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Is it time to get over the X? Assessing the global impact and future of social media conferences in animal behaviour

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Conferences are an integral part of academia, providing researchers with the opportunity to collaborate and disseminate their research. Traditionally these conferences have been in-person, but COVID-19 restrictions and growing recognition of systematic barriers have led many academic societies to reimagine the conference format. Social media platforms are often used to promote and broadcast in-person academic conferences, so with the development of online conferences they have naturally become hosting platforms. For example, during the peak of COVID-19 restrictions, when in-person meetings were not possible, Twitter conferences, like the first Global Animal Behaviour Conference (#AnimBehav2021), provided a much needed platform to collaborate and share science. Recently, conferences have returned to an in-person format. In addition, a change in ownership of Twitter led to widespread restructuring of the Twitter workforce and misinformation management policies that resulted in a massive exodus of academics from the platform. During these changes, we organized and held the second Global Animal Behaviour Twitter Conference (#AnimBehav2023) in January 2023. In this paper, we report (1) how engagement in the Twitter conference changed as a result of return to in-person conferences and changes in Twitter ownership, (2) how the community views online conferences in general and Twitter conferences in particular and (3) reflect on how online conferences can be organized moving forward. Given the widespread benefits of and need for online conferences, we urge academic societies and researchers to continue systematically exploring these alternative conference formats to ensure inclusivity and accessibility in academic spaces.

Conferences are an integral part of academia and provide various advantages for research careers. They offer a venue for early dissemination of and feedback on new results, in contrast to the often slower peer review process (Oester et al., 2017; Zierath, 2016). This can lead to new collaborations, although these can be skewed towards more established researchers (Chai & Freeman, 2019; Wang et al., 2017). For early career researchers (ECRs), they provide a venue to broaden peer networks, identify interesting research directions and seek out career advancement opportunities (Urban & Boscolo, 2013). Conferences can also help foster a strong sense of community, especially for ECRs and researchers from the Global South (Flaherty et al., 2019). Unfortunately, conferences also reproduce biases present in academia. Sexism is reflected in skewed gender ratios among invited speakers (Farr et al., 2017; Ford et al., 2019; Johannesen et al., 2023) and in inappropriate comments and behaviour, including sexual harassment and assault (Biggs et al., 2018; Flores, 2020). Furthermore, in-person conferences can also exacerbate barriers faced by researchers from underrepresented backgrounds. In-person international conferences come with a financial cost that can make attendance difficult for researchers from low-income and/or working class households, especially those in the Global South (Bos et al., 2019; Niner &

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Wassermann, 2021). There is growing impetus to make conferences more inclusive and accessible, reflecting larger changes in the academic world.

The COVID-19 pandemic has driven large-scale changes in how academics interact (e.g. rise of video conferencing), and conference organization has not been untouched. During the pandemic, organizers experimented with alternative conference formats, with several advantages linked to the removal of barriers associated with traditional in-person conferences (Moss et al., 2021, 2022; Parncutt et al., 2021; Raby et al., 2022; Tao et al., 2021). These alternatives can be broadly divided into five types based on their organizational structure and format: (1) 'replacement conferences', which act as temporary stand-ins for in-person conferences (e.g. Animal Behavior Society (ABS) 2020 Virtual Meeting); (2) 'hybrid conferences', which combine both in-person and online components (e.g. ABS 2022 and 2023); (3) 'satellite/hub conferences', in which in-person meetings are divided among several regional hub locations (e.g. Association of the Study of Animal Behaviour (ASAB) Winter Meeting 2021); (4) 'online conferences', which are designed from the ground up to be fully conducted online but still adhere to the format of a traditional conference (e.g. Animal Behaviour Live); and (5) 'alternative format conferences,' which experiment with different ways to present research and engage with other researchers (e.g. #AnimBehav2021). These types each have their own strengths and weaknesses, but all rely on adequate Internet access. The Animal Behaviour Twitter Conference and Animal Behaviour Live Annual Online Conference are both completely online and free to attend, thereby eliminating the financial cost and paving the way for greater participation of low-income researchers, especially those from the Global South (Kuehne et al., 2022; Niner & Wassermann, 2021). Online conferences are also beneficial in that they reduce the carbon cost of travel (Aron et al., 2020), which is necessary for in-person conferences (Epp et al., 2023; Gattrell et al., 2022). However, their online nature can make networking difficult (Raby & Madden, 2021a; Seidenberg et al., 2021), may reduce the creation of impactful collaborations (Lin et al., 2023) or reinforce geographical and financial academic structural barriers (Duncan & Shean, 2023). On the other hand, hybrid conferences offer the flexibility for researchers to decide their level of participation, but participants still have to pay the full cost to access the whole conference. Continuing to experiment with different formats will allow the development of solutions that make conferences (in-person and virtual) more inclusive and accessible spaces.

Growing discussions about equity, diversity, inclusivity and accessibility at academic conferences have gone hand in hand with the increasing presence of researchers on social media. Established societies like ASAB, ABS and the British Ornithologists' Union (BOU) have built strong networks on these platforms, composed of researchers and other stakeholders like educators, policy makers, journalists and the general public (e.g. Caravaggi et al., 2021). Social media platforms (e.g. Facebook, Instagram, TikTok, Twitter (renamed 'X' but referred to in this paper as Twitter) and YouTube) allow scientists to reach individuals beyond their usual networks and play a vital role in making research publicly accessible (Bik & Goldstein, 2013; Cavanah et al., 2023; Collins et al., 2016; McClain & Neeley, 2015; Shiffman, 2012). Twitter in particular is a useful platform for science outreach, as the short texts facilitate easy-to-digest summaries of scientific experiments and results, which can be reposted to share over a wide network of secondary connections (Bombaci et al., 2016; Insall, 2023; López-Goñi & Sánchez-Angulo, 2018). For academic societies, Twitter provides a platform to engage with educators and students, which has been leveraged to great effect by the ASAB Education Committee account.

Social media platforms are often an integral part of traditional in-person academic conferences. They are used to advertise conference dates and information, allowing conferences to reach more potential participants (Kwok, 2013; Wilkinson et al., 2015; Winandy et al., 2016). A social media hashtag associated with the conference can also be used by participants to promote their presentation and 'live tweet' the conference. Beyond these traditional uses, they can be used as platforms to host entire conferences (Avery-Gomm et al., 2016; Baker et al., 2020). Raby et al. (2022) previously described in detail how to organize a Twitter conference and reported participant feedback from the first Animal Behaviour Twitter Conference. Many barriers associated with traditional conferences can be overcome through these alternative platforms, and Twitter conferences have grown in popularity since their inception (Caravaggi et al., 2021).

Since we organized the first Animal Behaviour Twitter Conference, there have been two major developments. First, global COVID-19 restrictions that were in place during the early part of the pandemic have been lessened. This has led to a resurgence of traditional in-person conferences (e.g. ABS 2023, ASAB Summer 2023). Despite this resurgence, academics are continuing to organize and fine-tune alternative conferences, albeit less frequently (e.g. the Animal Behaviour Live Annual Online Conference had its fourth edition in 2023). Second, the ownership of Twitter changed in 2022 following a protracted legal case, and the platform is now called 'X'. After this transfer of ownership, there was a company-wide restructuring of the Twitter workforce, including mass redundancies of employees vital to maintaining the security of the platform, managing misinformation and liaising with the press (Chang et al., 2023; Fig. 1). The verification process for platform users was revamped and restrictions relating to misinformation in tweets were removed. The perception and use of Twitter as a platform changed drastically and many academics have moved from Twitter to other platforms like Bluesky and Mastodon (Brembs et al., 2023; Chang et al., 2023; Vidal Valero, 2023). Although there are several alternative microblogging platforms, none of them yet replicate Twitter's large user base, and the migration of academics away from Twitter will likely have a significant impact on science outreach efforts (Vidal Valero, 2023). While it is difficult to foresee how academics change their social media use, it seems unlikely that Twitter will remain a valid platform for scientific conferences based on its current trajectory.

It is against the backdrop of these major developments that we organized the second Global Animal Behaviour Conference for January 2023. The Twitter upheaval happened partway through conference organization, but based on feedback from participants, we decided to continue with the second edition (see Fig. 1). Organizing the conference during a period of uncertainty about Twitter's future allowed us to assess the perceptions of the animal behaviour community on several topics. First, by comparing metrics between the 2021 and 2023 conferences, we gained insights into how engagement in the Twitter conference changed as a result of both weakening COVID-19 restrictions and changes in Twitter ownership. Second, by conducting a feedback survey, we were able to identify how the community views online conferences in general and Twitter conferences in particular. Lastly, we reflect on how online conferences can be organized moving forward, suggesting alternative platforms and methods to take the place of a Twitter conference. Given the widespread benefits of online conferences,

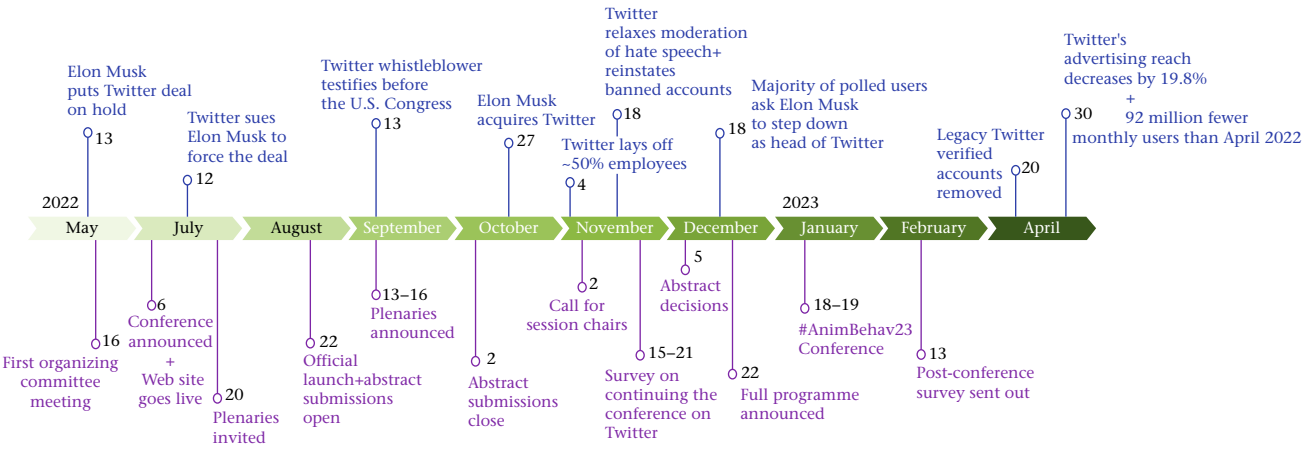

Figure 1. Timeline of conference planning and associated changes in X's (formally Twitter) ownership and policy.

we urge academic societies and researchers to continue exploring these alternative conference formats to ensure inclusivity and accessibility in academic spaces.

METHODS

Conference Planning

The second Global Animal Behaviour Twitter Conference was officially hosted by ABS and ASAB. Conference planning began in May 2022 and the conference occurred in January 2023 (timeline in Fig. 1). We screened 123 abstracts following a double-blind peer review process, which resulted in 115 accepted abstracts (four rejected based on review, three withdrew due to changes to the Twitter platform, and one withdrew for unrelated reasons).

Changes to the Twitter platform occurred concurrently with our conference planning (see Fig. 1). Elon Musk became the CEO on 27 October 2022 and quickly announced sweeping changes to the platform. Due to the overwhelmingly negative response (e.g. academics leaving Twitter, posting tweets in opposition), we became concerned that hosting a conference on Twitter would not be successful. In November 2022, while still reviewing abstracts (Fig. 1), we surveyed (Appendix, Table A1) our plenary and potential speakers (i.e. those who had submitted abstracts) to confirm whether they still wanted to participate. All plenaries opted to keep their accounts open until after the conference, while three abstracts were withdrawn due to these Twitter changes. We continued to monitor whether the changes in Twitter ownership influenced conference attendance and included questions on the topic in our post-conference survey (Appendix, Table A2).

