

Abstract

Vocal repertoire and disturbance-associated vocalisations in free-ranging Asian elephants

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Background:

Animals use various signal modalities such as visual, tactile, olfactory, and auditory to communicate with conspecifics. Several studies have shown that group-living animals (including elephants) have evolved well-developed acoustic communication for cohesion and coordination among the group members.

Elephants belong to the order Proboscidea, and the last three remaining species, African Savanna elephants (*Loxodonta africana*), African forest elephants (*Loxodonta cyclotis*), and Asian elephants (*Elephas maximus*) live in substantially different environmental conditions. Due to their gregarious nature and complex social interactions, communication systems are highly evolved in elephants. However, the majority of information on vocal communication system have come from African elephants. Much needs to be understood about the vocal repertoire and the context-dependent vocalisations in free-ranging Asian elephants. Therefore, to understand the vocal communication in Asian elephants, I conducted the study in the protected areas of Bandipur and the adjoining regions of Mudumalai national park, which shelters around 1,300 elephants within an area of 1227 km². The density of Asian elephants in this area is among the highest in India.

Methods:

The first objective was to understand the vocal repertoire of free-ranging Asian elephants. For this, the elephants were followed on foot as long as possible, maintaining a safe distance of 50–100 m between elephants and observers. The vocalisations associated with different behaviours or contexts were categorized as nine broad contexts. Elephants getting disturbed by humans and other species (which included species other than humans and elephants, such as birds, deer,

predators) were broadly categorized as 'disturbance.' Other interactions such as play, affiliative, inter-and intra-group antagonistic interactions, interactions with males, contact, and behaviours while approaching water were broadly categorized as undisturbed states.

Results:

Based on spectrograms and acoustic properties, the calls were classified as four individual calls: *chirps*, *trumpets*, *rumbles*, and *roars*. Two types of combination calls were also identified: *roar-rumble* and *rumble-roar*. I further identified four acoustic signals and classified them as *bark*, *trunk-bounce*, *air-burst*, and *snorts*. Among these call-types, *chirps*, *trumpets*, *rumbles* constitute almost 70% of total calls recorded. The vocal activity was significantly higher in disturbed context than in the undisturbed context.

In my second objective, I further examined the elephant's immediate behavioural responses, including vocal response to disturbance. Disturbance sources were further classified into humans on foot, humans in vehicle, and other species. I found that Asian elephants, moved a greater distance, showed longer vigilance time to humans on foot than vehicular disturbance. The vocal activity seems to vary with the initial distance of the disturbance stimuli. The rate of calling in smaller groups (≤ 5 individuals) observed to be higher than those of larger groups (>5 individuals). The call-types *trumpets*, *chirp*, and *rumbles* were frequently produced during disturbance and did not differ with respect to the type of disturbance. Females (above 10 years) produced more calls when disturbed by humans, whereas females (less than 10 years) appear to produce more calls when disturbed by other species.

The final objective was to elucidate the variations in acoustic properties. From the above results, it was evident that elephants produce similar vocalisations in both disturbed and undisturbed contexts. Therefore, I hypothesized that Asian elephants might use and alter the physical characteristics of their vocal signals in a disturbance state to alert or inform conspecifics about approaching danger. Physical attributes of two vocal signals, *rumbles* and *trumpets*, produced in both contexts were selected for further analyses, and 19 acoustic variables were measured. I found that Asian elephants prolong the duration of *rumbles* (low-frequency calls) and shorten that of *trumpets* (high-frequency calls) when disturbed. During the disturbance, they also lower the mean fundamental frequency (F_0) and mean formant positions (F_1 and F_2) of rumbles, and smaller elephant groups produce a longer duration of rumbles.

Discussion:

In general, free-ranging Asian elephants in my study population produce at least four basic call-types (*chirps*, *trumpets*, *rumbles*, and *roars*), two combination calls (*roar-rumbles*, *rumble-roars*) and four acoustic signals (*bark*, *trunk-bounce*, *air-burst*, and *snorts*). The production and use of these vocalisations in various behavioural contexts appear to be different within and between species. For instance, *chirps* are unique to Asian species. Similarly, *trumpets* and *rumbles* can be observed in both African and Asian species. However, the use of *trumpets* appears to vary within Asian elephants. That is, elephants in Sri Lanka produce *trumpets* only during the disturbance, whereas in this study, population *trumpets* were produced in all contexts. These differences between and within species could be due to geographic separation, social structure, interactions among individuals and possibly due to differences in habitats which the elephants live. Nonetheless, these results suggest that like African species, Asian elephants also exhibit rich vocal repertoire, which is used in various behavioural contexts.

The vocal activity of elephants was observed to be higher during disturbance than in undisturbed conditions (social interactions). Among various disturbance stimuli, elephants show more significant responses to humans, especially when they encountered humans on foot. The observed variations could be due to previous experiences, site-specific differences in the level of threats faced (such as facing human-induced disturbances and predators). The rate of calling was observed to be higher in smaller groups than in larger groups, which could be because smaller groups are exposed to greater threats than bigger groups. However, there were no differences in the type of vocalisations produced to different sources of disturbances indicating that Asian elephants do not follow any specific order during the disturbance.

By comparing vocalisations produced during disturbed and undisturbed states, I further show that Asian elephants modify acoustic properties of not just one but two types of signals which have high (trumpets)- and low-frequency (rumbles) components. In addition, I found that the group size had an influence on the acoustic properties of *rumbles*, i.e., smaller groups produced longer duration calls. These disturbance-induced modulations, especially modulated rumbles, could be an adaptive acoustic mechanism and may serve the functional role of alerting conspecifics about imminent danger.

Conclusion:

Through this study, I show that Asian elephants in southern India produce at least six call-types in various behavioural contexts. Elephants showed more significant responses to humans on foot than humans in vehicle. Moreover, when disturbed, elephants actively modulate both high-and low-frequency sounds, probably to alert the conspecifics about the imminent danger. These results are first insights into context-dependent vocalisations of Asian elephants and further be used to develop site-specific management plans.