. Fixed variables were survey type, time (*before*—question d; *after*—question e), the interaction effect between these two independent variables, and the identification (ID) of the scientist as a random intercept in a CLMM. Since we were focusing on the comparison of before and after the interaction with the scientist and the outcome of the media, we rearranged questions d and e to focus on these comparisons and to obtain letters of significance using the package *multcomp* (Hothorn et al. 2023).

**Aim 4: Perceived need for conservation and control of bee and wasp populations.** We were interested to hear of any bee/wasp conservation or control work that the scientist knew of in any country; their opinions on whether bee/wasp conservation or control initiatives are required; what role the media may play in influencing the public's approach to conservation or control measures, if any; and whether the scientist thinks more conservation effort is required to conserve or promote the organism populations (question g: "*We are interested to hear whether you think more conservation effort is required to conserve/promote wasp/bee populations*." & question i: "*We are interested to hear whether you think more effort is required to control wasp/bee populations*"). The rationale for asking about conservation and control measures is because in places where bees or wasps are considered invasive or a pest species, the role of media can be important in both ways. We asked the researchers to consider any country and any wasp genus and species. The replies were rated on a scale from 1 (definitely not needed) to 10 (definitely needed), with 5 indicating neutral (i.e., I have no opinion). To complete this question, we asked the researchers on whether they thought the media plays a role in promoting control measures (question h: "*How important do you think the media are in promoting wasp/bee control, e.g., by encouraging people to remove/kill wasps/bees, clearing wasp/bee-friendly habitats?*" & question j: "*We are interested to hear whether you think more effort is required to control wasp/bee populations*""). Responses were scored on a scale from 1 (not important at all) to 10 (extremely important), with 5 indicating neutral (i.e., neither important nor unimportant).

**Aim 5: Public's interest in wasps and bees.** We selected the two countries which contributed the most responses in our survey and used Google Trends to assess the level of public interest in bees and wasps. We selected the words "insect bee" or "insect wasp" under the categories "web search" and "news search" from 2017 to 2022 to retrieve data on the number of searches conducted using the Google search engine. "Web search" provides the general trending of a search term across all Google's search results more broadly (e.g., websites, images, videos and news). "News search" is more specific, providing information only on the search in Google News. The values obtained from Google Trends are normalized values indexed on a scale from 1 to 100. Each point was divided by the highest point. The proportion of searches was used as a response variable in a generalised linear model with Poisson distribution and log-link function. Explanatory variables were organism (bee or wasp), media type (web or news) and country (Brazil or USA). Analyses were

conducted in R using the package *stats* and *emmeans* (Russel 2020).

## Results

### Wasp and bee survey respondents share similar demographic traits

Over 18 days of promoting the survey, we obtained a total of 115 responses (60 from bee scientists and 55 from wasp scientists) (Fisher's exact test $p = 0.01$); 53% and 30% of respondents were female for bees and wasp questionaries respectively; respondents were located in 15 (bee) and 20 (wasp) countries respectively, and collectively represented the research community across seven continents (see Figs. 1, S1). The majority of bee scientists were located in the USA (18.6%) and Brazil (16.7%); this was similar for wasps' scientists with 12.7% in the USA and 12.7% in Brazil (see Figs. 1, S1, Table S1).

Respondents represented a wide taxonomic diversity of study organisms for both bees and wasps, although in both groups there were strong taxonomic biases to two or three social insect genera in each case [including the commonest genera of social bees (*Apis*, *Bombus*) and wasps (*Polistes*, *Vespula* and *Vespa*); Fig. 2].

Scientists defined media in broadly five common categories: TV, websites, newspapers, magazines and books (Fig. 2), and there was no difference between bee and wasp researchers in media definition (Chi-square = 34.83, $df = 35$, $p$ value = 0.47).