Conference Format

Following our protocol from the first Global Animal Behaviour Twitter Conference (Raby et al., 2022), we developed a schedule based on presenters' preferred time zones and research foci. We recruited volunteer session chairs and moderators to work throughout the two conference days and scheduled our conference organizers to be on call for troubleshooting issues like account access, missed time slots and hashtag spam or inappropriate comments.

The first day of the conference started on 18 January 2023 at 1200 hours GMT and ended at 2020 hours GMT. The second day of the conference started on 19 January 2023 at 0000 hours GMT and ended at 2110 hours GMT. As with the first Global Animal Behaviour Twitter Conference, presenters used their personal Twitter account to publish a thread consisting of five to six tweets containing their presentation and the conference hashtag at the start of their assigned 10 min time slot. After publishing their thread, presenters answered questions from the Twitter audience until the end of their 10 min time slot (plenaries were given 20 min for questions). Plenaries and presenters were hosted by session chairs who tweeted introductions from their personal Twitter accounts. Behind the scenes, moderators were logged into the official Twitter accounts of ABS and ASAB to assist when needed. These moderators retweeted presentations to create a live-feed of the conference from both societies' Twitter accounts, which was visible on the conference Web site (Raby et al., 2022).

Changes to the 2021 Format

To reflect the scope of the field and pedagogy of animal behaviour, we actively promoted presentations across a diversity of study species, geographical locations and areas of focus, while ensuring opportunities for under-represented groups and equitable gender representation. The 2023 organizing committee involved members external to the ABS/ASAB committee and were based outside of both societies' remits of the Americas and Europe, respectively. Additionally, we provided more flexibility to abstract submissions by increasing the number of time zones available for researchers to select from (e.g. +05:30 Coordinated Universal Time, UTC). We supported abstract submissions from languages other than English using the Wix Multilingual feature on the conference Web site for automatic translation to other languages and received one abstract in Spanish. We also expanded the available presentation topics, adding an education theme to promote discussions on pedagogical practice in animal behaviour and invited a specific plenary speaker to discuss their work on this theme.

Assessing Engagement with the Conference

Assessing individual impact of tweets

To determine the individual impact of presenting at #AnimBehav2023, we went through each presentation and reviewed the first tweet of the thread. We quantified various measurements of engagement with the tweet, including number of views, likes, retweets, questions and comments (as of 18 May 2023). Nine accounts were either no longer active or became private after the conference and were not included in the assessment.

Monitoring engagement with the conference hashtag

We determined the amount of engagement with the conference hashtag '#AnimBehav2023' to assess the number of people on Twitter who viewed or interacted with the conference. We used the analytical tool Tweet Binder to extract hashtag analytics from 17 to 22 January 2023 (i.e. starting from 1 day before the conference to 3 days after the conference) to capture engagement with tweets during the conference. Tweet Binder provided data on (1) the number of tweets, retweets, likes and impressions ('potential views') associated with the conference hashtag, (2) the most popular tweets (e.g. most liked and most retweeted), key accounts that contributed the most to using the conference hashtag and the language of communication used and (3) how activity changed over time.

To determine how hashtag engagement during the 2023 conference differed from the first Global Animal Behaviour Twitter Conference in 2021, we compared Twitter analytics of similar time frames across the two conferences. We noted that abstract submission was slightly lower in 2023 (see Results) and therefore expected to see lower engagement overall. To assess whether the decline in engagement was proportional to the decline in presentations, we calculated expected engagement values based on the rate of engagement calculated in 2021 and used a chi-square analysis to determine whether the actual engagement with the 2023 conference differed from the expected engagement values.

Monitoring engagement using the conference Web site analytics

We further assessed conference engagement using Web site analytics. The conference Web site was hosted by Wix and included instructions on how to participate, the programme of abstracts and a Twitter stream of the conference for those unable to visit Twitter directly. Using the Wix Analytics data from all visitors who had enabled cookies, we obtained the country they were visiting from, the pages they visited and the number of unique visitors. As data for 2021 were collated across the 2 days of the conference (Raby et al., 2022), we replicated the same method here. From this we established the geographical location of conference attendees and the amount of Web site traffic. This enabled us to compare between the interest and reach of the 2023 conference and the 2021 conference.

Monitoring engagement through a post-conference survey

After the #AnimBehav2023 conference, we circulated a Google Form questionnaire to presenters, chairs and attendees. We circulated the same questionnaire to ABS and ASAB members via email to capture the perceptions of animal behaviour researchers who may not have engaged with the conference. The qualitative data from the free-text questions were coded independently by two researchers, and the categories and interpretations were compared for agreement among the researchers. Each response was classified into specific categories (e.g. accessibility, cost, etc.) based on its content and identified as having a positive or negative connotation based on its tone. Given the free-form nature of the responses, a single response could belong to multiple categories.

To perform a quantitative analysis of the free-text survey responses, we grouped responses based on a combination of respondents' past experience with the Twitter conference (responses to questions 6 and 11: no experience: did not participate in any Twitter conference; past experience: participated in either the 2021 or the 2023 conference, or both) and their willingness to attend future online conferences (responses to question 12: will attend; will not attend). We obtained four types of respondents (past experience, will attend; past experience, will not attend; no experience, will attend; no experience, will not attend) covering the spectrum of enthusiasm with respect to online conferences. We then compared the categories and connotations of the free-text comments across the types of respondents to identify whether groups of respondents highlighted specific positive and negative aspects of Twitter and online conferences in their responses.

Ethical Note

We provided a statement to clarify that the survey was optional and that responses to the survey may be used in publications. All data were anonymized, there were no incentives for participating in the study, and all questions were optional. The survey consisted of multiple choice questions and free-text options (see Appendix, Table A2).

RESULTS

Individual Impact of Presenting at #AnimBehav2023

Four plenaries and 115 presenters presented at the #AnimBehav2023 conference. Based on the individual thread impact data, each presentation received a median of 4423 views, 47 likes, 17 quote/retweets and three bookmarks. However, there was considerable variation across presentations (Appendix, Fig. A1). The most popular tweet received 285 likes and 61 retweets, while others received far more limited engagement. The number of comment and question interactions was lower than likes and retweets but also appeared more uniform across the conference presentations. The five most 'liked' presentations received a median of six questions and comments, presentations with intermediate 'like' levels received a median of three questions/comments and the five presentations with the lowest number of likes received a median of two questions. This rate of questioning appears consistent with our post-conference survey data (Fig. 2), which showed that 50% of the 72 conference-attending respondents reported asking no questions, 34% either commenting or asking at least one question and 27% asked one to two questions across the whole conference. The majority of these respondents limited their engagement to views, likes and retweets, and only one individual reported asking more than 10 questions across the 2-day period (Fig. 2).

One of the goals of the 2023 Twitter conference was to focus on education, both in content and outreach. We encouraged abstract submissions about animal behaviour teaching pedagogy and encouraged advertising the conference to pre-university teachers (e.g. K-12) and higher education instructors. One of the four invited plenary presenters focused on animal behaviour education and received four questions, 31 quote/retweets, 73 likes, 11 bookmarks and was viewed 15 8000 times (as of 6 October 2023). Four submitted presentations focused on education topics within animal behaviour and received similar levels of engagement as their noneducation counterparts.

Global Impact of Presenting at #AnimBehav2023

Presenter contributions

We received abstracts from 18 time zones in 2023 compared to 16 in 2021 (after standardizing the number of time zones across conferences; Fig. 3). In 2021, six time zones contributed at least 5% of abstract submissions, whereas in 2023, eight time zones contributed to at least 5% of abstract submissions. The increase in participation from Eastern Europe and West Asia (UTC+2) as well as from Asia (UTC+5, UTC+8, UTC+9) was particularly noticeable in 2023 (Fig. 3). Engagement with the conference from otherwise under-represented countries similarly increased. In both years, the Web site primarily received visits from the U.S. and the U.K. (Table 1). In 2023, there was a considerable increase in visits from

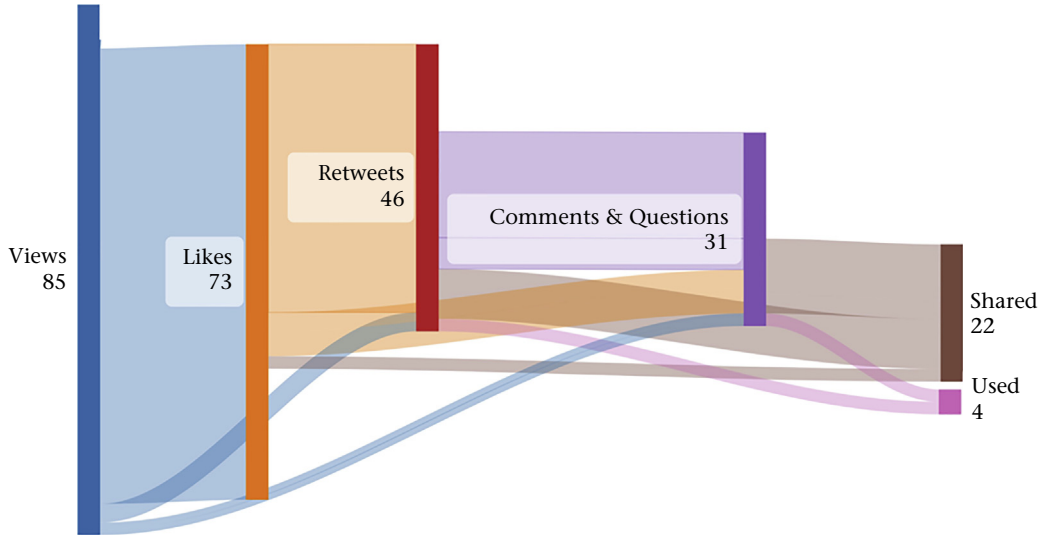

Figure 2. Flowchart summary of audience engagement as reported by survey participants, from viewing presentations and liking and retweeting content to asking presenters questions and sharing or using conference content in contexts beyond Twitter.

India (31 unique visitors (2% of attendees) in 2021; 53 (7% of attendees) in 2023; Table 1, Appendix, Fig. A2).

Conference engagement

There were 1044 original tweets using the conference hashtag '#AnimBehav2023' (Table 2). Tweets containing '#AnimBehav2023' were retweeted 3582 times and reached 2 600 108 Twitter accounts ('potential viewers'). Overall, the conference hashtag had over 15 million impressions ('potential views') on the Twitter platform. 'Potential viewers' represent the number of unique accounts that viewed content with the conference hashtag, while 'potential views' represent the total number of instances the hashtag was viewed, including repeated views from any unique account.

Global Impact: Comparing #AnimBehav2023 to #AnimBehav2021

There was a slight decrease in the number of presenters from 2021 to 2023, the number of original tweets using the conference hashtag and the total number of tweets using the conference hashtag (Table 2). However, conference hashtag activity remained relatively consistent across the 2 days of the conference (Fig. 4) and did not dramatically dip during certain hours of the conference as we had observed in 2021 (Fig. 4), likely due to the broader global reach. Although most tweets were communicated in English (96.1%), the use of Spanish in presentations (3.6%) significantly increased in 2023 compared to 2021 (Table 2).

Compared to 2021, in 2023 we observed a 40% decline in conference hashtag retweets, a 35% decrease in potential views of the hashtag and a 9% decrease in potential reach (Table 2). Given that we had fewer presenters in 2023 (−18%), which meant fewer tweets using the conference hashtag (−31%), we expected to see a proportional decline in engagement with the conference hashtag. However, the number of original tweets using the conference hashtag and the number of retweets in 2023 was significantly less than what we would expect if the decline were proportional to the decline in presenters using the hashtag (original tweets: observed = 1044; expected = 1247; $\chi^2_1 = 17.99$, $P < 0.01$; retweets: observed = 3582; expected = 4113; $\chi^2_1 = 36.64$, $P < 0.01$). Self-reported engagement from the post-conference survey revealed that the number of presentations each respondent viewed and the number of questions they asked was on average lower in 2023 than in 2021 (Fig. 5). Engagement with the conference Web site in 2023 (Table 1) was also markedly lower (74% decrease) from the number of visitors in 2021. Fifty-three visitors viewed the live Twitter feed on the Web site comprising 81 visits in all, which was 88% fewer visits than in 2021.

