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DECIBEL LEVEL OF FIRECRACKERS AND ITS POSSIBLE IMPACT ON THE HEARING OF MARAUDING ELEPHANTS IN SRI LANKA

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Abstract: Today the human-elephant conflict has come to its climax due to rapid urbanization and increase in population of humans as well as elephants in Sri Lanka. As a result damages to humans, crops and properties of the adjacent forest communities by the wild elephants and retaliatory killing of elephants by humans have received wide coverage in the press and media. The Department of Wildlife Conservation (DWC), in an effort to mitigate the escalating conflict, has been providing farmers with powerful firecrackers on a regular basis. It is alleged that the constant use of extremely loud firecrackers in agricultural areas and home gardens by farmers may have impaired the sense of hearing among some elephants thereby making them unresponsive to such deterrents. This research study was carried out to assess the impact of firecrackers on the hearing of elephants in Sri Lanka. The results from our preliminary study show that the decibel levels of the two types of firecrackers used by villagers ranged between 137 and 140 dB at a distance of 30 m. Spectrograms verify that the frequency generated in high sound pressure levels distributed from infra sound region to around 400 Hz. But in some cases the upper limit of the frequency reached even 1000 Hz with the sound pressure level around 125 dB which is the more sensitive range for elephants. Most of the time villagers throw crackers on to the body of the elephant itself, in which case, the high decibel level of the firecrackers could seriously impair its hearing.

Keywords: Elephant, Human-Elephant Conflict, Firecrackers, Spectrogram, Deafness, dB levels,

Introduction

One of the commonest methods used to chase marauding elephants off agricultural fields in Sri Lanka is by throwing firecrackers at them. Farmers faced with chronic crop raiding elephants try a variety of methods to stop their depredation of which the use of

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firecrackers has become routine. The Department of Wildlife Conservation (DWC), in an effort to mitigate the escalating conflict between man and elephant has been providing farmers with powerful firecrackers on a regular basis. In addition, villagers too buy firecrackers on their own to throw at elephants as a last ditch effort to keep them at bay. Elephants being extremely intelligent, soon come to differentiate between the weak and the powerful firecrackers. They seem to be wary of loud explosions, especially if they happened to go off very close to where they are. It is alleged that the constant use of extremely loud firecrackers in agricultural areas and home gardens by farmers may have impaired the sense of hearing among some elephants. Such "deaf" elephants will no longer be able to respond to shouts or noise made by farmers and hence may stray deeper into cultivated areas and linger longer thereby facing the danger of being killed by farmers in sheer desperation. The present study was carried out to understand the problem given that to date no one has attempted to assess the impact of firecrackers on the hearing of elephants in Sri Lanka.

Humans and animals can hear a wide range of sound frequencies, pitches or tones. If the sense of hearing is impaired, both man and elephant cannot fare well in their respective environments. Elephants typically do not have as far reaching eyesight as humans do, but their sense of smell is unparalleled given that they are able to track the location of family members by even sniffing their urine (McKenna, 2007; Bates *et al.*, 2008). In addition, they are capable of hearing sound well below human hearing limitation, from 5 Hz to 12,000 Hz. A normal human being can hear sound frequencies between 20 Hz and 20,000 Hz. Elephants can hear very low frequency sound (best sensitivity at 1,000 Hz) extending into the infrasound region (Heffner & Heffner, 1980; Reuter & Nummela, 1998), but their threshold for high-pitched sound is somewhat lower than that of human beings.

Sound can reach the mammalian inner ear via two routes: through (a) the air (air-conducted) and (b) the bones (bone-conducted) effective in aquatic and fossorial mammals (Reuter & Nummela, 1998). The intensity of sound is measured in decibels (dB). Decibel is a logarithmic unit used to describe the ratios of sound pressures; measured and the reference. By definition the sound pressure level in decibel scale is given by the following equation:-

$$dB = 20 \log \left(\frac{P}{P_0}\right)$$

Where the P is the measured pressure and the P_0 is the reference pressure, 2×10^{-5} N m^{-2}. It is clear from the above expression that the sound pressure level variation with the sound

pressure is not linear. That means when the sound pressure doubles the sound intensity level does not double, instead it increases by just 6 decibels.

The human ear is an extremely sensitive organ that can hear from the smallest audible sound such as a whisper (30 dB) to that of a gunshot (140 dB). In the case of humans, constant exposure to sound of 90-95 dB may lead to a loss of hearing, while exposure to sound at 125 dB is extremely painful; and at 140 dB even short exposure would lead to permanent ear damage. Therefore, given that the elephant's upper limit of hearing is slightly less than that of ours, we expect the use of loud firecrackers at close range may seriously impair the elephant's sense of hearing. Distance also affects the intensity of sound – if an animal is far away, the power is greatly diminished.