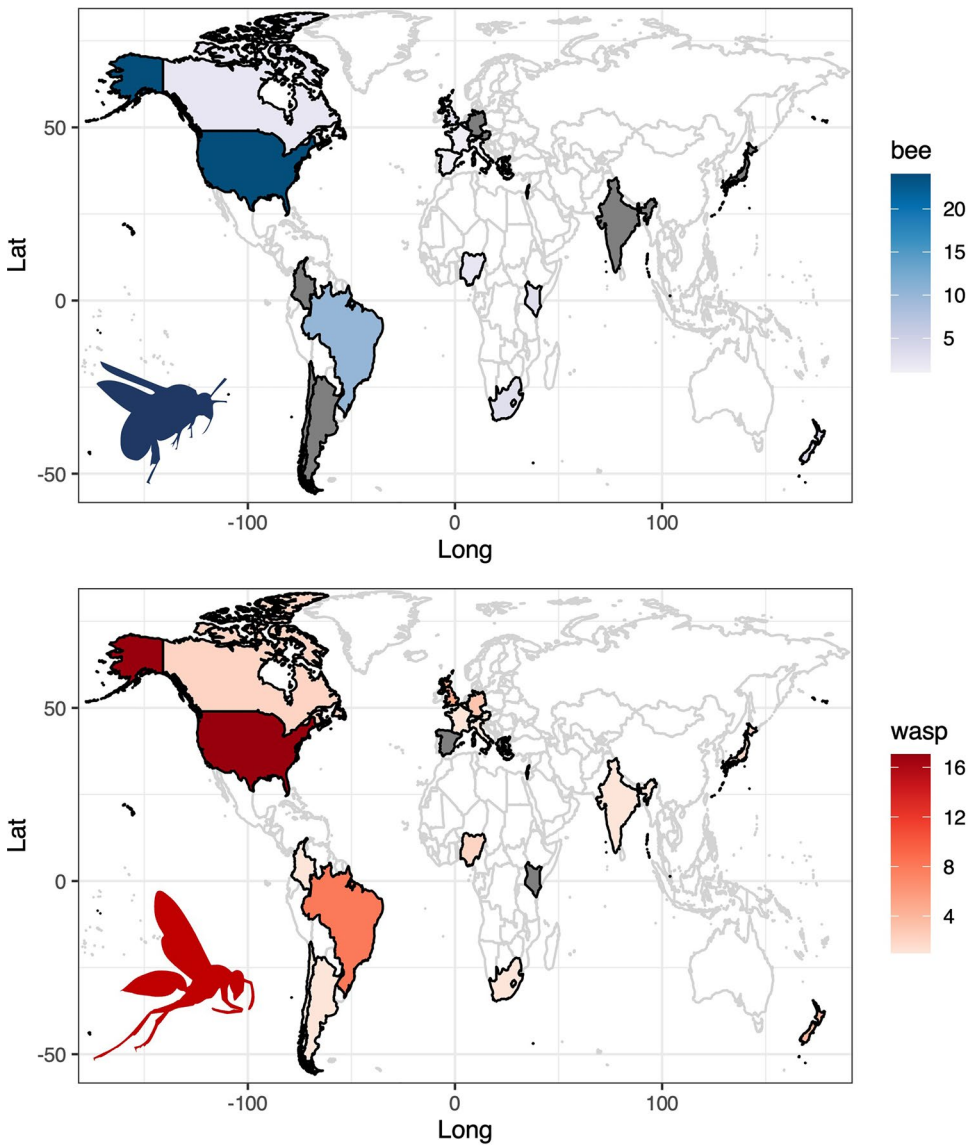


**Fig. 1** Distribution of survey responses from bee (upper panel) and wasp (below panel) scientists. For both groups, the USA and Brazil dominated the responses. The scale indicates the number of respondents. Our respondents spanned the full career structure from graduate student to full professor, although with a notable skew towards the most senior positions (Fig. S2). Across these diverse demographics, we found no evidence that academic position, gender or country (Table S1) influenced whether a researcher identified as wasp or bee expert. Thus, the two surveys are comparable from a demographic perspective. On the right, bar colour indicates the number of respondents. Countries in grey highlight data that was absent compared to the other survey


**Fig. 2** On the right, self-reported main study groups of survey respondents for wasp (upper panel) and bee (below panel) researchers. On the left, words used by survey respondents to describe what they understand to be 'the media'. The size of the word indicates the frequency with which that word was used

## Testing the aims and hypotheses

### Aim 1: Attitudes to bees and wasps by media and the public

Almost all wasp scientists (85.8%) perceived wasps as being portrayed negatively by the media ('wasp-negative', scales 1–4); by contrast only one bee scientist cited bee-negative reporting, and in this case, it was only mildly negative (scale 4, Fig. 3a). The reason given for wasp-negative media is the nuisance wasps cause people and the risks they pose to human health. Comments by wasp scientists included: "*Vespa velutina is consistently depicted as the "killer wasp" in popular media*"; "*Wasps are too aggressive*". Conversely, our respondents attributed the bee-positive media coverage to the benefits of bees to humans (e.g., bee products such as wax and honey) and for their ecosystem services as pollinators. Comments included "*Bees as popular charismatic, sometimes "memey" animals, like cats.*" or "*Cultural—beekeeping practices and forest/natural honey gathering*". However, they also reported a perceived bias towards honeybees with little attention given other bee genera: "*A very heavy focus on managed honeybees while wild bees are almost absent from popular media*".

The scientists' perceptions of how the general public feel towards bees or wasps was in line with previous surveys (Sumner et al. 2018): overall, bees were perceived in a significantly more positive light than wasps (Fig. 3b, $p < 0.00$). 87.2% of wasp scientists said that the public would rate wasps in the negative spectrum (1–4 score), with 21.8% rating wasps as the most extreme end of the scale (1—strongly negative). The most positive score given was 7/10 and this was given by 3.6% of respondents. The opposite was true among the bee scientists, with 73.4% of them rating the public's attitudes to bees as positive (scores 7–10), although 23.3% were neutral (scales 5 and 6) and 1.7% were 'strongly negative' (one respondent from Kenya) (Fig. 4).

### Aim 2: Scientists' attitudes towards their study organism

Almost all scientists felt positive about their study organisms, irrespective of taxa; there were two exceptions (one bee scientist and one wasp scientist) who reported neutral feelings towards their study organisms. Overall, there was no significant difference in attitudes of bee and wasp scientists towards their own study organisms ($p = 0.65$, Fig. 3c). This suggests that wasp scientists are unlikely to be fuelling any wasp-negative media reporting, and both groups are likely to be presenting a positive angle for their study organism when interviewed by the media.

### Aim 3: Influence of scientists on media

Bee and wasp scientists reported differences in the angle taken by the media at the point of interview request (Fig. 3d). Of our 115 respondents, 83 reported having been interviewed by the media about bees/wasps (71.6% for bee scientists; 80% for wasp scientists). The angle of initial media interactions with scientists differed significantly by taxa regarding the nature of the request: 50% of interviews about wasps were negative (scales 1–4), compared to only 2.3% for bees (and these were only very mildly negative) (scale 4, Fig. 3d). Conversely, 27.9% bee enquires were 'strongly positive' (scale 10) compared to only 2.5% of wasp enquiries (1 respondent scale 10). Media requests directed at wasp scientists were concerned with science outreach (31.7%; e.g., a new scientific paper), seasonal cycles of wasps (19.5%) and wasps as non-native species (14.6%). Media requests to bee scientists also included science outreach (36.6%), but the majority concerned the role of bees in the environment (41.5%, e.g., ecosystem services). These results suggest that from the outset, the media are biased in terms of their choice of subject matter when reporting on bees and wasps, as well as their positivity.

We were interested to know whether the scientists perceived that their interactions with the media had shifted the emphasis of the story to be more positive (or negative) than the nature of the original enquiry (Fig. 3d, e). There was a trend for both bee and wasp scientists to perceive the final media story to have shifted to be more positive after their interview; however, only the wasp interviews showed a statistically significant shift $p = 0.00$ *vs* bee $p = 0.16$ (Figs. 3d, e, S3, Table 1), although this could be due to the differences among taxa in the starting premise of the initial enquiry (see result for 3d). Importantly, 59% ($n = 23$) of wasp scientists thought that their interview had influenced the final outcome shifting it from a negative angle to a more positive one (scales 7–10, question e). The majority of bee scientists also thought that their interviews influenced the final outcome resulting in a shift to bee-positive (43.9%, question 3e).