Perceptions of Online Conferences

We received a marked increase in post-conference survey responses after our most recent Twitter conference (108 versus 68 after 2021's conference, Raby et al., 2022). Survey respondents included academic researchers (56%), students (undergraduate and postgraduates: 33%) and nonacademics (animal behaviour professionals: 4%; educators: 1%; members of the public: 1%; other: 5%). While 2021's respondents consisted of 26 presenters and 42 attendees, the ratio in 2023 was reversed, with 46 respondents listing themselves as presenters, 26 as attendees and 36 as nonattendees. The additional responses from nonattendees gave us alternative perspectives on the perception and utility of Twitter conferences in the animal behaviour community.

In the survey, we asked respondents to provide a free-text response to expand upon their answer to the following question 'As conferences return to in-person format, would you still want to attend virtual/online conferences in the future' (question 13; Appendix, Table A2). The majority (80%) were willing to engage in future online conferences (Appendix, Fig. A3). Similar to 2021 (Raby et al., 2022), respondents indicated the benefits of online conferences as cost, accessibility, reduced need for travel, networking opportunities, sustainability and outreach (see Fig. 6, Appendix, Fig. A3). Several considered online events as suitable additions to traditional conferences.

> *Yes, they don't replace in-person meetings and interactions, but they sustain professional relationships and help start new ones, and also have additional advantages.* **(Attendee36)**

> *It is hard to truly replicate the social side of in person meetings, which can build community and networks in a different way. But connections can still be made on twitter!* **(Attendee18)**

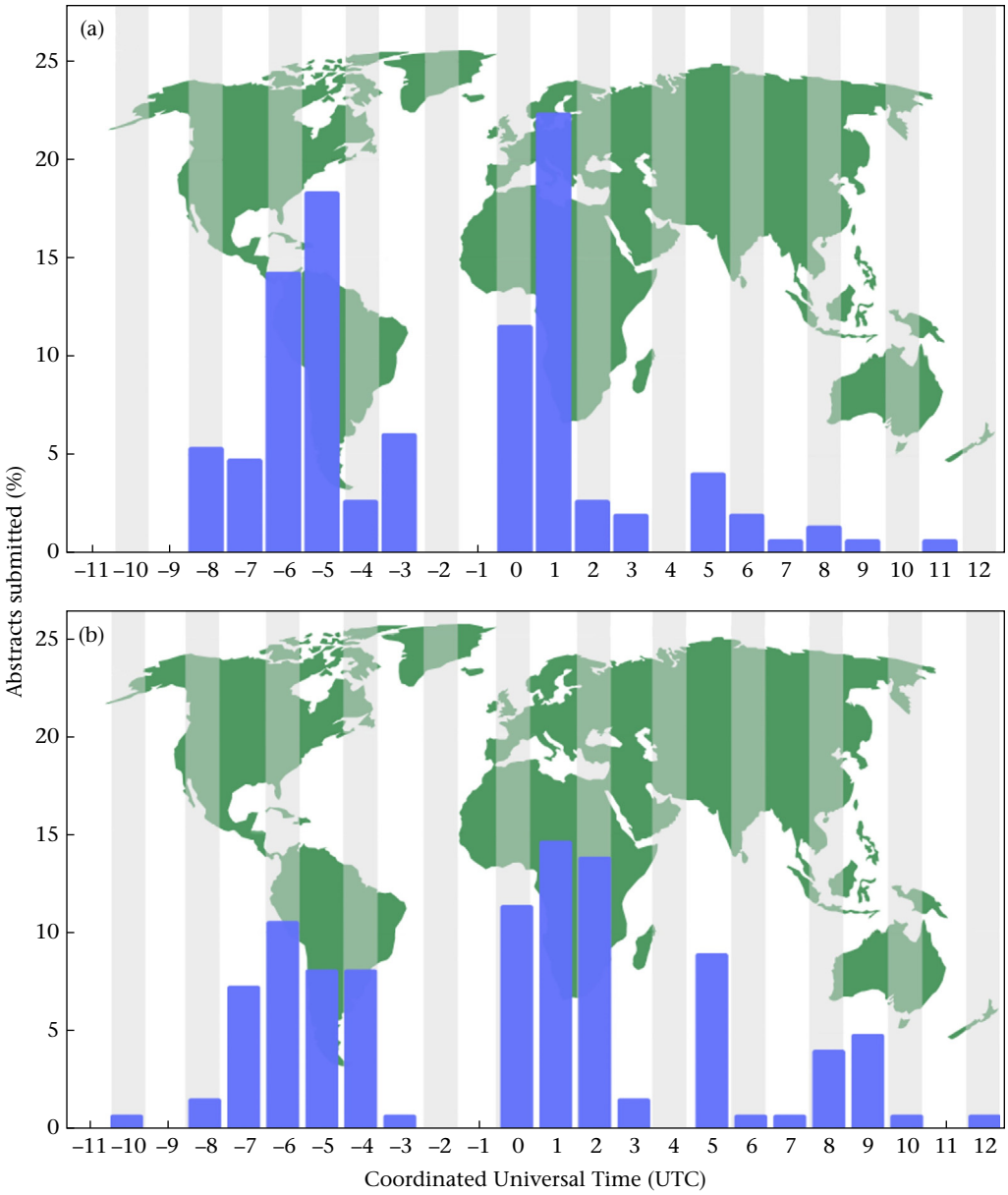

Figure 3. The percentage of abstracts that were submitted from different time zones during the (a) 2021 and the (b) 2023 Twitter conferences. The total number of abstracts submitted was 145 in 2021 and 123 in 2023. To ensure the graphs are comparable, we combined the data for the number of abstracts submitted in the +05:30 UTC zone ($N = 8$) into +05:00 UTC zone ($N = 3$) and combined the data for the +09:30 UTC zone ($N = 1$) into the +09:00 UTC zone ($N = 5$).

Some respondents stated that they do not like online conferences generally (10% of responses; Appendix, Fig. A3). Others cited that the lack of interactions and networking opportunities were limiting features of online conferences (10%; Appendix, Fig. A3). Several respondents indicated that they did not think that Twitter was a suitable platform for online conferences (20%; Appendix, Fig. A3). Interestingly, this included respondents who had participated in one of the two editions of the Twitter conference and indicated a willingness to participate in future online conferences.

Perceptions of Twitter as a Conference Platform

To further understand the perception of Twitter as a conference platform, we asked respondents to provide us with the positives (question 14; Appendix, Table A2) and the negatives (question 15; Appendix, Table A2) of using this format. Nine respondents provided further reflections on Twitter as a conference platform for question 17 (Appendix, Table A2). These perspectives are from January 2023 and may not reflect opinions of the changes to Twitter since this date.

Positives of Twitter

Similar to the earlier responses, cost, accessibility, diversity and outreach were highlighted as positives (Fig. 7), with accessibility most frequently highlighted. Three key features under accessibility included the ability to return to presentations at a later date, the global reach of the conference and the ease with which one can join the conference.

Table 1
Conference Web site analytics assessing interactions with the Web site during the 2 days of the conference

	#AnimBehav2021 First Global Twitter Conference	#AnimBehav2023 Second Global Twitter Conference
Number of unique visitors	1990	750
Top pages by visitor	Schedule: 1551 (78%)	Schedule: 515 (69%)
	Homepage: 866 (44%)	Homepage: 260 (35%)
	Twitter feed: 439 (22%)	Twitter feed: 146 (19%)
Visitor countries (top five countries, total and %)	**71 countries**	**55 countries**
	United States: 846 (43%)	United States: 199 (27%)
	United Kingdom: 282 (14%)	United Kingdom: 108 (14%)
	Germany: 113 (6%)	India: 53 (7%)
	Canada: 112 (6%)	Finland: 43 (6%)
	France: 61 (3%)	Canada: 40 (5%)

Numbers represent unique visitors (2021: 26–27 January; 2023: 18–19 January).

Content is available to everyone even after the conference is ended. It's easier to engage with the presentations/presenters you're really interested in rather than following all of them. **(Attendee44)**

Outreach was highlighted as a benefit of this conference format by 19% of attendees who expressed an interest in attending future events (Fig. 7). No other group of respondents mentioned outreach as being beneficial, except for one respondent who had attended a conference but did not intend to participate in future events.

Global engagement is hard to get, so is public engagement. This offers both. **(Attendee19)**

Slightly more oriented towards outreach and lay audiences. I have also been approached by a journalist about the work I presented. **(Attendee36)**

The diversity of Twitter conference attendees was considered a benefit of this format. We had designed this conference with international time zones in mind, and the positive outcomes were highlighted with responses reflecting on the conference's global reach ('wider international participation', Nonattendee33). However, only a small percentage of free-text responses mentioned the increase in diversity as a benefit (8%). Nevertheless, this method of communicating animal behaviour research serves a broad community, reaches international academics and makes science digestible for a nonacademic audience.

This is a very useful concept among the conventional conferences. Also the fact that everyone can access is super important and helps spreading the knowledge. Short presentations to this audience also helps to make the science more understandable. **(Attendee56)**

Useful way of seeing lots of work in a succinct [and] easy to view way. Also helpful for the presenter to think about how to present their work in just 5–6 tweets. **(Attendee6)**

Negatives of Twitter

Some of the points raised when asked about the negative aspects of Twitter conferences included lack of social interactions, limited networking opportunities, condensed format of presentations and unsuitability of Twitter to host conferences. When considering whether Twitter was a suitable platform for online conferences, three key themes emerged from the responses.

(1) Some respondents either did not have a Twitter account or had closed theirs due to changes in ownership.

Supporting a social media platform that has been extremely unethical past few months. **(Nonattendee35)**

(2) Others suggested using other online platforms because they are more user friendly or have had a recent influx in academics that have moved away from Twitter (e.g. Zoom, Discord, Mastodon).

Zoom conferences would be great. I don't use Twitter, so figuring out how to participate in the conference was a disaster. **(Attendee46)**

(3) The platform was difficult to use, including possible changes to the visibility of the conference tweets.

This year, the algorithm really seemed to not show the Animal Behavior Twitter tweets. I saw much fewer of them than I remember seeing in the past. **(Attendee43)**

Impact of the Change in Ownership of Twitter

The change in Twitter ownership had an impact on the attendance and number of presentations at the #AnimBehav2023 conference. In addition to the four abstracts withdrawn before the conference started, six respondents from the post-conference survey also indicated they did not attend the conference due to Twitter changes. Twenty-two replied that they had considered not attending but did (out of 102 respondents). The rest of the replies

Table 2
Twitter analytics for #AnimBehav2021 and #AnimBehav2023

	#AnimBehav2021 First Global Twitter Conference	#AnimBehav2023 Second Global Twitter Conference	Difference between conferences
Number of presenters	145 (including four plenaries)	119 (including four plenaries)	−18%
Number of original tweets with conference hashtag	1516	1044	−31%
Total number of tweets with conference hashtag	7497	4626	−38%
Likes with conference hashtag	–	15 713	–
Number of retweets	5981	3582	−40%
Number of Twitter accounts reached (potential reach)	4 million	2 600 108	−35%
Number of impressions (potential views)	17 million	15 million	−12%
Language used	English (98%)	English (96.15)	English −2%
	Spanish (1.5%)	Spanish (3.6%)	Spanish +58%