Methodology

Three types of firecrackers, large, small and one referred to as "signal" issued by the Department of Wildlife Conservation (DWC) were used in the experiment to determine their decibel levels at various distances from the target. The large and small crackers are designed to produce loud sound whereas the "signal" firecracker is designed to jump up and down once it explodes. The experiment was conducted at an open field at University of Ruhuna (Sri Lanka) and in a home garden at a southern border village in Hambantota (Sri Lanka) in 2011, using microphones, preamplifier, conditioning amplifier and signal acquisition device. Three Bruel & Kjaer type 4198 pre-polarized, free-field ½" microphones, stable under a variety of conditions were used. Sensitivity of the microphones was 50 mV/Pa. The frequency response of ±1 dB ranged from 10 Hz to 8 kHz and of ±2 dB from 6.3 Hz to 16 kHz. The preamplifier 2669C had wide frequency and dynamic ranges with low noise and operated over a wide range of temperatures, humidity and other environmental conditions. 2690 Nexus conditioning amplifier was used with NI 4472, 24 bits resolution, high-performance and high accuracy dynamic signal acquisition device. Experimental setup was calibrated using B&K sound calibrator type 4231. Wind screens were used to reduce the ambient wind noise. The sampling rate was set to 100,000 per second. The data was analyzed using MATLAB software.

Results

Fig. 1 illustrates the variations in sound level with distance as measured in the case of the three types of firecrackers issued by the DWC on an open area.

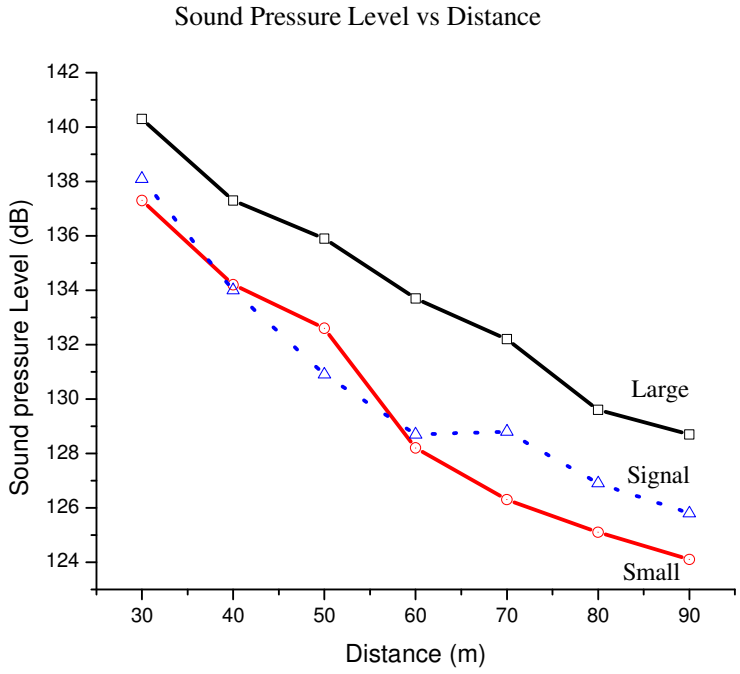

Fig. 1. Sound pressure level variation with distance measured in the case of the large, small and "signal" firecrackers on an open field at University of Ruhuna, Sri Lanka.

Fig. 1 shows how the sound pressure level (calculated using $2x10^{-5}$ N m^{-2} as reference) varies with distance from the point of explosion, as measured on an open field using the three different types of firecrackers issued by the DWC. Due to high sound pressure produced by the crackers and the inherent limitations of the instrument used, the closest distance at which an accurate measurement could be made was 30 m from the point of explosion.

Even at 30 m distance from the point of explosion, the sound pressure levels recorded for all large, small and "signal" crackers ranged between 137 to 140 dB. The uncertainty of the microphone reading in this frequency range was ±1 dB. Both "signal" type and the small cracker produced the same sound level but the large type has about 3 dB more than the other two at 30 m distance, and such a difference increased with distance away from the explosion point.

Three microphones were placed at 10 m intervals. There was variation in the quality of the firecrackers. The sound intensity produced by the firecrackers produced different intensity of sound at the same distance. As a result, the last three sound intensities from the "signal" type were higher than that from the small firecracker (Fig. 1). Furthermore, from Fig. 1 it appears that the variation of attenuation of sound intensity is a function of the firecracker. Sound

levels produced by small firecracker attenuate more rapidly than those produced by the larger one.