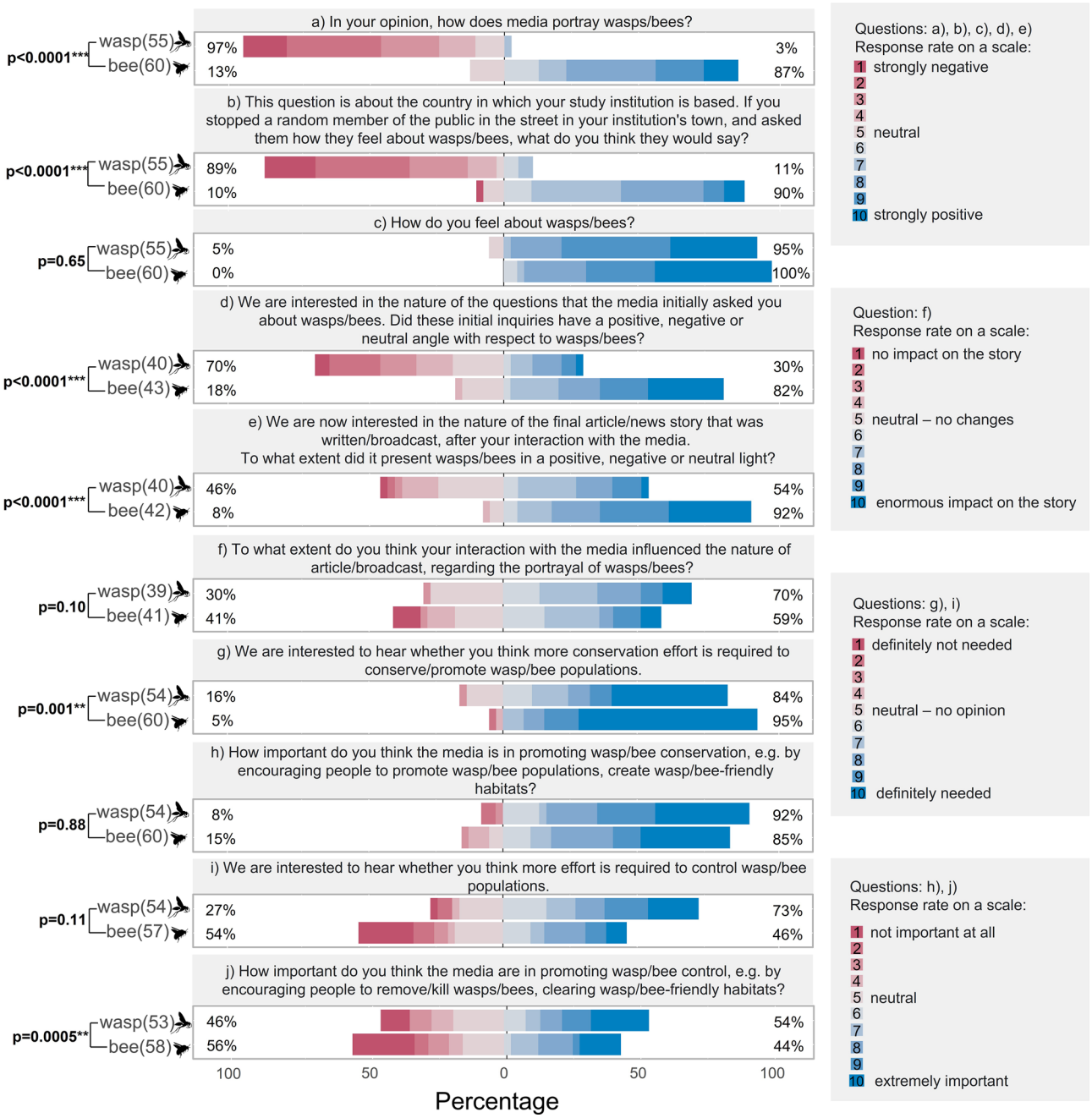


**Fig. 3** Likert plots reporting results from the questionnaire with wasp and bee scientists. The questions are indicated by the letters a) to j). Right hand panel explains the response scale for each of the questions. Left hand provides number of respondents (*N*) and *p values* for the pairwise differences between the survey of wasps and bees scientists

Bee and wasp scientists reported similar levels of influence in their interactions with the media (Fig. 3f, $p = 0.10$). However, 10.3% of wasp scientists perceived their interaction to have had an '*enormous impact*' on shifting the story narrative to be wasp-positive and 2.6% ($n = 1$) of wasp scientists thought they had had little/very little impact on the angle of the story (score of 3); importantly none of the wasp scientists scored '1' (where '1' would mean their interview had 'no impact on the story'). By contrast, only 7.3% of bee scientists considered their interactions to have had '*enormous impact*' on the story (Fig. 3f); furthermore, 24.3% of bee scientists felt that their interactions with the media had little impact on the story (scales 1–4), with 31.7% claiming their interactions resulting in no real shift (score 1) in the positive/negative angle of the final article or broadcast.

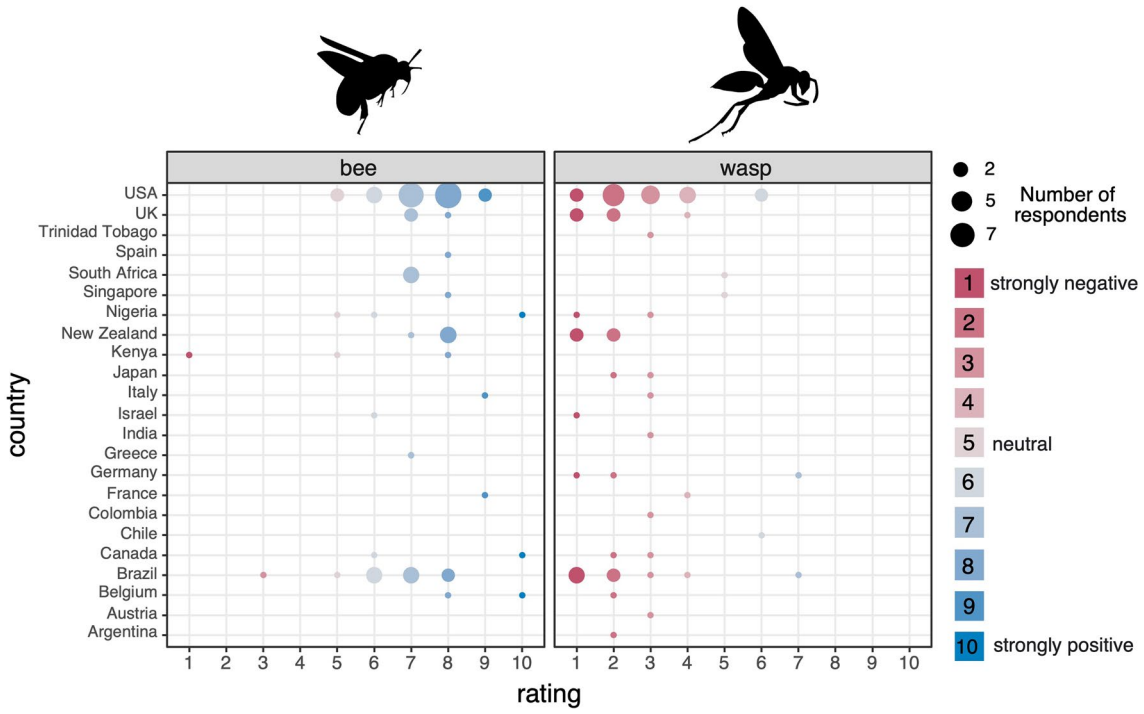


**Fig. 4** Bee and wasp scientists' scores for their view of their local community's perceptions of these organisms, where 1 represents a strongly negative and 10 strongly positive emotions

