The reaction of African elephants towards African honeybees in northern Botswana

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Introduction

There is compelling evidence to suggest that areas of outstanding conservation value, which often coincide with expanding human populations, are at risk (Balmford et al. 2001). The African elephant (*Loxodonta Africana*) is the world's largest generalist herbivore and, due to its large size, requires a substantial amount of space and resources (Dublin et al. 1990; van Aarde et al. 2006). Consequently, mitigating human-elephant conflict (HEC) has become a focal topic in elephant conservation and research (Karidozo and Osborn 2005). Many countries in southern Africa that still have substantial elephant populations face the challenge of managing these populations. At the same time, biodiversity has declined in protected areas (PAs) while reducing the impacts on humans (Balmford et al. 2001). Encounters between elephants and people (/communities) often result in negative interactions, which pose serious social, political and conservation conflicts (King et al. 2009). Botswana holds the largest elephant concentration on the African continent with approximately 130,000 individuals (Bussière and Potgieter 2023). Botswana's need for effective deterrents is vital in managing and maintaining its current elephant population. A wide range of mitigation methods have been trialled and used in high HEC areas across African elephant range States. These include the use of chillies, explosive devices, lights, organic repellent, trenches, and electric fences (Sitati et al. 2003; Osborn and Parker 2003; Graham and Ochieng 2008; Davies et al. 2011; Oniba and Robertson 2019; Adams et al. 2021; King et al. 2023). Davies et al. (2011) outlined the importance of first evaluating deterrent methods to determine their effectiveness, before wide-range deployment. Each deterrent method has varying degrees of success, which are dependent on the local elephant population, the location, deployment of the deterrent, and the community buy-in both economically and socially (Osborn and Parker 2003; Davies et al. 2011).

The use of African honeybees (*Apis mellifera scutellata*) and beehive fences is one of the most novel deterrent innovations. The development in Kenya from 2007 has been a success, as evidenced in studies there (King et al. 2009; 2017; 2024), where it was observed that elephants exhibit avoidance behaviour when exposed to acoustic playbacks of African honeybees (King et al. 2007). Beehives are interlinked and hang between posts to function as a fence-like barrier between crops and elephants (King et al. 2017). They have shown positive deterrent results during field trials elsewhere, including Mozambique (Branco et al. 2019), and Tanzania (Scheijen et al. 2019).

However, some field studies using bees have shown limited results (Kazidozo and Osborn 2005), possibly due to challenges with bee activity (Ngama et al. 2016) or occupation rates (Kiffner et al. 2021). Hence, it is essential to assess the validity of the deterrent under local conditions before implementation in the Chobe area of Botswana. Currently, it is unknown

how Botswana's elephant populations respond to the sound of African honeybees.

This study aimed to assess the behavioural reactions of elephants in northern Botswana to audio recordings of disturbed African honeybees. By determining how different elephant populations will respond to the sound of bees, we can assist in determining the relative success of beehive fences in relieving and reducing HEC in the country.

Methods

Study Area

The research was conducted in Chobe district in the north-east corner of Botswana, which shares borders with Zimbabwe, Namibia, and Zambia. The area is made up of Chobe National Park (NP) (10,740 km^2), community settlements, smallholder farms and forest reserves (Adams et al. 2021). The area has a high density of elephants, with approximately 34,087 elephants in the district (Bussière and Potgieter 2023). The townships of Kasane and Kazungula are the urban administration centres of the district, with a combined human population of 17,655 (Census Office 2022).

Playback procedure

The playback experiment is based on the methodology and recordings of King et al. (2007). Two signals were used for the playback trials: 1) the test stimulus was 180 seconds of sound produced by disturbed wild African bees (*Apis mellifera scutellata*); and 2) the control stimulus, which was natural white noise recorded from a waterfall.

Playbacks were conducted on randomly selected, resting family units, preferably with small calves present, and replicating the same protocol as King et al. (2007). Playbacks were performed on families that were resting under trees (Fig.1) with no mature bulls present, as male elephants can disturb the family's resting behaviour (King et al. 2007). Upon identification of a resting family unit, the number, demography, the matriarch's distinguishing features, and whether individuals were lying down were recorded. The age and sex were based on traits defined in Moss (1996). The playbacks were conducted in the dry season (May–October in 2013), at the hottest time of day (10.00 hrs–15.00 hrs).