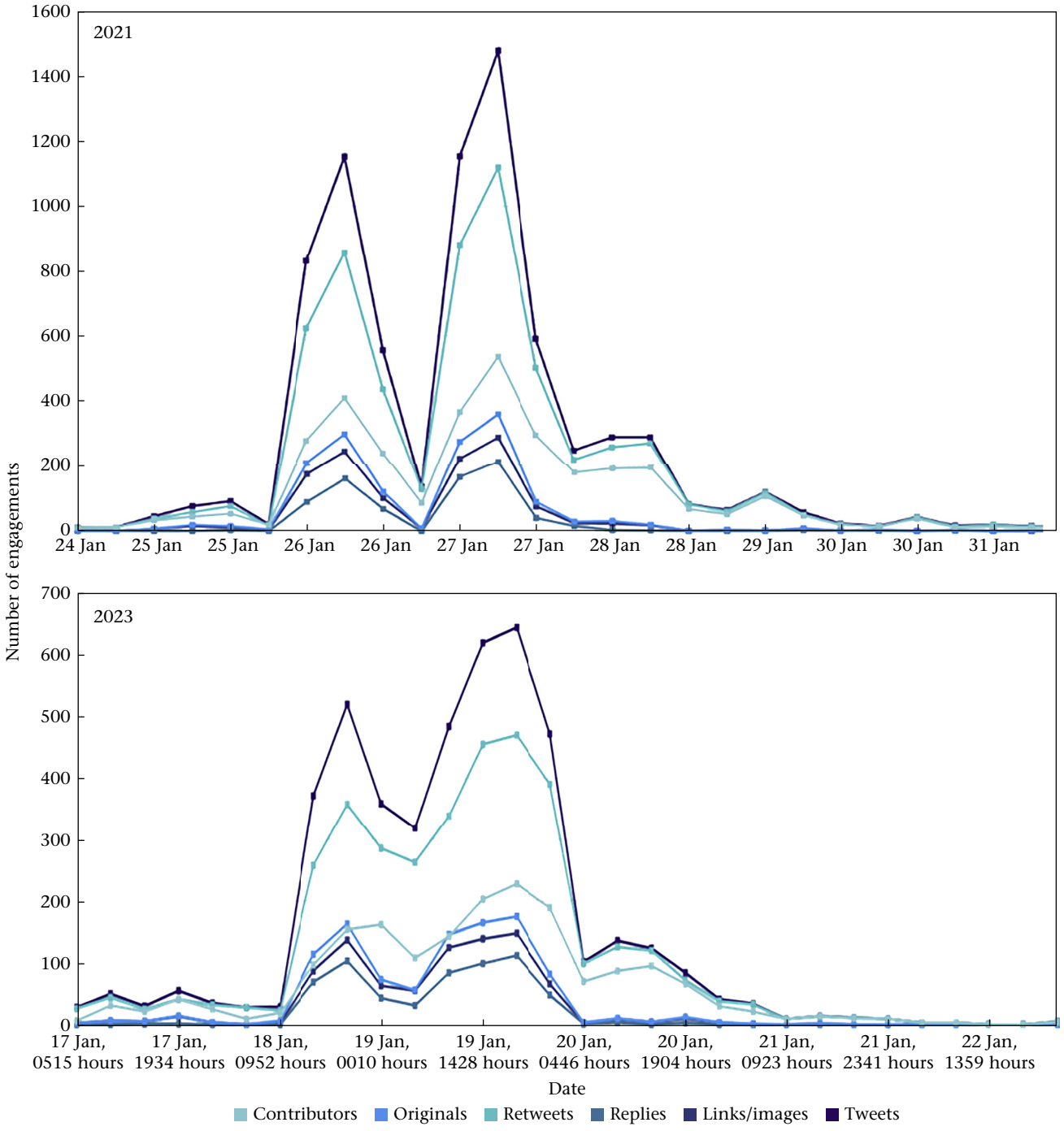

Figure 4. Number of engagements with the #AnimBehav2021 and #AnimBehav2023 hashtags during the days leading up to the respective conference dates, the dates of the conferences and the days after the conference. Data from 2021 extracted from Raby et al. (2022).

stated that it made no difference as to whether they were planning on attending, either because they had no plans to attend (25%) or were always planning on attending (48%).

Future Engagement with Online Conferences

Respondents were asked if they would continue attending online conferences ('As conferences return to in-person format, would you still want to attend virtual/online conferences in the future', question 12; Appendix, Table A2). Most indicated that they would (80%) and some indicated that they would not (20%). Of the respondents who attended any previous Animal Behaviour Twitter conferences (2021 and 2023), 89% would attend more online conferences and 11% did not plan to attend any more. Of the participants who did not attend the Twitter conference (either 2021 or 2023), 50% would attend a future online conference and 50% would not (Appendix, Fig. A3). There were a range of views on whether online conferences should continue.

> *It was a nice idea during COVID, but is too non-interactive and slow for anything else. I have no issues with it continuing if it's not too*

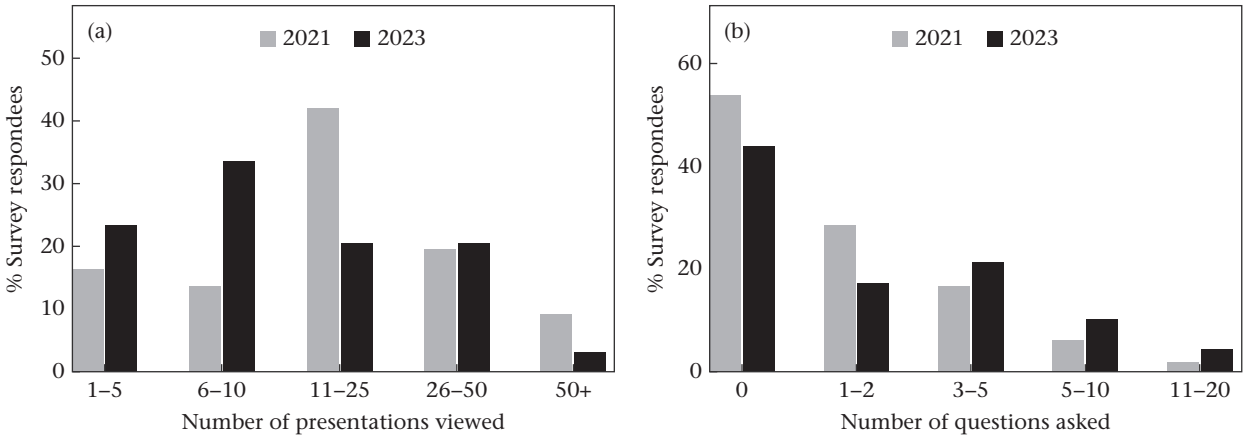

Figure 5. Comparison of (a) presentation viewing and (b) question asking frequency across both Twitter conferences.

much of a burden, but it's not something I am interested in participating in. **(Nonattendee16)**

Being a researcher in an Asian country, it is not that easy on the pocket to travel to Europe or America for conferences. Therefore, an online conference helps to connect researchers across the globe without thinking of the monetary issues. **(Attendee61)**

I don't see the utility of virtual conferences and have no plans to ever attend one. **(Nonattendee9)**

It's a really wonderful initiative, and I'm glad folks are trying stuff like this even if it's not personally my jam. **(Attendee35)**

However, views on the format of virtual conferences indicated negative experiences with hybrid formats.

Hybrid doesn't work because the in person attendees don't load their talks online for virtual folks and don't engage with them either. The virtual folks are left in the cold which is really unfortunate and unnecessary. **(Nonattendee3)**

DISCUSSION

Social media, especially Twitter, became a critical tool for scientists to communicate information to peers and colleagues (Bik & Goldstein, 2013; Collins et al., 2016). Twitter conferences, like those hosted by Biotweeps and the British Ornithological Union (Caravaggi et al., 2021; Raby et al., 2022), emerged in the mid-2010s as a novel format in which scientists could present their work to both their academic colleagues and the broader public. With the start of the COVID-19 pandemic (Fulcher et al., 2020), the first Global Animal Behaviour Twitter Conference in 2021 (#AnimBehav2021) represented a much needed mode of professional and personal connection (Raby et al., 2022). The timing of the second Global Animal Behaviour Twitter Conference provided three unique opportunities: (1) to assess how engagement in the Twitter conference changed as a result of return to in-person conferences and changes in Twitter ownership; (2) to assess how the community views online conferences in general and Twitter conferences in particular; and (3) to reflect on how online conferences can be organized moving forward.

Individual Impact of Presenting at #AnimBehav2023: A Professional Take

Conferences are important spaces to further one's career, and Twitter conferences are no different. During #AnimBehav2023, engagement with individual presentations was relatively high, consistent with other Twitter conferences (Caravaggi et al., 2021), and likely much higher than for standard in-person or virtual conference presentations. For example, assessment of engagement during ASAB's 1-day online conference in 2020 found that between 320 and 450 delegates viewed the talk pages, with about 82% engaging with at least one talk (Raby & Madden, 2021a). In contrast, #AnimBehav2023 conference presentations received a median of 4423 views. Twitter presentations during #AnimBehav2023 received a similar number of questions (#AnimBehav2023 Twitter Conference: median of 2–3 questions) as in-person and virtual presentations (median of 4 questions per presentation) at comparable conferences (e.g. International Congress for Conservation Biology and European Congress for Conservation Biology in Montpellier, France in August 2015; Hinsley et al., 2017). These high levels of Twitter engagement are career relevant because disseminating research via Twitter has long-term benefits to presenters in metrics important for job acquisition and retention. Existing literature highlights that a Twitter presence and higher numbers of followers can increase rates of engagement with and subsequent citation metrics of published research (Finch et al., 2017; Lamb et al., 2018; Ortega, 2016; Shu et al., 2018; but also see Branch et al., 2023). Given that 74% of our survey respondents reported 'following' presenters, disseminating research at Twitter conferences could result in citation payoffs down the line.

Individual Impact of Presenting at #AnimBehav2023: Outreach and Education

One of the largest benefits of Twitter as a hosting platform for scientific meetings is the continued availability of content to those outside of academic research as long as presenters maintain their public Twitter accounts. Scientists are regularly expected to engage in public outreach and education either as part of the scientific process (Côté & Darling, 2018), or because it is required for one's professional position (e.g. academic tenure). Using social media platforms like Twitter for public outreach provides users with the opportunity to connect directly with nonscientific audiences (Côté & Darling, 2018), which we observed during #AnimaBehav2023 (5% of the 109 survey respondents classified themselves as either 'public', 'nonacademic professionals' or 'other'). Twitter presentation threads offer a concise and digestible summary of the research undertaken and an immediate way to contact the researchers. During #AnimBehav2023, journalists engaged directly with presentations and contacted presenters to discuss their research. This resulted in at least one presenter featured in an international news