**Table 1** Estimated marginal mean [emmean ± standard error (SE)] of pairwise comparisons of scientists' responses to questions d (rate the angle of media story at first interaction with researcher) and e (rate the angle of final media story after interview with researcher)

| Researcher type | Time point | emmean | SE | Significance |
|---|---|---|---|---|
| Wasp | initial interaction (question d) | − 1.069 | 0.526 | T |
| Wasp | post-interview (question e) | 0.799 | 0.518 | R |
| Bee | initial interaction (question d) | 4.017 | 0.645 | U |
| Bee | post-interview (question e) | 4.909 | 0.706 | U |

'Significance': different letters indicate where a statistically significant difference was detected (Mann–Whitney *U* test), with same letters indicating no significant difference

**Aim 4: Perceived need for conservation and control of bee and wasp populations**

***Need for conservation:*** Overall, the attitudes of scientists on the need for conservation of their study organism differed significantly $p = 0.00$* (Fig. 3g). Ninety-five percent of bee scientists thought that more conservation efforts are required to conserve/promote bee populations (scales 7–10); 70% gave the highest rating for this: "definitely needed (scale 10)" (Fig. 3g). By contrast, 74% of wasp scientists thought that more conservation effort is required to conserve/promote wasp populations. A small but similar proportion of wasp (3.8%) and bee (3.4%) scientists stated that conservation effort was not required. Interestingly, 22.4% of wasp researchers had no opinion (scales 5 and 6), compared to only 1.7% of bee researchers.

Despite these differences, the two types of scientists were equally positive about the influence of the media in promoting conservation $p = 0.88$, for example, popularisation of wasp and bee friendly habitats by adding bee (wasp) hotels to gardens and changing gardening habits; 78.3% of bee scientists and 75.9% of wasp scientists rated this influence as positive to strongly positive (scales 7–10, Fig. 3h).

***Need for control:*** There was a non-significant trend of wasp scientists seeing more need for control of their study organism than did bee scientists (see above and Fig. 3i—$p = 0.11$). We expected a stronger effect here, given social wasps are notorious invasive species (Fig. 3i). Bee scientists

were split between the need to control bees (19.8%, scales 7–10) and those who believe such control is not needed (45.6%, scales 1–4) (Fig. 3i). However, based on the comments and demographic of the scientists, the scientists pointed out that some bee groups would need more attention, e.g., wild bees and solitary bees in Europe are not well studied; non-native honeybees in New Zealand are invasive but provide valuable manuka honey; managed *Bombus terrestris* in any country (native or non-native) are useful for pollination. The call for more control of bee populations is often with reference to the Africanised honeybees that dominate pollinator communities in some countries, and other species of managed bees which can spread diseases and outcompete native wild bees (Graystock et al. 2016). By contrast, 40% of wasp researchers thought that more effort was needed to control wasp populations (scales 7–10, Figs. 3i, 5). Notably, the scientists advocating the need for more control of wasp populations worked in New Zealand where non-native *Vespula* wasps present a huge ecological and economic problem (Lester and Beggs 2019; Stratford et al. 2023); conversely, *Vespa* was mentioned by researchers in USA, Europe and Canada, where non-native *Vespa* are causing problems (Monceau et al. 2014; Laurino et al. 2020). Wasp scientists in Brazil and the UK feel that control of wasp populations is not needed. Brazil supports a large community of wasp researchers studying wasp biodiversity and ecology (Prezoto et al. 2021); and the UK has few problems currently with invasive wasps (Jones et al. 2020). These factors may explain the wasp-positive attitudes in these countries.

Wasp and bee scientists were not united in their opinions on the role of the media in promoting control measures for their organisms, e.g., by encouraging people to remove or kill bees and wasps, or clearing bee and wasp-friendly habitats as there was a significant difference $p = 0.00$** (Fig. 3j). Both communities were divided more-or-less equally in their opinions on the extent to which the media are important, although there was a trend towards wasp-reporting in the media having a larger role in promoting control (56.6% of wasp scientists) compared to bees (32.8% of bee scientists; scales 7–10). This result is difficult to interpret and may be better understood if the specific taxa the respondent is thinking about was reported, e.g., the responses by a *Vespula* scientist in New Zealand may differ from those of a *Vespula* scientist in the UK (Lester 2018).

**Aim 5: Public's interest in wasps and bees**

For our Google Trends analysis, we selected the two countries with the most respondents to our survey: Brazil and USA (see Fig. 1). Over the last 5 years (2017–2022) wasps received significantly fewer web searches than bees in both countries, suggesting lower levels of public interest in wasps relative to bees ($p = 0.00$***, Table 2). A fraction of web searches were news searches, which are not specified by the platform.

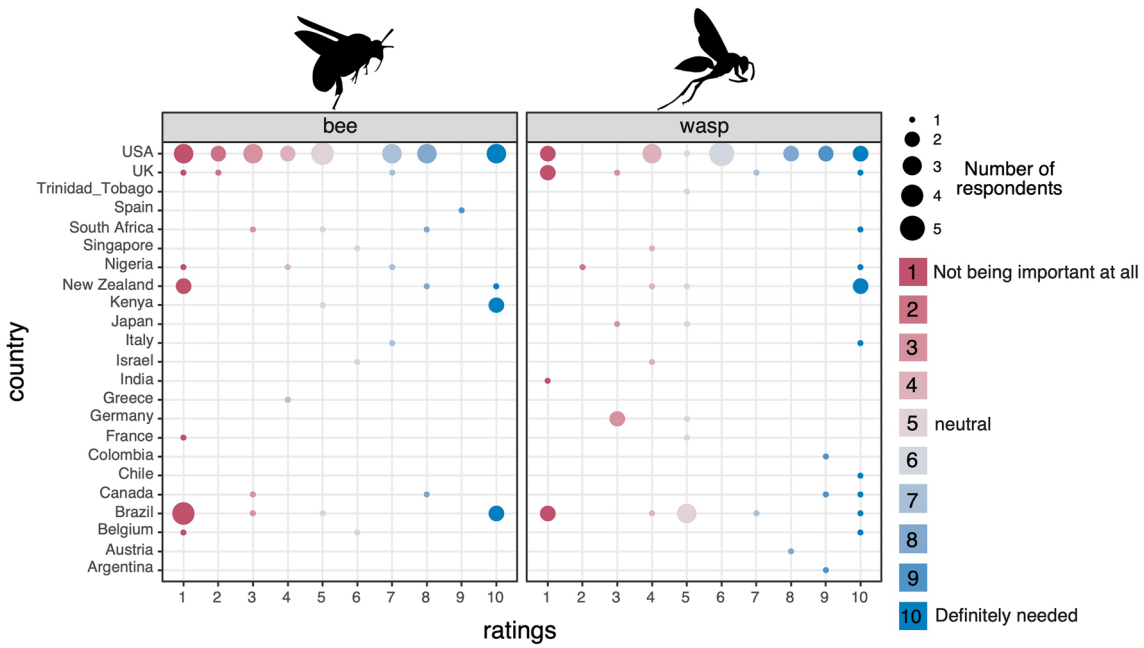


**Fig. 5** Responses to the question of whether bee (left panel) or wasp (right panel) scientists think more effort is necessary to control their study organisms, where 1 indicates not being at all important, 5 and 6 being neutral and 10 being extremely important. The size of the circle indicates the number of respondents who chose that score. Data distributions are too skewed to USA and Brazil for statistical analyses. Qualitative discussion is given in the text