Before starting a playback, the resting behaviour of the focal elephants was recorded for two minutes. A wireless Bluetooth speaker (A33 TDK) was placed as close to the family as possible, and a vehicle was parked at a 90-degree angle to the speaker. After the playback finished, a further 30 seconds of the family's behavioural reaction were recorded. All images were recorded using a Nikon Camera. The stimulus output and the background noise were measured using a sound level meter.

Although a total of 95 playbacks were attempted, only 30 playbacks on 30 family units (15 in the Park and 15 in the community area) were successfully conducted, as the elephants frequently moved away when our vehicle stopped or we drove by. This could be due to high-density safari vehicle traffic in the area or the presence of other elephants or other wildlife.

Figure 1. An example of a resting family unit, in the shade of a tree (with no mature bull present with the group).

Table 1: Summary of the number of playbacks, average family unit size, number of resting calves, and the estimated distance subjects were from the playback speaker during the 30 trials.

Playback Trial	Total number of playbacks	Mean number of animals in family unit (±SE)	Number of playbacks with calves lying down	Estimated mean distance herd from speaker (m) (±SE)	Mean max./min. The sound output of the speaker (at herd distance from the speaker dB) (±SE)
Bee	15	7.3 (0.8)	7	15–18 (5)	-
Control	15	6.6 (0.6)	6	15–18 (5)	-
Combined	30	7.0 (0.5)	13	15–18 (5)	49.6(1)–46.1 (1.5)

Playback behavioural reactions

For this study, behavioural reactions were defined into four separate categories based on behavioural definitions from Poole and Granli (2021) studies, which were as follows:

1. *Non-reaction*: where no individuals show any behavioural reaction to the sound being played.
2. *Weak*: behavioural response includes not moving from the resting place and only displaying a mild behavioural reaction (smelling, raised heads, or swaying of the body).
3. *Medium*: behavioural responses include movement/shuffling within the rest area, changes in body orientation, smelling, head shaking, the family not moving off, further than 10 metres from the shade, but there is a clear response to the audio playback.
4. *Strong*: behavioural response is a marked reaction in the entire resting family unit. For example, when they move away from their resting area, out of the shade area (distance measurement >10 m). This can involve rapid, bunched movement, smelling, a change of body orientation, and/or fanning out of mature individuals. The results are that the entire family unit behaves adversely because of the playback.

Additionally, aggressive displays were recorded during playbacks; these included mock charges, or ears moving forward, and individuals leaning in on their front legs.

Statistical analysis

A Chi-squared Fisher's Exact test was used to test whether the bee stimulus altered the distribution of counts for different behaviours in the controls compared to the control (behaviour versus treatment interaction). A Mann-Whitney U test was used to test significance in specific behavioural responses between the bee and the control playback. A Pearson's correlation was performed to test whether or not there was a correlation between the number of individuals to show a reaction and the time to show the first reaction. The total percentage was calculated for behavioural response within each playback and the reaction across all playbacks. All statistics and data processing were done within IBM SPSS Statistics Version 22.0 (2010).

Results

Overall, 86.6% of the bee trials, compared to 60% of the control trials, produced a reaction from the resting family units. The number of reactions for each defined behavioural category between the bee and control playbacks (Fig.2) was not significantly different (Fisher's Exact test, $\chi^2 = 4.14$, p>0.23).

The data revealed that more elephants responded to bee sounds with a medium or strong reaction compared to elephants responding to white noise (Chi-squared test 3.39, p>0.06).

The control stimulus produced a slower reaction time (mean of 18.3 s; SE ± 4.5 s; n = 15) compared to the reaction time of the bee trial (mean reaction time = 11.1 s; SE ± 2.8 s; n = 15). The difference between the latency of response for the herds was not significantly different between the bee and control playbacks (Mann-Whitney U, U = 77.50, p>0.145).

Aggressive displays were recorded from 26.6% of the control trials and 33.3% of the bee trials.

Of the family units, 53.3% moved to within the resting area in response to the bee trials compared with the control trials, which was 26.6%. Four family units moved away completely (>20 m) from the resting/shaded area during the bee trial, whereas only one resting family unit moved away during a control trial.