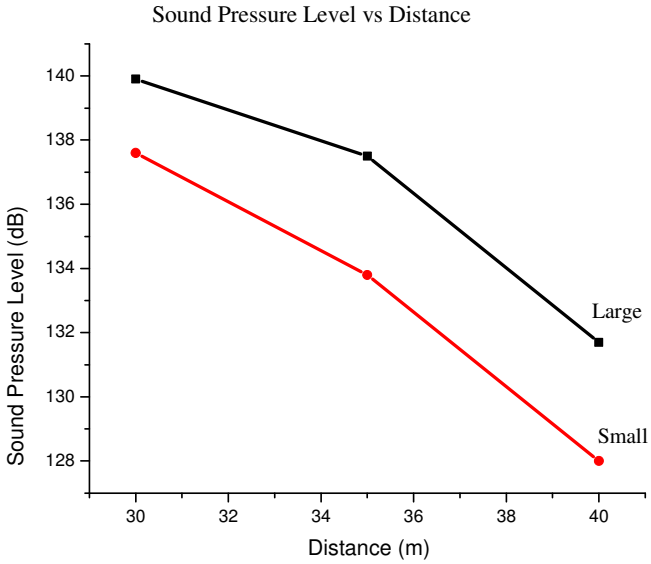

Fig. 2. Sound pressure level variation with distance measured in the case of large and small firecrackers in a southern border village, near Hambantota, Sri Lanka.

As can be seen from Fig. 2, the closest distance to make an accurate measurement of sound pressure was at 30 m from the point of explosion. Owing to many restrictions, only three measurements were taken at 30, 35 and 40 m from the point of explosion, using two types of firecrackers, large and small. At 30 m distance, the sound pressure level of both firecrackers was between the 137 and 140 dB range, similar to that recorded on the open ground.

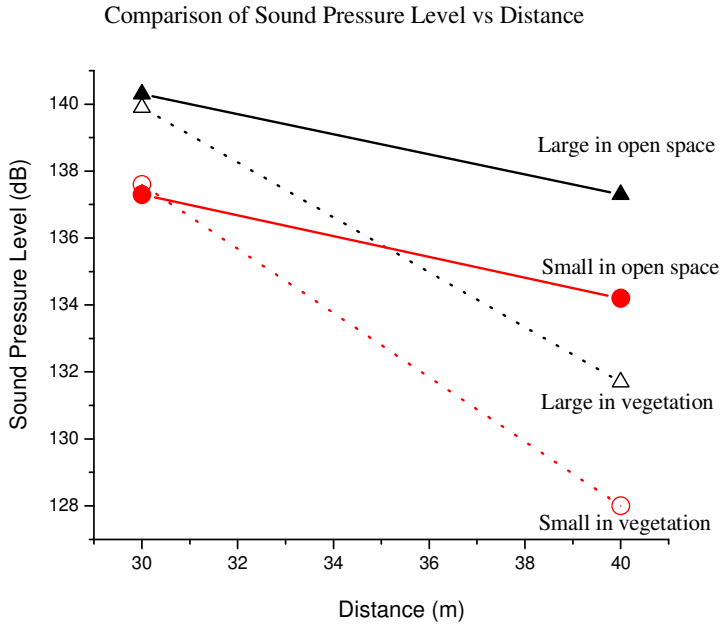

Fig. 3. Comparison of sound pressure level variation with distance measured for large and small type crackers in both open and border village areas

Fig. 3 shows the comparison of the variation in the sound intensity level within 30 – 40 m from the point of explosion measured on the open ground and in the home garden in the border village. The attenuation of sound intensity level in the village is much higher than that on the open ground. As seen in Fig. 3, within 10 m range on the open ground the sound pressure level attenuated by 0.3 dB for every one meter distance while this decay in the village area was in the range of 0.8 - 1.0 dB per meter. This shows that the propagation of sound wave is influenced by both geometrical spreading and access attenuation. Though the geometrical spreading is similar in both cases, access attenuation is high in village area.

Fig. 4 shows the spectrograms of both large and small firecrackers measured at 30 m from the blasting point. Frequency distribution during the blast is almost the same in both cases. The frequency generated in high sound pressure levels distributed from infra sound region to around 400 Hz. But for large firecrackers, the upper limit of the frequency even increases to 1000 Hz with the sound pressure level around 125 dB. It should be noted that the elephants are more sensitive to 1000 Hz frequency (Heffner & Heffner, 1980; Reuter & Nummela, 1998). Spectrograms also verify the sound pressure levels generated by firecrackers are increased instantly up to 140 dB and the level retain few milliseconds with the background noise.