**Table 2** Search events for insect 'bee' or 'wasp' over a 5-year period (2017–2022) obtained using Google Trends

| Row labels | News | | News total | Web | | WEB total | Grand total |
|---|---|---|---|---|---|---|---|
| | Bee | Wasp | | Bee | Wasp | | |
| Brazil | 1475 | 966 | 2441 | 6307 | 580 | 6887 | 9328 |
| USA | 3886 | 915 | 4801 | 10147 | 2458 | 12605 | 17406 |
| Grand total | 5361 | 1881 | 7242 | 16454 | 3038 | 19492 | 26734 |

The values extracted from Google Trends are normalized values indexed on a scale from 1 to 100. Each point was divided by the highest point

## Discussion

It is clear that the public generally appreciate bees and hate wasps (Sumner et al. 2018). But the extent to which the media may be fuelling this, and the influence of scientists in this narrative was unclear. We analysed the opinions of 115 bee and wasp scientists from across 23 countries to determine their perceptions on the role of the media in fuelling the wasp-negative/bee-positive agenda, and whether they felt they had any influence over this narrative, their opinions on the need for conservation or control, and how the media influence this. Our respondents represented a good spread of the diversity among bee and wasp researchers in terms of geographical distribution, study species, career stage and gender. There was a predominance of social insect biologists in our respondent pool, possibly because we capitalised on the global network of social insect researchers through IUSSI mailing lists; but also likely because solitary bees and wasps are less popular study organisms than social bees and wasps (Brock et al. 2021). There was a geographical bias to researchers from Brazil and USA, which may reflect the relatively high number of bee and wasp researchers in these countries, but may also have been influenced by active promotion of the survey via country-specific social insect mailing lists and social media. Because the survey was only circulated in English, this may have made it inaccessible to some scientists; for example, notably few responses were received from people in Japan and none from China, despite these countries hosting active bee and wasp scientists. Notably, these countries also have better relationships with wasps than perhaps any other country, as they value wasps as sources of food (e.g., larvae and pupae) (Feng et al. 2018; Van Itterbeeck et al. 2021) and medicines (e.g., adults and combes are used to make wines to treat rheumatism and arthritis) (Dai et al. 2021). Indeed, vespine wasps are frequently found for sale at markets in these countries; in China, the income from a single hornet nest sold at market is equivalent to the average disposable income per year for a rural citizen (Dai et al. 2021). Despite these obvious geographical limitations, our survey provides a first global vision of the opinions of bee and wasp scientists and their professional interactions with the media.

In the opinion of our respondents, the media, almost universally, presents a negative view of wasps and a positive view of bees. The topics of the stories also differed with taxa: wasp stories cited were typically about the nuisance wasps cause people and the risks they pose to human health; conversely the bee stories were about the benefits of bees to humans, and their ecosystem services as pollinators [e.g., media have been skewed to portray honeybees as pollinators (Smith and Saunders 2016)]. Since the media play a role in educating the public, the lack of media stories about the ecosystem services of wasps is likely to be reinforcing the '*What's the point of wasps?*' rhetoric among the general public, and fuelling ill-founded horrors about wasp stings and swarms. One of the drivers of this media bias is that the research effort from the wasp research community is 40 times smaller than that of the bee research community, meaning that fewer research papers about wasps and their role in the environment are being generated for the media to report on (Sumner et al. 2018). As the ecosystem services of wasps become better recognised and studied (Prezoto et al. 2019; Brock et al. 2021), a more representative balance may be presented by the media. The current prejudice, however, is likely to have a substantial impact on how the public perceive these insects and, ultimately, have consequences in their conservation (Sumner 2022).

The end-users of media are the public; their opinions and attitudes are shaped by what they read and hear in the news, social media etc. If there are differences in how people feel about wasps and bees in different parts of the world, then this may reflect differences in reporting styles of the local media. It was therefore important to determine whether there are likely to be any regional differences in attitudes among the local lay communities of the scientists we surveyed. In the opinion of our respondents, their local communities exhibit typical attitudes to bees and wasps. A previous study found that wasps are universally disliked by the public, with the sting being the main source of discontent (Sumner et al. 2018). Although this older study was much larger, surveying 750 members of the public, it was largely limited to the UK. Our current study reflects the opinions of scientists on their local communities from around the world, suggesting that this dislike of wasps and appreciation of bees is largely a global phenomenon. Although we did not survey

the public directly (as (Sumner et al. 2018) did), we used Google Trends data and found that the public were much more likely to search for information on the internet about bees than wasps, suggesting that the public have a deeper interest in bees and less likely to seek to learn more about wasps. Our analysis was unable to ascertain what the nature of these internet searches were: for example, it would be interesting to compare the proportion of searches for the two taxa that were concerned with how people can encourage those insects in their gardens, versus the proportion of searches concerned with how to get rid of a bee or wasp nest. Future work could utilize AI text-mining methods to dig more deeply into this, checking the differences among countries and languages.

Contrary to their perceptions of lay communities, the scientists expressed universally positive attitudes towards their study organism, irrespective of whether it was bees or wasps. Although this may be unsurprising, we needed to rule out the possibility that wasp researchers may be unconsciously fuelling the media's wasp-negative coverage through their own negative attitudes. What is interesting about this result is that even those who work on invasive, aggressive, ecologically and economically damaging wasps (e.g., *Vespula* wasps in New Zealand) and bees (e.g., Africanized honeybees in Brazil) still report positive feelings towards their study organisms. In their interactions with the media, therefore, both bee and wasp scientists are likely to be encouraging a positive view of their study organisms. Importantly, wasp scientists are unlikely to be fuelling the media's wasp-negative tendencies.

Interactions with the media can be stressful and daunting for scientists, who worry about being misquoted (personal observation) or taken out of context (Peters 2013). Scientists worry about critical details of their study being missed (Peters 2013). Scientists also tend to have a very narrow view of their own expertise (Peters 2013); for example, a wasp scientist may decline talking to the media about a bee article if they consider themselves a wasp expert, and not a bee expert (and vice versa). However, scientists have an important role in helping journalists understand new material, and their interactions provide an opportunity to encourage high-integrity reporting (Dudo 2015). Our survey provides some suggestive evidence that wasp scientists have the potential to influence the angle of a media story about wasps such that they are portrayed more positively than the journalist first intended. Almost 60% of our wasp scientists perceived that their interactions with the media had shifted the original story to be more wasp-positive, and 10% of these thought their influence had been 'enormous'. This is an encouraging result for wasps and wasp scientists. This implies that speaking up when given the chance is an influential and powerful way to inform the public and ultimately improve the public's perception of wasps. This emphasizes how crucial it is for scholars to actively participate in media opportunities and may also help direct investment focus for institutions with their media training (Varner 2014; Peters 2022).