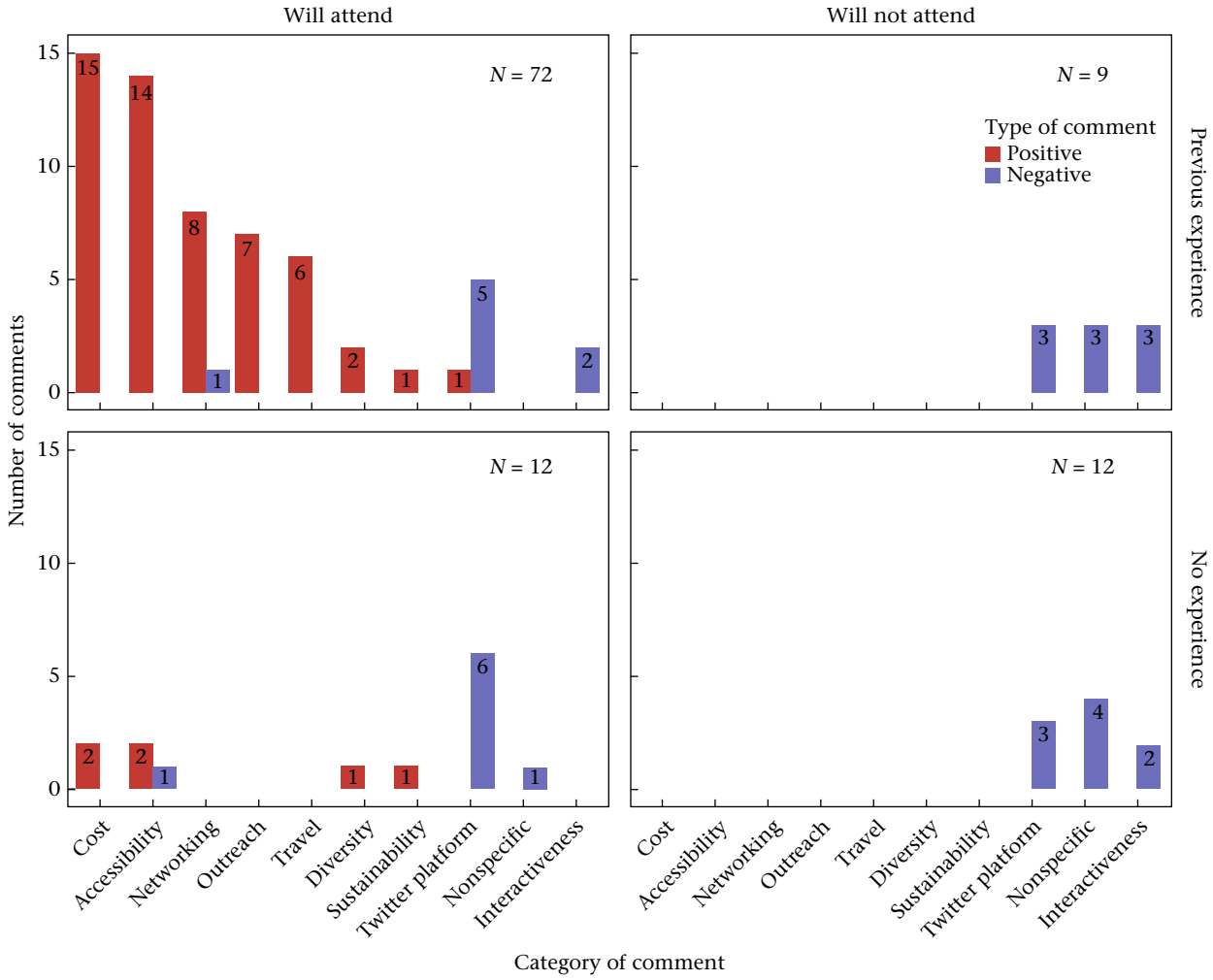

Figure 6. Compilation of results from the free-form question asking for comments to support responses to the question 'As conferences return to in-person format, would you still want to attend virtual/online conferences in the future (e.g. Twitter conference)?' The 105 respondents are classified into whether the respondent indicated willingness to attend future online conferences (will attend/will not attend) and whether the respondent previously attended the ABS Twitter Conference (previous experience/no experience). The free-form answers are coded according to the themes (cost of attending, accessibility, etc.) and tone (positive/negative response) they convey. A comment may contain a combination of multiple themes and tone (e.g. a positive response regarding the cost of attending and a negative response regarding interactiveness of online conferences). Some respondents did not provide comments to support their answers. Bars denote the number of comments conveying a particular theme, with the numbers in each bar representing the number of respondents.

publication, furthering the outreach potential of these conference presentations (Clavijo, 2023).

We found that educators were integrating content from #AnimBehav2021 into their courses, so in 2023, our goal was to engage with teachers and educators. The presentations in the dedicated Education section received similar levels of engagement as the rest of the conference content, and the majority of comments and questions in response to these threads were from attendees with a self-described academic background or position. Our engagement with pre-university educators was lower than expected. Engagement with Twitter by pre-university teachers was on the rise and was recognized as a valuable professional development and learning tool (Owens, 2020; Pollard, 2015), but this may have shifted as a result of changes to Twitter. Whether pre-university educators continue to utilize this social media platform will likely depend on its suitability and if it remains a safe resource for students to use in real time. Pre-university educators may use conference content after the conference ends (e.g. as part of assignments) rather than directly engage with the conference in real time (Pollard, 2015) due to safety concerns.

Engagement and Perceptions of Online Conference in a Post-COVID Restriction Era

After the success of the first Global Animal Behaviour Twitter Conference, a major objective for future conferences was to increase global participation (Raby et al., 2022). Compared to #AnimBehav2021, #AnimBehav2023 conference participation from Europe was more evenly spread among countries and there was proportionally higher participation from countries in Asia and Africa. This is a much larger global reach than comparable in-person animal behaviour conferences (Raby & Madden, 2021b) and particularly significant given that Asia and Africa are generally under-represented at in-person conferences (Fraser et al., 2017; Walton et al., 2023). Global engagement with the #AnimBehav2023 conference hashtag encompassed over 18 time zones (compared to

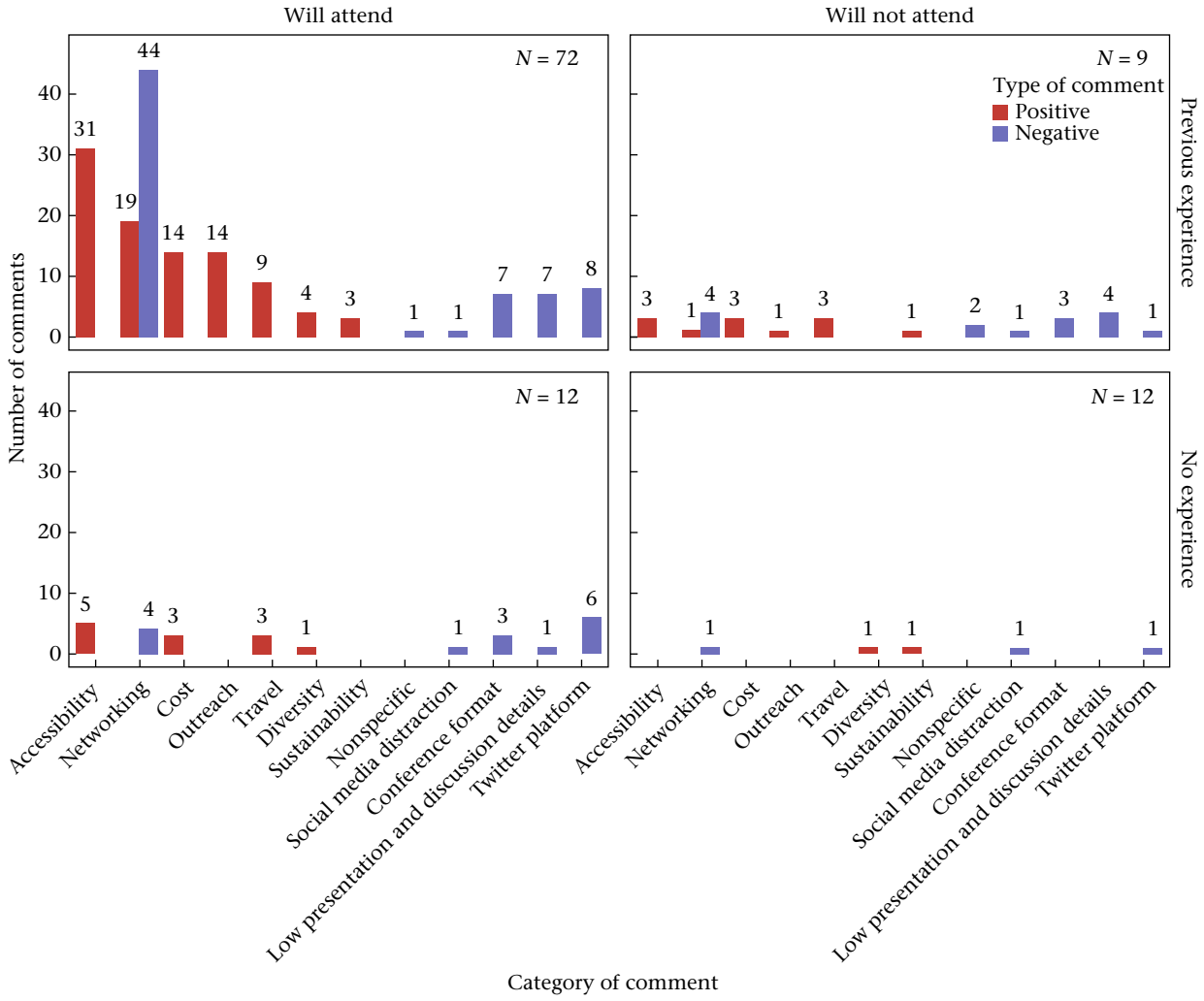

Figure 7. Compilation of results from the free-form questions. (1) What, if any, do you consider to be the advantages of the format of this Twitter conference over a conventional scientific meeting? (2) What, if any, do you consider to be the disadvantages of the format of this Twitter conference over a conventional scientific meeting? Bars denote the number of comments conveying a particular theme, with the numbers in each bar representing the number of respondents.

the 16 in 2023) and reached over 2 million Twitter accounts with over 15 million potential views. However, overall engagement in 2023 was less than in 2021, even when accounting for the decrease in the number of presenters. These changes may reflect the reduced need for online conferences after a return to in-person conferences post-COVID restrictions.

Online conferences have many benefits beyond those resulting from COVID restrictions, and there remains a need for affordable and inclusive virtual options (Estien et al., 2021; Raby et al., 2022). Feedback about online conferences illustrated interest in continuing this format. In our survey, 80% of respondents indicated that they would be interested in attending a virtual/online conference in the future (Appendix, Fig. A3). Of the 20% of respondents who do not intend to attend online conferences in the future, most cited the lack of interaction in these meeting formats as a major deterrent. This feedback reflects sentiments towards online conferences during the COVID-19 pandemic, where academics indicated that networking is greatly restricted when meeting online (Raby et al., 2022; Raby & Madden, 2021a). Unfortunately, despite continued interest in attending online conferences, most conferences have returned to in-person meetings, with some societies organizing hybrid conferences and even fewer retaining virtual-only conferences (Falk & Hagsten, 2023).

The overall engagement and enthusiasm for Twitter conferences remained quite high. By summer 2022, many societies in animal behaviour were returning to in-person meetings. Yet they still provided a virtual, asynchronous component to their conference, recognizing what many suspected after 2020: virtual meetings, in some capacity, are here to stay (Dua et al., 2020; Estien et al., 2021; Raby et al., 2022; Stefanoudis et al., 2021). Virtual conferences remain vital for maintaining an international network while minimizing the financial and carbon cost for participants (Dua et al., 2020; Estien et al., 2021; Raby et al., 2022; Stefanoudis et al., 2021). Hybrid options have been proposed as the ideal alternative: providing access to academics who cannot attend in person and allowing in-person meetings to aid networking for those who can (Puccinelli et al., 2022). There is little research on the perceptions of hybrid conferences, but initial feedback suggests that it is a challenging format to organize (Puccinelli et al., 2022), and participants from our survey describe their experiences in hybrid conferences as generally negative. That being said, our respondents expressed they would support a mix of in-person-only and online-only conferences. Puccinelli et al. (2022) found that 74% of their attendees felt that future society meetings should be held as hybrid events.

Table 3
Nonexhaustive list of online platforms that can be used for hosting conferences

Platform	Type	Pricing	Networking features	Presentation format	Comments
X(https://twitter.com/)	Microblogging	Free + paid ($84/year) access to features	Polls, direct messages, engagement via responding to posts	Text messages + *short videos*	Alternatives include Mastodon, Threads, Bluesky
Mastodon(https://joinmastodon.org/)	Microblogging	Free + optional costs to set up a server	Polls, direct messages, engagement via responding to posts	Text messages + videos up to 40 MB	Posts are visible across servers, so conferences can be organized on pre-existing servers
Threads (https://www.instagram.com)	Microblogging	Free	Access Instagram followers, posting and responding to posts, future social networking	Text-based conversation linked to Instagram	Alternatives include Mastodon, Slack, Bluesky; not universally available (e.g. EU)
Zoom (https://zoom.us/)	Video conferencing	Free + paid ($149.90/year) access to features	Chat, direct messages, breakout rooms, polls, Q&A	Live presentation + *recording*	Good for live events, but is difficult to make presentations accessible for replay
Meet (https://apps.google.com/meet/)	Video conferencing	Free + paid ($72/year) access to features	Chat, direct messages, *breakout rooms*, *polls*, *Q&A*	Live presentation + *recording*	Good for live events, but is difficult to make presentations accessible for replay
Skype Meet Now (https://www.skype.com/en/free-conference-call/)	Video conferencing	Free	Chat, direct messages	Live presentation + recording	Free for up to 100 participants but has limited features for interactivity
CrowdCast (https://www.crowdcast.io/)	Video conferencing	Paid ($408/year) access to features	*Chat*, *polls*, *Q&A*	*Live presentation* + *recording*	Video streaming is limited to 10 h/month in the basic plan. More suitable for seminars and monthly recurring events
YouTube (https://www.youtube.com/)	Video sharing	Free (paid access to features for viewing)	Chat	Live presentation + replay	Limited interaction options (only through the chat)
Vimeo (https://vimeo.com/)	Video sharing	Free (paid access to features for uploading and viewing)	Chat	*Live presentation* + replay	Limited interaction options (only through the chat). Hosting live events requires an expensive advanced subscription (65$/month)
Discord (https://discord.com/)	Messaging	Free + paid ($49.99/year) access to features	Channels, Chat, direct messages, polls	Text messages + videos + *live presentation*	Useful for networking asynchronously but with limited live presentation options (limited to 25 people)
Slack(https://slack.com)	Messaging	Free + paid ($87/year) access to features	Channels, Chat, direct messages, polls	Text messages + videos + *live presentation*	Useful for networking asynchronously but with limited live presentation options (limited to 50 people)
Gather (https://www.gather.town/)	Virtual workspace	Free (limited to 10 users) + paid ($3/user/day) access to features	*Personalized avatars*, *interactive virtual workspace*, *breakout rooms*, *spatial video*, *Chat*, *Q&A*	*Live presentation* + *recording*	Simulates an interactive environment for users to move through and communicate with others, but expensive

Values in the pricing column refer to the cheapest available plan (in U.S. dollars) in August 2023, although several platforms have more expensive plans with advanced features. Features in italics and underlined are either limited to paid plans or have limitations in the free plan of the platform.