Discussion

Family units showed a greater behavioural reaction to the bee stimulus than to the control stimulus (Fig. 2). A higher proportion of families and a higher number of individuals showed a behavioural reaction to the bee stimulus (86%; 61 individuals) compared to the control stimulus (60%; 35 individuals). Though the response latencies—the latency response between the bee and control playbacks—were not as statistically different.

When all behavioural reactions were compared to one another per playback, the bee stimuli, overall "strength of behavioural" responses, did not display a significant difference from the control. However, when specific behavioural responses were combined in the analysis, a small p-value (0.06) was obtained, testing the medium and strong reaction to the non- and weak reaction between each stimulus.

This study demonstrated that elephants in the north-east of Botswana reacted to the recorded sound of the bees; however, their reactions varied between individuals of the same family and between different family units. The inconsistent behavioural reaction of elephants in response to the playbacks could potentially be related to the current state of the African honeybee population in Botswana. If it is the case that certain elephants "know about" bees as was suggested by King et al. (2007), whereas others do not, then it can be predicted that areas with large bee populations would have an elephant population that shows a strong negative reaction to the sound of bees. Following a study conducted by Lepetu et al. (2009) investigating the potential of the beekeeping industry in Botswana it was revealed that the current beekeeping culture is not well developed and needs to be strengthened for it to be profitable (Government, 2005). The major problems outlined for Botswanan beekeeping are the lack of bee management skills (Lepetu et al. 2009). Additionally, high summer temperatures in Botswana that frequently reach 36ºC–40ºC (Nkemelang et al. 2018) could affect wax consistency and hive cooling capabilities, which might in turn impact honeybees' activity levels, as well as their ability to breed.

Acknowledging non-significant results in HEC mitigation is relevant as it helps prevent the repetition of ineffective strategies and highlights the context-specific nature of such interventions (Catalano et al. 2019). A "one size fits all" approach rarely works to mitigate HEC, as the conflict is related to both location and situational factors (Kiffner et al. 2021). Testing and assessing mitigation methods in HEC priority areas and regions ensures that interventions are both ecologically
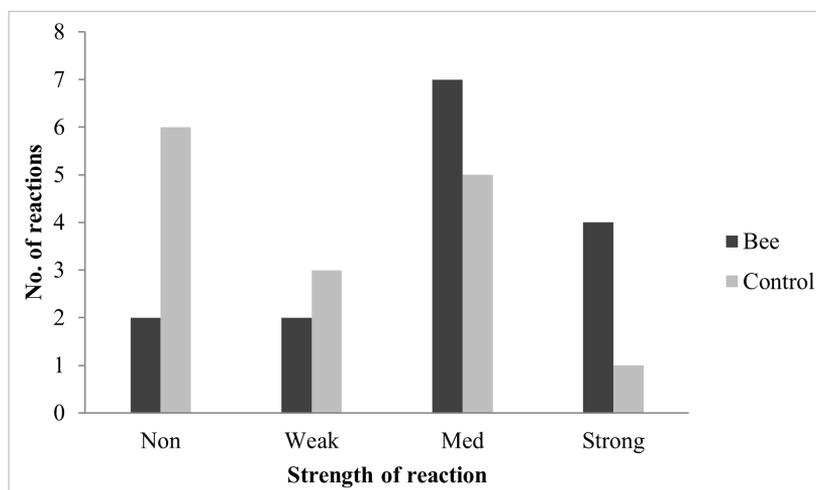

Figure 2. The number of different reactions of the behavioural family unit to both the bee (n=15) and the control playback (n=15).

and socially appropriate, increasing the likelihood of long-term success and community acceptance.

Future research is needed to unravel the relationship between honeybee density and behaviour, and elephant crop-raiding activities in Botswana. This study demonstrates the value of conducting behavioural trials on specific elephant populations under local conditions to gauge reactions to differing deterrents before investing in mitigations. It has been suggested that the function of the elephant's reaction to the sound of bees is one of fear because of the associated sting the bee can deliver, especially in sensitive areas such as the inside of the trunk, eyes and ears (King et al. 2010). However, if an individual or matriarch elephant has never had a negative association with bees, then it may not know how to react. Despite the need for further research, our preliminary results demonstrate that Botswanan elephants did display elevated reactions to the sound of bees. However, it does highlight the value and need to test and trial mitigations first before implementing these management tools more broadly.

Acknowledgements

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