In stark contrast to the wasp researchers, only 7% of bee scientists thought they had influenced the story through their interactions with the media, and 31% reported no impact. This may be because the original bee story was already positive, and that their contributions as bee experts were in clarifying details of the study or on some aspect of bee biology. Interestingly, bee media coverage was criticised by the scientists, however, for its focus on farmed honeybees and bumble bees rather than wild bees, and especially solitary species. This is especially important given that, unlike solitary bees and wild social bees (e.g., stingless bees) (Colla 2022), managed honeybees and some bumble bees are not of conservation concern. Bee researchers have previously highlighted this problem (Esquivel et al. 2021; Colla 2022; Lohrmann et al. 2022); future research may seek to determine how attitudes of the media can be changed by interactions with bee scientists who are not working on honeybees.

Media reporting can shift attitudes and influence the extent to which people engage with and/or support conservation actions (Ladle et al. 2005). Wasp and bee scientists were united in their opinions that the media is important in promoting organism conservation effort; intriguingly, wasp scientists perceived this as being a bigger effect than did bee scientists. This may reflect the fact that wasp reporting often highlights the risks wasps present to human health or the beekeeping industry, and thus promotes the need to destroy nests of aggressive (and often invasive) wasp species. The scientists differed in their opinions on how much conservation effort their study organism needed; almost all the bee scientists reported a need for more conservation effort on their study organism, whilst only 75% of wasp scientists believed this is necessary for wasps. There was an indication of conservation needs for underappreciated insects such as solitary species (Burns et al. 2021) and wild species. The difference in relative amounts of conservation effort for bees and wasps is likely reflected by the invasive nature of a few social wasp species in some of the countries represented by our sample size. It might also reflect the relative paucity of research on the status of wasp populations (Jönsson et al. 2021), in stark contrast to the extensive literature on the state of bee populations (Dejean et al. 2011; Senapathi et al. 2015).

As well as influencing conservation action, the media may also be a powerful messenger for promoting the control of insect populations through the behaviour of the public; e.g., through destroying wasp or bee nests. Some of the world's most successful invasive species are bees and wasps. Equally, the vast majority of bees and wasps do not need controlling, and instead may need protection

and conservation. Bee and wasp scientists were equally split on whether more or less control measures were needed for their taxon. But intriguingly, they differed in their perceptions of how important the media are in promoting control measures. Wasp scientists perceived the media in having a stronger influence in promoting control than did bee scientists. This again, may reflect the geographical spread of our respondents and their exposure to the media hype around invasive wasp species such as Asian hornets (*Vespa velutina* and *Vespa mandarinia*) and the yellowjacket wasps (*Vespula germanica* and *Vespula vulgaris*) (Wilson Rankin 2021). It may also reflect the low research output on wasps and their ecosystem services compared to bees, with manifesting impact on media reporting. The need to control invasive species is well covered by the media when they pose an imminent harm to humans [e.g., murder hornets invasion (Alaniz et al. 2021)]. Few studies have evaluated the possible effects and costs of invasive and managed bees to local biodiversity (Kojima et al. 2011; Graystock et al. 2016), although the invasion of Vespine social wasps in New Zealand is projected to have a cost to native species approaching millions of dollars (Lester et al. 2013).

The media's biased reporting on wasps is likely to be perpetuating the public's negative attitudes towards these important insects. Whilst this narrative is warranted in the few parts of the world where wasps are invasive (e.g., New Zealand, Australia, South Africa, Argentina), it is unhelpful and damaging for native wasp populations, which perform important ecosystem services as pest-controllers and pollinators (Brock et al. 2021). However, our study suggests that scientists can play a powerful role in being able to steer the narrative. By scientists readily offering their expert advice and working together with the media for a fair and balanced portrayal of wasps across all forms of media, these much maligned insects may ultimately enjoy some of the positive media experienced by their vegetarian relatives. Outreach activities can encourage people to interact with and learn about wasps (e.g., Big Wasp Survey (Sumner et al. 2019; Cunningham-Eurich et al. 2023); popular science books about wasps can help the public learn more about the science and natural history of wasps [e.g., Lester 2018; Jones 2019; Eaton 2021; Sumner 2022]. However, mainstream media hold the key to achieving wide-spread shifts in behaviour change towards these insects, and thus promoting conservation efforts. Future surveys should aim to dissect taxon relationships to understand the complexities behind the opinions of scientists, and combine with surveys of public opinions across languages and cultures. At a time of widespread global insect declines (Outhwaite et al. 2022) is it more critical than ever to recognise the value of all insects in ecosystems as key facets of nature, no matter how ingrained our cultural prejudices may be.


**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s00040-024-00952-9.

**Acknowledgements** We thank the bee and wasp scientists who took part anonymously in this survey and those who helped share it across social media, especially the IUSSI community. We also thank members of the lab of Sumner lab, for feedback on survey design and interpretation. CAO was funded by a Marie Sklodowska Curie fellowship (grant no. WASSUP 101028937). RLB was funded by the Ministry for Business, Innovation and Employment SSIF. CAO and SS were funded by Natural Environment Research Council (grant NE/W004437/1).

**Author contributions** All authors contributed to the article and approved the final version.

**Funding** CAO was funded by a Marie Sklodowska Curie fellowship (grant no. WASSUP 101028937). RLB was funded by the Ministry for Business, Innovation and Employment SSIF. CAO and SS were funded by Natural Environment Research Council (grant NE/W004437/1).