Changes to Twitter ownership and content policy could be another reason for the decline in participation in #AnimBehav2023. Around 2 weeks after abstract submission for #AnimBehav2023 opened, Elon Musk finalized the purchase of Twitter, which resulted in ~50% employees being laid off, banned accounts being reinstated and policy changes that relaxed moderation of hate speech (Fig. 1). Both the scientific community and broader public's response was largely in opposition to this change, with many scientists tweeting about leaving Twitter, moving to alternative platforms (e.g. Bluesky, Mastodon; Table 3). We think it is unlikely that changes in ownership affected total abstract submission (three participants asked to withdraw). However, the protracted fallout of Musk's Twitter acquisition has been marked by less engagement or complete disengagement with the platform (Chang et al., 2023; Vidal Valero, 2023). So, although our presenters were keen on continuing with the Twitter conference, it is possible that many Twitter users who would have engaged were no longer active on Twitter by January 2023, partially explaining the decline in overall conference hashtag engagement. Despite these changes, we observed continued engagement with #AnimBehav2023 and an interest in participating in future events from our survey, confirming that academics still require online conferences.

Saying Bye to the 'X'? The Future of Social Media Conferences

Online conferences held on social media platforms provide unique and important professional benefits, improve diversity and inclusion within the academic community (Estien et al., 2021; Raby et al., 2022) and provide a way for the public to engage with the scientific community in a user-friendly manner (Côté & Darling, 2018; Raby et al., 2022). Twitter has been unique in that, as a conference platform, it provides 'in real-time' engagement from presenters and audience members both from the scientific community and the broader public. However, the relationship between Twitter and inclusivity is complex, and biases in networking still exist even when conferences are hosted on Twitter (Duncan & Shean, 2023).

Unfortunately, Twitter's acquisition and subsequent policy changes have impacted its suitability for academic meetings. Changes to Twitter policy have resulted in academics leaving

Twitter altogether (Chang et al., 2023; Vidal Valero, 2023), an increase in hate speech (Hickey et al., 2023), a decrease in accessibility to desired content due to Twitter algorithm changes (Milli et al., 2023) and limitations in the number of Tweets that can be viewed per day (Clayton, 2023), to name a few. Even as we write this paper, Musk has proposed switching Twitter to a subscription-based model rather than a free model (Milmo, 2023), which would dramatically limit content access to those most in need of an open platform. This would significantly impact the availability of scientific content and the global reach of a Twitter conference (i.e. minimize public outreach). Ultimately, while Twitter historically provided many beneficial features to support academic conferences and networking, recent changes suggest that alternative platforms may be the future of online social media meetings.

Enthusiasm for future Twitter and other online conferences is encouraging and it is clear that there is a need for online conference options, even as in-person conferences have returned after COVID-19 restrictions. Online conferences, regardless of platform, need not aim to replace in-person meetings (Raby et al., 2022) but provide an equivalent option that is low-cost and with real-time engagement. Our survey respondents highlighted Twitter as a useful tool for conferences and public outreach and expressed interest in attending future events while suggesting other platforms that could be used moving forward.

For alternative options for future conferences, we have compiled a nonexhaustive list of platforms that can be used to host online conferences (see Table 3). Unfortunately, most of these platforms do not currently have the same reach as Twitter to disseminate research beyond academic networks. An intriguing alternative possibility would be to use multiple platforms to host an online conference. For example, Animal Behavior Live livestreams talks and round table discussions on YouTube, uses Discord for the networking part of meetings and advertises using social media. While microblogging platforms like Bluesky, Mastodon and Twitter ensure greater accessibility for a wide community, they are less successful at hosting videos and more interactive sessions. Video conferencing platforms (Meet, Skype, YouTube, Zoom) provide a robust solution for hosting live meetings but have limited scope for interactions beyond the specific time of the event. Platforms based on messaging (Discord, Slack) have multiple tools to engage a community effectively but have limited spontaneous reach. The pandemic has also given rise to virtual workspace platforms (e.g. Gather), which can be used to host conferences, but their costs can be prohibitive. Organizers could consider using a microblogging platform like Mastodon to reach a wider community, host talks on YouTube to provide live and replay access to talks and provide a Slack workspace or Discord server for more focused interactions between the participants of the conference. While the management of multiple platforms can increase organizational burden, such an integrative strategy may address concerns raised by our respondents regarding the asynchronous virtual components of in-person meetings.

Considering all the benefits of these various platforms, academics and societies should continue to experiment with ways to make science content more available to the general public and other scientists. Irrespective of which strategies are chosen to host online conferences, it should be highlighted that academic societies are in an experimental phase to uncover which type of conference format works best for both organizers and attendees. Therefore, it is essential to obtain feedback from participants to identify the strengths and weaknesses of these strategies. Academic societies should collect data on the effectiveness of various conference formats (e.g. in-person versus hybrid versus asynchronous online versus social media-based) to identify the most effective, equitable and inclusive online options. We urge organizers and societies to make this feedback available in the public domain to inform others about their process for organizing online conferences. Online conferences are clearly beneficial and in high demand. Social media conferences provide a unique opportunity to convey science to both academic colleagues and the general public. The continued decline of Twitter usage should not discourage the organization of social media conferences, and we urge organizers to explore alternative platforms to provide this unique and valuable conference experience.

Author Contributions

Jessica A. Cusick: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Visualization, Writing (Original draft), Review & Editing, Supervision. **Ebi Antony George**: Conceptualization, Data curation, Formal analysis, Visualization, Writing (Original draft), Review & Editing. **E. V. (Ginny) Greenway**: Conceptualization, Data curation, Formal analysis, Visualization, Writing (Original draft), Reviewing & Editing. **Mukta Watve**: Conceptualization, Writing (Original draft), Review & Editing. **Kirsty Graham**: Conceptualization, Methodology, Visualization, Review & Editing. **Cassandra L. Raby**: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Visualization, Writing (Original draft), Review & Editing, Supervision.

Data Availability

All data, including raw data and percentages, are reported in the manuscript, with the exception of questionnaire qualitative responses that had the potential of containing identifying information. Any data are available upon reasonable request.

Declaration of Interest

None.

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References

Aron, A. R., Ivry, R. B., Jeffery, K. J., Poldrack, R. A., Schmidt, R., Summerfield, C., & Urai, A. E. (2020). How can neuroscientists respond to the climate emergency? *Neuron, 106*(1), 17–20.

Avery-Gomm, S., Hammer, S., & Humphries, G. (2016). The age of the Twitter conference. *Science, 352*(6292), 1404–1405. https://doi.org/10.1126/science.352.6292.1404-b

Baker, M. J., Gempf, K. L., McDonald, H., Kerr, H. E., Hodges, C., Anastasaki, A., Noel, T., & Randviir, E. P. (2020). Five years of the #RSCPoster Twitter conference. *Chemical Communications, 56*(89), 13681–13688. https://doi.org/10.1039/D0CC90441D

Biggs, J., Hawley, P. H., & Biernat, M. (2018). The academic conference as a chilly climate for women: Effects of gender representation on experiences of sexism, coping responses, and career intentions. *Sex Roles, 78*, 394–408.

Bik, H. M., & Goldstein, M. C. (2013). An introduction to social media for scientists. *PLoS Biology, 11*(4), Article e1001535. https://doi.org/10.1371/journal.pbio.1001535

Bombaci, S. P., Farr, C. M., Gallo, H. T., Mangan, A. M., Stinson, L. T., Kaushik, M., & Pejchar, L. (2016). Using Twitter to communicate conservation science from a professional conference. *Conservation Biology, 30*(1), 216–225. https://doi.org/10.1111/cobi.12570

Bos, A. L., Sweet-Cushman, J., & Schneider, M. C. (2019). Family-friendly academic conferences: A missing link to fix the 'leaky pipeline'? *Politics, Groups, and Identities, 7*(3), 748–758. https://doi.org/10.1080/21565503.2017.1403936

Branch, T. A., Côté, I. M., David, S. R., Drew, J. A., LaRue, M., Márquez, M. C., Parsons, E. C. M., Rabaiotti, D., Shiffman, D., Steen, D. A., & Wild, A. L. (2023). Controlled experiment finds no detectable citation bump from Twitter promotion. *bioRxiv*. https://doi.org/10.1101/2023.09.17.558161

Brembs, B., Lenardic, A., Murray-Rust, P., Chan, L., & Irawan, D. E. (2023). Mastodon over mammon: Towards publicly owned scholarly knowledge. *Royal Society Open Science, 10*, Article 230207. https://doi.org/10.1098/rsos.230207

Côté, I. M., & Darling, E. S. (2018). Scientists on Twitter: Preaching to the choir or singing from the rooftops? *Facets, 3*(1), 682–694. https://doi.org/10.1139/facets-2018-0002

Caravaggi, A., Olin, A. B., Franklin, K. A., & Dudley, S. P. (2021). Twitter conferences as a low-carbon, far-reaching and inclusive way of communicating research in ornithology and ecology. *Ibis, 163*(4), 1481–1491. https://doi.org/10.1111/ibi.12959

Cavanah, S., Owens, S., Kemink, K., Riley, C., Kim, S., Lee, J., & Ellis-Felege, S. (2023). Birds of feather flock together: A longitudinal study of a social media outreach effort. *Biological Conservation, 281*, Article 109999. https://doi.org/10.1016/j.biocon.2023.109999

Chai, S., & Freeman, R. B. (2019). Temporary colocation and collaborative discovery: Who confers at conferences. *Strategic Management Journal, 40*(13), 2138–2164. https://doi.org/10.1002/smj.3062

Chang, C. H., Deshmukh, N. R., Armsworth, P. R., & Masuda, Y. J. (2023). Environmental users abandoned Twitter after Musk takeover. *Trends in Ecology & Evolution, 38*(10), 893–895. https://doi.org/10.1016/j.tree.2023.07.002

Clavijo, V. M. (1 February 2023). Comportamiento felino: Los gatos juegan a buscar y traer objetos de forma natural, como los perros, sin entrenamiento. *20minutos*. https://www.20minutos.es/noticia/5094882/0/comportamiento-felino-los-gatos-juegan-a-traer-y-buscar-objetos-de-forma-natural-como-los-perros-sin-entrenamiento-mediante/.

Clayton, J. (3 July 2023). Why is Twitter limiting how many tweets you can see? *BBC News*. https://www.bbc.com/news/technology-66093324.