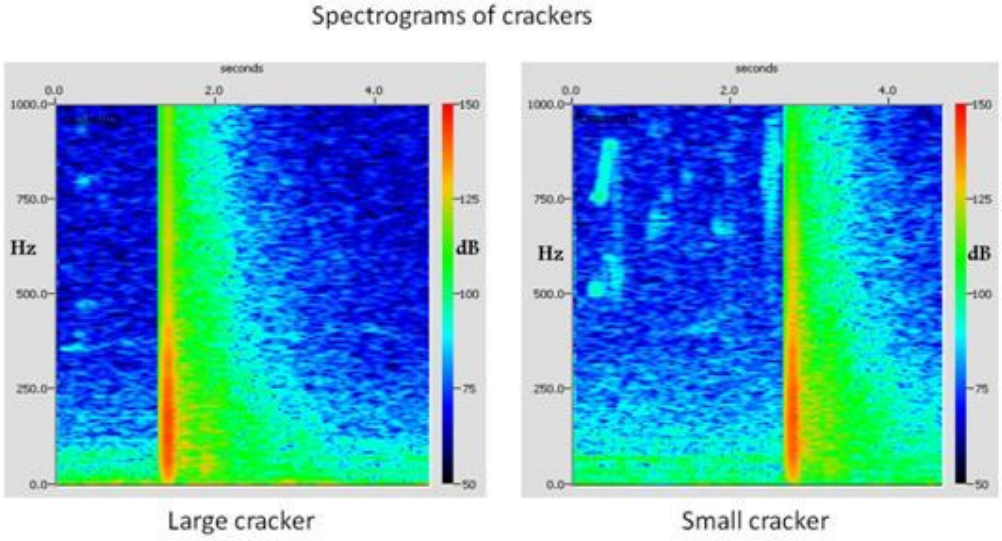

Fig. 4. Spectrograms of large and small crackers. Horizontal axis reads the time in seconds, and vertical axis reads frequency in Hz. The color of spectrogram represents the sound pressure level in dB according to the given scale in right side of the graph.

Discussion

Of all the vertebrates, it is only the mammals that can hear high-frequency sounds. However mammals differ in their ability to hear high-frequency sounds. While a healthy human being can hear a frequency range from 20-20,000 Hz, an elephant's hearing range lies between 5-12,000 Hz. Elephants seem to hear well low frequency sounds. High frequency hearing has been shown to be correlated not with body weight but with the functional distance (i.e. the interaural distance divided by the speed of sound) between the two ears (Bates *et al*., 2008). This is the reason why small mammals such as shrews are better able to hear high frequency sounds compared to such large mammals as elephants. Loudness is subjective and varies from people to people with age. Similarly, elephants too could differ in their perception of sound, with young animals being more sensitive than older ones. Loud explosions that peak for a few milliseconds at levels greater than 130-140 dB are known to cause loss of hearing in man. The human audiogram and that of the elephant are essentially similar in shape.

The results from our preliminary study show that the decibel levels of the two types of firecrackers used by villagers range between 137 and 140 dB at a distance of 30 m. Human hearing will certainly be impaired if exposed constantly to such high sound levels. Given that the audiograms for both man and elephant are very similar, we suspect that even elephants subject to such high intensity sound constantly could be affected. But elephants can also use their pillar-like bones in their legs to conduct the surface waves to the inner ear (Reuter & Nummela, 1998). But the fact that some individual bull elephants seem to be unaffected by loud noise and linger in human settlements and raid crops indicates that they may be partially deaf or very old and thus insensitive to the impact of fire crackers. Hearing range can decrease after long-term or constant exposure to loud noise. The Department of Wildlife Conservation (DWC) provides extremely powerful firecrackers to the villagers for use against marauding elephants. However, given that the demand for such firecrackers exceeds the supply, the DWC invariably provides just 3 firecrackers per family per month in areas of high human-elephant conflict. As a result, the families reserve these firecrackers as a last ditch defense against marauding elephants, and throw them only when an animal is close enough, often on the body itself, in which case, the high decibel level of the firecrackers could seriously damage the hearing in elephants. Thus conservation education programs need to be carried out in villages to offer alternative solutions to mitigate the conflict between man and elephant.

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