**Data availability** The dataset and R script for this study can be found online.

## Declarations

**Conflict of interest** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



## References

Alaniz AJ, Carvajal MA, Vergara PM (2021) Giants are coming? Predicting the potential spread and impacts of the giant Asian hornet (*Vespa mandarinia*, Hymenoptera: Vespidae) in the USA. Pest Manag Sci 77:104–112. https://doi.org/10.1002/ps.6063

Beggs JR, Brockerhoff EG, Corley JC, Kenis M, Masciocchi M, Muller F, Rome Q, Villemant C (2011) Ecological effects and

management of invasive alien Vespidae. Biocontrol 56:505–526. https://doi.org/10.1007/s10526-011-9389-z
Brock RE, Cini A, Sumner S (2021) Ecosystem services provided by aculeate wasps. Biol Rev 96:1645–1675. https://doi.org/10.1111/brv.12719
Bryer J, Speerdschneider K (2016) likert: Analysis and Visualization Likert Items. R package version 1.3.5
Burns KLW, Fitzpatrick Ú, Stanley DA (2021) Public perceptions of Ireland's pollinators: a case for more inclusive pollinator conservation initiatives. J Nat Conserv 61:125999. https://doi.org/10.1016/j.jnc.2021.125999
Celli G, Maccagnani B (2003) Honey bees as bioindicators of environmental pollution. Bull Insectol 56:137–139
Christensen RHB (2022) ordinal - Regression models for ordinal data. R package version 2022.11–16
Colla SR (2022) The potential consequences of 'bee washing' on wild bee health and conservation. IPJ-PAW 18:30–32. https://doi.org/10.1016/j.ijppaw.2022.03.011
Costanza R, D'arge R, De Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'neill RV, Paruelo J, Raskin RG, Sutton P, Van Den Belt M (1997) The value of the world's ecosystem services and natural capital. Nature 387:253–260. https://doi.org/10.1038/387253a0
Cunningham MM, Tran L, Mckee CG, Ortega Polo R, Newman T, Lansing L, Griffiths JS, Bilodeau GJ, Rott M, Marta Guarna M (2022) Honey bees as biomonitors of environmental contaminants, pathogens, and climate change. Ecol Indic 134:108457. https://doi.org/10.1016/j.ecolind.2021.108457
Cunningham-Eurich I, Kontou D, Yordanova M, Maeda-Obregon A, Favreau E, Wang J, Hart AG, Sumner S (2023) Using citizen science data to assess the population genetic structure of the common yellowjacket wasp, *Vespula vulgaris*. Insect Mol Biol. https://doi.org/10.1111/imb.12862
Dai C, Chen S, Wang X (2021) Flagging positive images for sting wasps: the use of vespine wasps in Guiyang City, China and its conservation implications. J Insects Food Feed 7:1263–1273. https://doi.org/10.3920/JIFF2021.0011
De Souza MM, Louzada J, Eduardo Serráo J, Cola Zanuncio J (2010) Social wasps (Hymenoptera: Vespidae) as indicators of conservation degree of riparian forests in Southeast Brazil. Sociobiology 56:387
Dejean A, Céréghino R, Carpenter JM, Corbara B, Hérault B, Rossi V, Leponce M, Orivel J, Bonal D (2011) Climate change impact on neotropical social wasps. PLoS ONE 6:e27004. https://doi.org/10.1371/journal.pone.0027004
Donovan BJ (2003) Potential manageable exploitation of social wasps, *Vespula* spp. (Hymenoptera: Vespidae), as generalist predators of insect pests. Int J Pest Manag 49:281–285. https://doi.org/10.1080/0967087031000123698
Dudo A (2015) Scientists, the media, and the public communication of science. Sociol Compass 9:761–775. https://doi.org/10.1111/soc4.12298
Eaton ER (2021) Wasps: the astonishing diversity of a misunderstood insect. Princeton University Press, Princeton
Elizalde L, Arbetman M, Arnan X, Eggleton P, Leal IR, Lescano MN, Saez A, Werenkraut V, Pirk GI (2020) The ecosystem services provided by social insects: traits, management tools and knowledge gaps. Biol Rev 95:1418–1441. https://doi.org/10.1111/brv.12616
Esquivel IL, Parys KA, Brewer MJ (2021) Pollination by non-apis bees and potential benefits in self-pollinating crops. Ann Entomol Soc Am 114:257–266. https://doi.org/10.1093/aesa/saaa059
Feás X, Vidal C, Remesar S (2022) What we know about sting-related deaths? Human fatalities caused by hornet, wasp and bee stings in Europe (1994&2016). Biology. https://doi.org/10.3390/biology11020282
Fellows I (2018) wordcloud: word clouds. R package version 2.6
Feng Y, Chen X-M, Zhao M, He Z, Sun L, Wang C-Y, Ding W-F (2018) Edible insects in China: utilization and prospects. Insect Sci 25:184–198. https://doi.org/10.1111/1744-7917.12449
Girotti S, Ghini S, Ferri E, Bolelli L, Colombo R, Serra G, Porrini C, Sangiorgi S (2020) Bioindicators and biomonitoring: honeybees and hive products as pollution impact assessment tools for the Mediterranean area. Euro-Mediterr J Environ Integr 5:62. https://doi.org/10.1007/s41207-020-00204-9
Gould WP, Jeanne RL (1984) *Polistes* wasps (Hymenoptera: Vespidae) as control agents for lepidopterous cabbage pests. Environ Entomol 13:150–156. https://doi.org/10.1093/ee/13.1.150
Graystock P, Blane EJ, Mcfrederick QS, Goulson D, Hughes WOH (2016) Do managed bees drive parasite spread and emergence in wild bees? IPJ-PAW 5:64–75. https://doi.org/10.1016/j.ijppaw.2015.10.001
Hart AG, Sumner S (2020) Marketing insects: can exploiting a commercial framework help promote undervalued insect species? Insect Conserv Divers 13:214–218. https://doi.org/10.1111/icad.12405
Hothorn T, Bretz F, Heiberger RM, Schuetzenmeister A, Scheibe S (2023) multcomp: Simultaneous inference in general parametric models. R package version 1.4–23
Jernelöv A (2017) African "Killer Bees" in the Americas. In: Jernelöv A (ed) The long-term fate of invasive species: aliens forever or integrated immigrants with time? Springer, Cham
Jerome F (1990) Media resource service: Getting scientists and the media together. IAEA Bull 32:36–39
Jones R (2019) Wasp. Reaktion Books, London
Jones EP, Conyers C, Tomkies V, Semmence N, Fouracre D, Wakefield M, Stainton K (2020) Managing incursions of *Vespa velutina nigrithorax* in the UK: an emerging threat to apiculture. Sci Rep 10:19553. https://doi.org/10.1038/s41598-020-76690-2
Jönsson GM, Broad GR, Sumner S, Isaac NJB (2021) A century of social wasp occupancy trends from natural history collections: spatiotemporal resolutions have little effect on model performance. Insect Conserv Divers 14:543–555. https://doi.org/10.1111/icad.12494
Koide T (2001) Effects of the predator *Vespula shidai* Linnaeus on a reductions in pesticide culture in cabbage *Brassica oleracea capitata*. Res Bull Aichi-Ken Agric Res Cent 33:135–141
Kojima Y, Toki T, Morimoto T, Yoshiyama M, Kimura K, Kadowaki T (2011) Infestation of Japanese native honey bees by tracheal mite and virus from non-native European honey bees in Japan. Microb Ecol 62:895–906. https://doi.org/10.1007/s00248-011-9947-z
Ladle RJ, Jepson P, Whittaker RJ (2005) Scientists and the media: the struggle for legitimacy in climate change and conservation science. Interdiscip Sci Rev 30:231–240. https://doi.org/10.1179/030801805X42036
Lassiter U, Wolch JR, Gullo A (1997) Changing attitudes toward California's cougars. Soc Anim 5:95–116. https://doi.org/10.1163/156853097X00015
Laurino D, Lioy S, Carisio L, Manino A, Porporato M (2020) *Vespa velutina*: an alien driver of honey bee colony losses. Diversity 12:5. https://doi.org/10.3390/d12010005
Lester P (2018) The vulgar wasp: the story of a ruthless invader and ingenious predator. Victoria University Press, Wellington
Lester PJ, Beggs JR (2019) Invasion success and management strategies for social *Vespula* wasps. Annu Rev Entomol 64:51–71. https://doi.org/10.1146/annurev-ento-011118-111812
Lester PJ, Beggs JR, Brown BA, Edwards ED, Gorenteman R, Toft R, Twidle AM, Ward DF (2013) The outlook for control of New Zealand's most abundant, widespread and damaging invertebrate pests: social wasps. N Zeal Sci Rev 70:56–62