Collins, K., Shiffman, D., & Rock, J. (2016). How are scientists using social media in the workplace? *PLoS One, 11*(10), Article e0162680. https://doi.org/10.1371/journal.pone.0162680

Dua, N., Fyrenius, M., Johnson, D. L., & Moos, W. H. (2020). Are in-person scientific conferences dead or alive? *FASEB BioAdvances, 3*(6), 420–427. https://doi.org/10.1096/fba.2020-00139

Duncan, N. W., & Shean, R. (2023). Analysing the effectiveness of Twitter as an equitable community communication tool for international conferences. *PeerJ, 11*, Article e15270. https://doi.org/10.7717/peerj.15270

Epp, S., Jung, H., Borghesani, V., Klower, M., Hoeppeli, M., Misiura, M., Thompson, E., Duncan, N. W., Urai, A. E., Veldsman, M., Sadaghiani, S., & Rae, C. L. (2023). How can we reduce the climate costs of OHBM? A vision for a more sustainable meeting. *Aperture Neuro, 3*, 1–16. https://doi.org/10.52294/001c.87678

Estien, C. O., Myron, E. B., Oldfield, C. A., Alwin, A., & Ecological Society of America Student Section. (2021). Virtual scientific conferences: Benefits and how to support underrepresented students. *Bulletin of the Ecological Society of America, 102*(2), Article e01859.

Falk, M. T., & Hagsten, E. (2023). Reverse adoption of information and communication technology among organisers of academic conferences. *Scientometrics, 128*(3), 1963–1985.

Farr, C. M., Bombaci, S. P., Gallo, T., Mangan, A. M., Riedl, H. L., Stinson, L. T., Wilkins, K., Bennett, D. E., Nogeire-McRae, T., & Pejchar, L. (2017). Addressing the gender gap in distinguished speakers at professional ecology conferences. *BioScience, 67*(5), 464–468. https://doi.org/10.1093/biosci/bix013

Finch, T., O'Hanlon, N., & Dudley, S. P. (2017). Tweeting birds: Online mentions predict future citations in ornithology. *Royal Society Open Science, 4*(11), Article 171371. https://doi.org/10.1098/rsos.171371

Flaherty, E. A., Day, C. C., Urbanek, R. E., Wood, D. M., D'Acunto, L. E., Quinn, V. S., & Zollner, P. A. (2019). Mentored conference experiences support students' career exploration and professional development. *Wildlife Society Bulletin, 43*(4), 565–575. https://doi.org/10.1002/wsb.1013

Flores, N. M. (2020). Harassment at conferences: Will #MeToo momentum translate to real change? *Gender and Education, 32*(1), 137–144.

Ford, H. L., Brick, C., Azmitia, M., Blaufuss, K., & Dekens, P. (2019). Women from some under-represented minorities are given too few talks at world's largest Earth-science conference. *Nature, 576*(7785), 32–35. https://doi.org/10.1038/d41586-019-03688-w

Fraser, H., Soanes, K., Jones, S. A., Jones, C. S., & Malishev, M. (2017). The value of virtual conferencing for ecology and conservation. *Conservation Biology, 31*(3), 540–546.

Fulcher, M. R., Bolton, M. L., Millican, M. D., Michalska-Smith, M. J., Dundore-Arias, J. P., Handelsman, J., Klassen, J. L., Milligan-Myhre, K. C., Shade, A., Wolfe, N. E., & Kinkel, L. L. (2020). Broadening participation in scientific conferences during the era of social distancing. *Trends in Microbiology, 28*(12), 949–952.

Gattrell, W. T., Barraux, A., Comley, S., Whaley, M., & Lander, N. (2022). The carbon costs of in-person versus virtual medical conferences for the pharmaceutical industry: Lessons from the Coronavirus Pandemic. *Pharmaceutical Medicine, 36*, 131–142. https://doi.org/10.1007/s40290-022-00421-3

Hickey, D., Schmitz, M., Fessler, D., Smaldino, P., Muric, G., & Burghardt, K. (2023). Auditing Elon Musk's impact on hate speech and bots. *arXiv:2304.04129v2*. https://doi.org/10.48550/arXiv.2304.04129

Hinsley, A., Sutherland, W. J., & Johnston, A. (2017). Men ask more questions than women at a scientific conference. *PLoS One, 12*(10), Article e0185534. https://doi.org/10.1371/journal.pone.0185534

Insall, R. (2023). Science Twitter—Navigating change in science communication. *Nature Reviews Molecular Cell Biology, 24*(5), Article 5. https://doi.org/10.1038/s41580-023-00581-3

Johannesen, E., Barz, F., Dankel, D. J., & Kraak, S. B. M. (2023). Gender and early career status: Variables of participation at an international marine science conference. *ICES Journal of Marine Science, 80*(4), 1016–1027. https://doi.org/10.1093/icesjms/fsad028

Kuehne, L. M., Rolls, R. J., Brandis, K. J., Chen, K., Fraley, K. M., Frost, L. K., Ho, S. S., Kunisch, E. H., Langhans, S. D., LeRoy, C. J., McDonald, G., McInerney, P. J., O'Brien, K. R., & Strecker, A. L. (2022). Benefits of permanent adoption of virtual conferences for conservation science. *Conservation Biology, 36*(4), Article e13884. https://doi.org/10.1111/cobi.13884

Kwok, R. (2013). Mobile apps: A conference in your pocket. *Nature, 498*(7454), Article 7454. https://doi.org/10.1038/nj7454-395a

López-Goñi, I., & Sánchez-Angulo, M. (2018). Social networks as a tool for science communication and public engagement: Focus on Twitter. *FEMS Microbiology Letters, 365*(2), Article fnx246. https://doi.org/10.1093/femsle/fnx246

Lamb, C. T., Gilbert, S. L., & Ford, A. T. (2018). Tweet success? Scientific communication correlates with increased citations in ecology and conservation. *PeerJ, 6*, Article e4564. https://doi.org/10.7717/peerj.4564

Lin, Y., Frey, C. B., & Wu, L. (2023). Remote collaboration fuses fewer breakthrough ideas. *Nature, 623*(7989), 987–991.

McClain, C., & Neeley, L. (2015). A critical evaluation of science outreach via social media: Its role and impact on scientists. *F1000Research, 3*, Article 300. https://doi.org/10.12688/f1000research.5918.2

Milli, S., Carroll, M., Wang, Y., Pandey, S., Zhao, S., & Dragan, A. D. (2023). Engagement user satisfaction and the amplification of divisive content on social media. *arXiv:2305.16941v2*. https://doi.org/10.48550/arXiv.2305.16941

Milmo, D. (19 September 2023). Elon Musk says Twitter, now X, could charge all users subscription fees. *The Guardian*. https://www.theguardian.com/technology/2023/sep/19/elon-musk-twitter-x-subscription-fees-users-posts.

Moss, V. A., Adcock, M., Hotan, A. W., Kobayashi, R., Rees, G. A., Siégel, C., Tremblay, C. D., & Trenham, C. E. (2021). Forging a path to a better normal for conferences and collaboration. *Nature Astronomy, 5*(3), Article 3. https://doi.org/10.1038/s41550-021-01325-z

Moss, V. A., Balaguer-Nuñez, L., Bolejko, K., Burtscher, L., Carr, A., Di Teodoro, E. M., Gregory, B., Hanko, E., Hill, A. S., Hughes, A., Kaper, L., Kerrison, E. F., Lockman, F. J., Lowson, N., & Stevens, A. R. H. (2022). Around the hybrid conference world in the COVID-19 era. *Nature Astronomy, 6*(10), Article 10. https://doi.org/10.1038/s41550-022-01806-9

Niner, H. J., & Wassermann, S. N. (2021). Better for whom? Levelling the injustices of international conferences by moving online. *Frontiers in Marine Science, 8*, Article 638025. https://doi.org/10.3389/fmars.2021.638025

Oester, S., Cigliano, J. A., Hind-Ozan, E. J., & Parsons, E. C. M. (2017). Why conferences matter—an illustration from the international marine conservation Congress. *Frontiers in Marine Science, 4*, Article 257. https://doi.org/10.3389/fmars.2017.00257

Ortega, J. L. (2016). To be or not to be on Twitter, and its relationship with the tweeting and citation of research papers. *Scientometrics, 109*, 1353–1364. https://doi.org/10.1007/s11192-016-2113-0

Owens, T. (2020). *The influence of Twitter educational opinion leaders on K-12 classrooms* (Ph.D. thesis). Lindenwood University ProQuest Dissertations Publishing, Article 27961333.

Parncutt, R., Lindborg, P., Meyer-Kahlen, N., & Timmers, R. (2021). The multi-hub academic conference: Global, inclusive, culturally diverse, creative, sustainable. *Frontiers in Research Metrics and Analytics, 6*, Article 699782. https://doi.org/10.3389/frma.2021.699782

Pollard, J. W. (2015). *The use of Twitter as a collaborative environment for K-12 teachers; perceptions of 140 character professional learning communities* (Ph.D. thesis). Wilkes University ProQuest Dissertations Publishing, Article 10015220.

Puccinelli, E., Zeppilli, D., Stefanoudis, P. V., Wittische-Helou, A., Kermorgant, M., Fuchs, S., Menot, L., Easton, E. E., & Weber, A. A. (2022). Hybrid conferences: Opportunities, challenges and ways forward. *Frontiers in Marine Science, 9*, Article 902772.

Raby, C. L., Cusick, J. A., Fürtbauer, I., Graham, K. E., Habig, B., Hauber, M. E., Madden, J. R., Strauss, A. V. H., & Fernández-Juricic, E. (2022). An inclusive venue to discuss behavioural biology research: The first global Animal Behaviour

Twitter Conference. *Animal Behaviour, 187*, 191–207. https://doi.org/10.1016/j.anbehav.2022.02.015
Raby, C. L., & Madden, J. R. (2021). Moving academic conferences online: Understanding patterns of delegate engagement. *Ecology and Evolution, 11*(8), 3607–3615.
Raby, C. L., & Madden, J. R. (2021). Moving academic conferences online: Aids and barriers to delegate participation. *Ecology and Evolution, 11*(8), 3646–3655.
Seidenberg, N., Scheffel, M., Kovanovic, V., Lynch, G., & Drachsler, H. (2021). Virtual academic conferences as learning spaces: Factors associated with the perceived value of purely virtual conferences. *Journal of Computer Assisted Learning, 37*(6), 1694–1707. https://doi.org/10.1111/jcal.12614
Shiffman, D. S. (2012). Twitter as a tool for conservation education and outreach: What scientific conferences can do to promote live-tweeting. *Journal of Environmental Studies and Sciences, 2*(3), 257–262. https://doi.org/10.1007/s13412-012-0080-1
Shu, F., Lou, W., & Haustein, S. (2018). Can Twitter increase the visibility of Chinese publications? *Scientometrics, 116*, 505–519. https://doi.org/10.1007/s11192-018-2732-8
Stefanoudis, P. V., Biancani, L. M., Cambronero-Solano, S., Clark, M. R., Copley, J. T., Easton, E., Elmer, F., Haddock, S. H. D., Herrera, S., Iglesias, I. S., Quattrini, A. D., Sigwart, J., Yesson, C., & Glover, A. G. (2021). Moving conferences online: Lessons learned from an international virtual meeting. *Proceedings of the Royal Society B: Biological Sciences, 288*, Article 20211769. https://doi.org/10.1098/rspb.2021.1769
Tao, Y., Steckel, D., Klemeš, J. J., & You, F. (2021). Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy. *Nature Communications, 12*(1), Article 1. https://doi.org/10.1038/s41467-021-27251-2
Urban, E. R., & Boscolo, R. (2013). Using scientific meetings to enhance the development of early career scientists. *Oceanography, 26*(2), 164–170. https://doi.org/10.5670/oceanog.2013.16
Vidal Valero, M. (2023). Thousands of scientists are cutting back on Twitter, seeding angst and uncertainty. *Nature, 620*(7974), 482–484. https://doi.org/10.1038/d41586-023-02554-0
Walton, E., Yates, J., Blake, L., Waage, J., & Kadiyala, S. (2023). Virtual academic conferences: A mixed-methods study of equitable participation according to gender and country-income level. *Research Square Pre-Print*. https://doi.org/10.21203/rs.3.rs-2250662/v1
Wang, W., Bai, X., Xia, F., Bekele, T. M., Su, X., & Tolba, A. (2017). From triadic closure to conference closure: The role of academic conferences in promoting scientific collaborations. *Scientometrics, 113*(1), 177–193. https://doi.org/10.1007/s11192-017-2468-x
Wilkinson, S. E., Basto, M. Y., Perovic, G., Lawrentschuk, N., & Murphy, D. G. (2015). The social media revolution is changing the conference experience: Analytics and trends from eight international meetings. *BJU International, 115*(5), 839–846. https://doi.org/10.1111/bju.12910
Winandy, M., Kostkova, P., de Quincey, E., Louis, C. S., & Szomszor, M. (2016). Follow #eHealth2011: Measuring the role and effectiveness of online and social media in increasing the outreach of a scientific conference. *Journal of Medical Internet Research, 18*(7), Article e4480. https://doi.org/10.2196/jmir.4480
Zierath, J. R. (2016). Building bridges through scientific conferences. *Cell, 167*(5), 1155–1158. https://doi.org/10.1016/j.cell.2016.11.006

Appendix

Table A1
2023 Animal Behaviour Twitter Conference (#AnimBehav2023) survey administered to plenary speakers and those that submitted abstracts to gather information about desire to continue with Twitter conference after ownership change (Fig. 1)

Question	Response type	Response options
(1) What is your name?	Free response	
(2) Do you plan to engage with the Animal Behaviour Twitter Conference on 18–19 Jan 2023? This includes, but is not limited to presenting (if accepted), viewing presentations on Twitter, asking questions, or using Twitter conference materials for teaching/education purposes?	Multiple choice	Yes/No
(3) If your abstract is accepted for the #AnimBehav2023 Twitter conference on 18–19 Jan 2023, are you ok with presenting on the Twitter platform as originally planned?	Multiple choice	Yes/No
(4) If your abstract is accepted for the #AnimBehav2023 Twitter conference on 18–19 Jan 2023, which of the following best represents your views on presentation platforms?	Multiple selection (select all that apply)	I am comfortable with presenting and engaging with the #AnimBehav2023 conference on the Twitter platform I am comfortable with presenting and engaging with the #AnimBehav2023 conference, but only if the conference takes place on a different social media platform (not Twitter) I am comfortable with presenting and engaging with the #AnimBehav2023 conference on the Twitter platform and I am ok with having my presentation materials presented on a separate social media platform I am comfortable with presenting and engaging with the #AnimBehav2023 conference on the Twitter platform and will only engage if the conference occurs on the Twitter platform
(5) Additional thoughts or comments	Free response	

Table A2
Details of the questions asked in the survey circulated to attendees and nonattendees of the #AnimBehav2023 conference

Questions	Response type	Response options
(1) What continent are you currently based in?	Multiple choice	Europe North America South America Asia Africa Australasia
(2) What is your current position?	Multiple choice	Contracted academic with professional interest in animal behaviour (e.g. postdoc) Educator other Nonacademic professional with interest in animal behaviour (e.g. zoo/aquarium, industry conservationist) Permanent academic with professional interest in animal behaviour (e.g. tenured or tenured-track PI; permanent lecturer, adjunct) Postgraduate student (M.Sc.) Postgraduate student (Ph.D.) Public (e.g. not in education or animal behaviour-related research or industry) Undergraduate student Other
(3) What is your gender? (please self-identify if willing)	Free text	–
(4) What is your ethnicity? (please self-identify if willing)	Free text	–
(5) How did you hear about the Twitter Conference?	Free text	–
(6) Did you engage with or participate in the Twitter conference?	Multiple choice	No Yes, after the conference was over Yes, both during the conference days and after the conference was over Yes, live on the days of the conference
(7) How did you engage in the Twitter conference? Select all that apply	Multiple choice (can choose more than one response)	I did not engage with the Twitter conference I viewed presentations only I 'liked' presentations on Twitter from my Twitter account I asked a question in response to their presentation I retweeted presentations from my Twitter account I left a comment in response to their presentation I followed the presenter on Twitter I shared presentations with others privately (e.g. via email, direct message, text) Other
(8) Approximately how many presentations did you view?	Multiple choice	0 1–5 6–10 11–25 26–50 50+
(9) Approximately how many presentations did you ask questions of?	Multiple choice	0 1–2 3–5 6–10 10–20 20+
(10) Did you present work at the Twitter Conference?	Multiple choice	Yes No
(11) Did you engage in the 2021 Twitter conference? #AnimBehav2021	Multiple choice	No, this is my first time Yes, as a presenter Yes, as a session chair or organizer Yes, as an audience member Yes, in multiple ways (e.g. presenter and organizer)
(12) As conferences return to in-person format, would you still want to attend virtual/online conferences in the future (e.g. Twitter conference)?	Multiple choice	Yes No
(13) Please use the space here to expand on your response above: As conferences return to in-person format, would you still want to attend virtual/online conferences in the future (e.g. Twitter conference)?	Free text	–
(14) What, if any, do you consider to be the advantages of the format of this Twitter conference over a conventional scientific meeting?	Free text	–
	Free text	–

Table A2 (*continued*)

Questions	Response type	Response options
(15) What, if any, do you consider to be the disadvantages of the format of this Twitter conference over a conventional scientific meeting?		
(16) Did the recent changes in Twitter ownership and policy impact your desire to engage with the #AnimaBehav2023 Animal Behaviour Twitter Conference?	Multiple choice	No, it did not impact me. I was not planning to engage in the Twitter conference and this did not change No, it did not impact me. I was planning to engage and did participate and engage in the Twitter conference Yes, it impacted me. I was planning on engaging with the conference but decided not to Yes, it impacted me. I was questioning whether to engage but decided to participate and engage in the Twitter conference
(17) Any other comments	Free text	–

All questions were optional and there was no requirement to provide a statement for the free-text responses or choose an answer for the multiple choice questions.

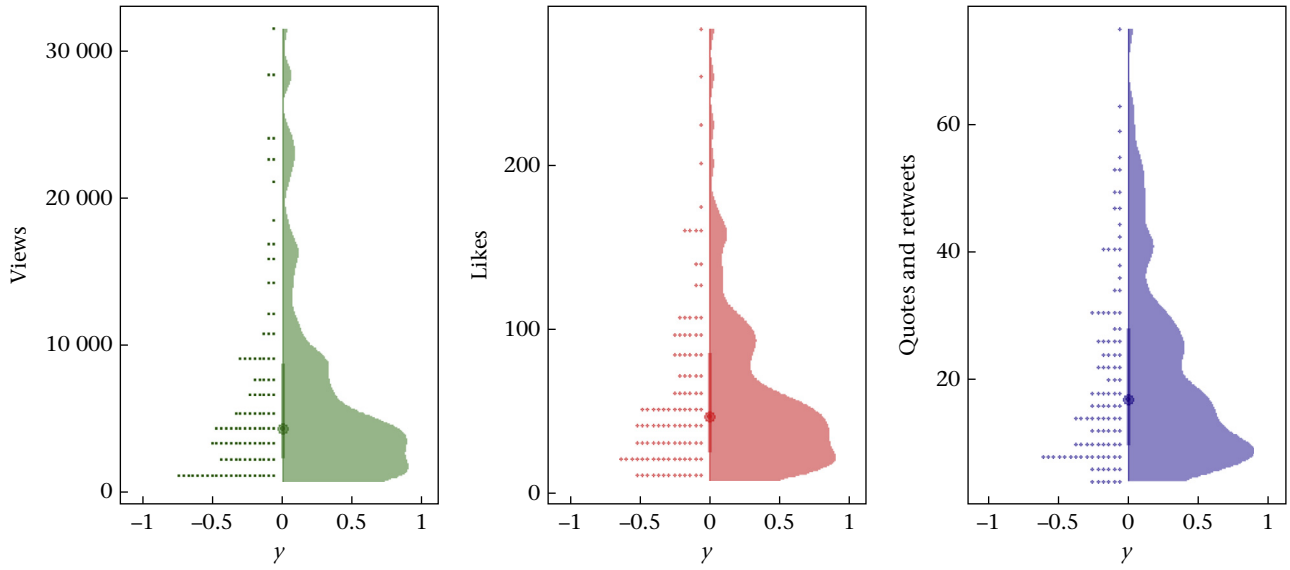

Figure A1. Summary (density plots) of views, likes and quotes/retweets across all #AnimBehav2023 initial tweets in each presentation thread (as of 18 May 2023).

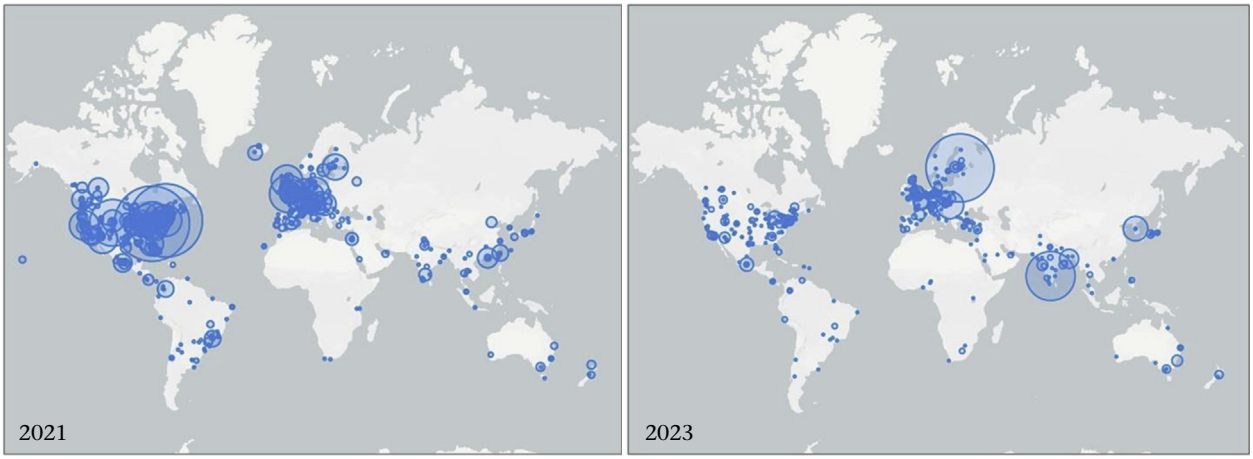

Figure A2. Country level locations of visitors (counting unique visitors only) that visited the conference Web site during the 2 days of the conference (26–27 January 2021, 18–19 January 2023). Data were exported from Wix analytics and included data from any visitor who accepted the Web site cookies.

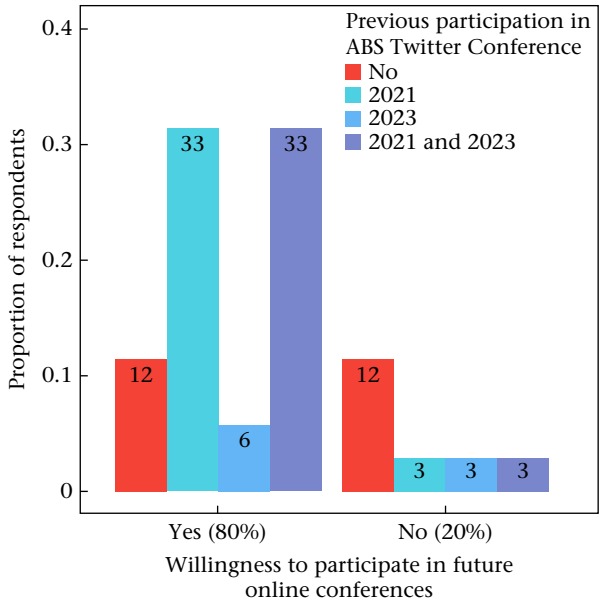

Figure A3. Compilation of results from three questions asked in the survey. (1) Did you engage with or participate in the Twitter conference? (2) Did you engage in the 2021 Twitter conference? #AnimBehav2021. (3) As conferences return to in-person format, would you still want to attend virtual/online conferences in the future (e.g. Twitter conference)? Bars denote the proportion of total respondents that fell into different categories, with the numbers in each bar representing the number of respondents.