Lewandowski EJ, Oberhauser KS (2017) Butterfly citizen scientists in the United States increase their engagement in conservation. Biol Conserv 208:106–112. https://doi.org/10.1016/j.biocon.2015.07.029

Lohrmann J, Cecchetto NR, Aizen N, Arbetman MP, Zattara EE (2022) When bio is not green: the impacts of bumblebee translocation and invasion on native ecosystems. CABI Int. https://doi.org/10.1079/cabireviews202217006

Loyau A, Schmeller DS (2017) Positive sentiment and knowledge increase tolerance towards conservation actions. Biodivers Conserv 26:461–478. https://doi.org/10.1007/s10531-016-1253-0

Monceau K, Bonnard O, Thiéry D (2014) *Vespa velutina*: a new invasive predator of honeybees in Europe. J Pest Sci 87:1–16. https://doi.org/10.1007/s10340-013-0537-3

Novacek MJ (2008) Engaging the public in biodiversity issues. PNAS 105:11571–11578. https://doi.org/10.1073/pnas.0802599105

Outhwaite CL, Mccann P, Newbold T (2022) Agriculture and climate change are reshaping insect biodiversity worldwide. Nature 605:97–102. https://doi.org/10.1038/s41586-022-04644-x

Peters HP (2013) Gap between science and media revisited: scientists as public communicators. PNAS 110:14102–14109. https://doi.org/10.1073/pnas.1212745110

Peters HP (2022) The role of organizations in the public communication of science—early research, recent studies, and open questions. Stud Commun Sci 22:551–558. https://doi.org/10.24434/j.scoms.2022.03.3994

Prezoto F, Maciel TT, Detoni M, Mayorquin AZ, Barbosa BC (2019) Pest control potential of social wasps in small farms and urban gardens. Insects. https://doi.org/10.3390/insects10070192

Prezoto F, Nascimento FS, Corrêa Barbosa B, Somavilla A (2021) Neotropical social wasps: basic and applied aspects. Springer, Cham

R Development Core Team (2012) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna

Russel LV (2020) emmeans: Estimated marginal means, aka least-squares means. R package version 1.5.3

Senapathi D, Carvalheiro LG, Biesmeijer JC, Dodson C-A, Evans RL, Mckerchar M, Morton RD, Moss ED, Roberts SPM, Kunin WE, Potts SG (2015) The impact of over 80 years of land cover changes on bee and wasp pollinator communities in England. Proc R Soc B Biol Sci 282:20150294. https://doi.org/10.1098/rspb.2015.0294

Shiffman DS, Bittick SJ, Cashion MS, Colla SR, Coristine LE, Derrick DH, Gow EA, Macdonald CC, More O'ferrall M, Orobko M, Pollom RA, Provencher J, Dulvy NK (2020) Inaccurate and biased global media coverage underlies public misunderstanding of shark conservation threats and solutions. iScience 23:101205. https://doi.org/10.1016/j.isci.2020.101205

Smith TJ, Saunders ME (2016) Honey bees: the queens of mass media, despite minority rule among insect pollinators. Insect Conserv Divers 9:384–390. https://doi.org/10.1111/icad.12178

Southon RJ, Fernandes OA, Nascimento FS, Sumner S (2019) Social wasps are effective biocontrol agents of key lepidopteran crop pests. Proc R Soc B Biol Sci 286:20191676. https://doi.org/10.1098/rspb.2019.1676

Stratford JE, Stratford FMW, Brown RL, Oi CA (2023) Nest visitors of *Vespula* wasps and their potential use for biological control in an invaded range. J Pest Sci. https://doi.org/10.1007/s10340-023-01643-3

Sugiura S, Tsujii M (2022) Male wasp genitalia as an anti-predator defense. Curr Biol 32:R1336–R1337. https://doi.org/10.1016/j.cub.2022.11.030

Sumner S, Law G, Cini A (2018) Why we love bees and hate wasps. Ecol Entomol 43:836–845. https://doi.org/10.1111/een.12676

Sumner S, Bevan P, Hart AG, Isaac NJB (2019) Mapping species distributions in 2 weeks using citizen science. Insect Conserv Divers 12:382–388. https://doi.org/10.1111/icad.12345

Sumner, S. (2022). *Endless Forms: The Secret World of Wasps*, HarperCollins UK.

Todd JH, Barratt BIP, Tooman L, Beggs JR, Malone LA (2015) Selecting non-target species for risk assessment of entomophagous biological control agents: evaluation of the PRONTI decision-support tool. Biol Control 80:77–88. https://doi.org/10.1016/j.biocontrol.2014.09.014

Unger SD, Hickman CR (2020) A content analysis from 153 years of print and online media shows positive perceptions of the hellbender salamander follow the conservation biology. Biol Conserv 246:108564. https://doi.org/10.1016/j.biocon.2020.108564

Van Itterbeeck J, Feng Y, Zhao M, Wang C, Tan K, Saga T, Nonaka K, Jung C (2021) Rearing techniques for hornets with emphasis on *Vespa velutina* (Hymenoptera: Vespidae): a review. J Asia Pac Entomol. https://doi.org/10.1016/j.aspen.2021.03.009

Varner J (2014) Scientific outreach: toward effective public engagement with biological science. Bioscience 64:333–340. https://doi.org/10.1093/biosci/biu021

Wilson Rankin EE (2021) Emerging patterns in social wasp invasions. Curr Opin Ins Sci 46:72–77. https://doi.org/10.1016/j.cois.2021.02.014

Yeo SK, Brossard D (2017) The (changing) nature of scientist-media interactions: a cross-national analysis. In: Jamieson KH, Kahan DM, Scheufele DA (eds) The oxford handbook of the science of science communication. Oxford University Press, Oxford