Using Infrasound to Prevent Elephant Deaths in Railway Accidents

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Abstract: *As high-speed rail infrastructure is being developed at breakneck pace throughout India, rail accidents are becoming more frequent. While the number of people killed or injured in such accidents is well-documented, little research has been done to analyse the number of animal casualties in Indian railways. This paper examines the causes of such accidents, the need to prevent them, current preventive methods being employed by the Government and proposes a novel solution to overcome this problem.*

Keywords – *Infrasound, Doppler Effect, Reverse Square Law, Newton-Laplace equation*

I. INTRODUCTION

In the past decade, tracks running through protected forest areas have been converted from meter gauge to broad gauge, allowing the trains to run faster than before. Furthermore, movement of goods train has also increased in the last four years. This scenario is apparent in Eastern and North Eastern states where railway tracks run through forest areas to transport raw materials like coal and iron ore from the mines to the industry. Goods trains pass through prime forest areas at odd hours, including the periods when animals go out searching for food; thus, contributing to a rise in accidents involving various species.

According to a recent survey by *Wildlife Trust of India (WTI),* 72 animals are dying each year due to collision with speeding trains. One of the major victims of the train accidents is the Asian elephant, with more than 170 train-hit deaths recorded since 1987 (as per a 2010 report by the *Elephant Task Force*). Other animals affected include leopards, cows, deer etc.

II. STATISTICAL FIGURES AND OVERVIEW OF THE PROBLEM

Elephant deaths in railway accidents have been reported from numerous parts of India; however, the problem is prevalent in the North East, including the states of Assam (*see Fig.1 and Fig.2*), West Bengal, Uttarakhand and certain areas of Jharkhand and Orissa. Of the total death since 1987, Assam tops the list with 36% of the casualties; West Bengal is second with 26% and Uttarakhand third with 14%.

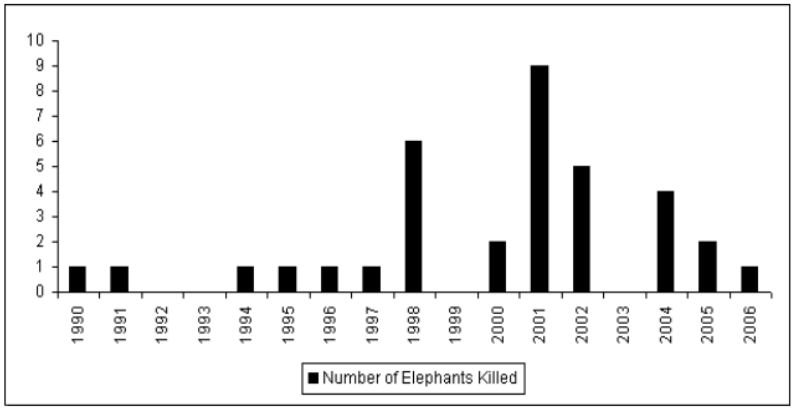

Fig.1 Elephant mortality due to train hit in Assam between 1990 and May 2006

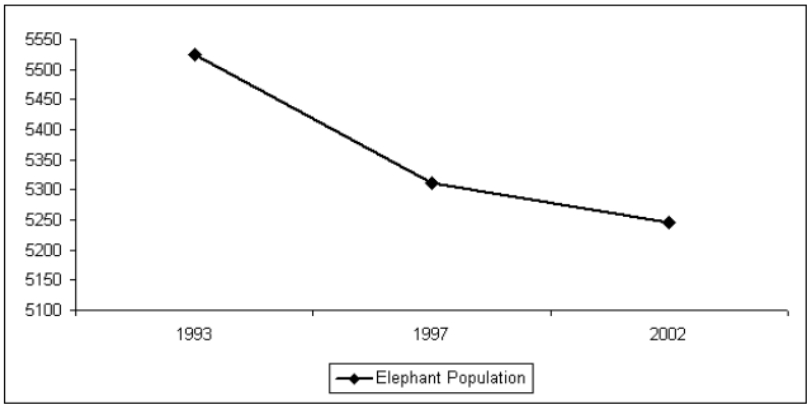

Fig.2 Trend of elephant population in Assam between 1993 and 2002

However, only recently, there has been a drastic rise in the deaths in West Bengal. According to forest officials, there are three main migratory herds of elephants which walk the forests of north Bengal while migrating to and fro between Assam and Nepal. The railway tracks pass through the migratory corridors at 15 places. Since 2000, when locomotives began using the 120km Siliguri-Alipurduar rail route, there have been 10 elephant deaths. The situation in Bengal worsened so much that the Supreme Court in 2013 labelled the Gulma-Alipurduar track, which claimed 40 lives in a period of ten years, as a death trap for elephants and prohibited trains from using the track at night. The aggregate death toll in West Bengal since 1974 has been 70. More than 28 elephants have died in the past five years alone.

III. PAST INCIDENTS

Description of some accidents:

- The *2013 Chapramari Forest train accident* occurred in the eastern area of the Chapramari Wildlife Sanctuary, West Bengal. The accident killed or injured 17 Indian elephants and has been described as the worst of its kind in recent history. An Assam-bound passenger train travelling through the forest collided with a herd of 40–50 Indian elephants. The track was reopened for service after 12 hours. The train was travelling at 80 km/h even though guidelines specify a limit of 40 km/h.

- In November 2010, at least seven elephants were mowed down by a passenger train in Upper Assam before the engine derailed.

- In 2004, an elephant calf was fatally injured in a train accident at Mahanadi wildlife sanctuary in West Bengal. The elephant was hit by a goods train while crossing a railway line on the outskirts of the sanctuary in Siliguri, in search of food in the nearby fields.

IV. FACTORS CONTRIBUTING TO SUCH ACCIDENTS

- The National Wildlife Action Plan (2002-2016) prescribes regulations and mitigation measures, such as slowing traffic speed, providing wildlife crossing structures and increasing driver awareness. But such measures have been rarely implemented on the ground.

- Trains operating during night-time don't take extra precautions. The risk of damage increases after sundown since that is when the wild animals are more active and the visibility is poor.

- Conversion of meter gauge to broad gauge along forested areas has allowed trains to run faster than before. Sometimes the prescribed speed limit is also violated.

- Inefficient and inadequate current methods being employed (discussed later in the document).

It is ironic how the mascot of the Indian railways- the elephant calf- is its biggest victim.

V. THE NEED TO PREVENT SUCH ACCIDENTS

These accidents are detrimental to both the animal and the human community and lead to:

- Injury to, or death of, vehicle occupants. While animals may be the primary victims, vehicle occupants may also suffer unforeseen injuries.
- Harm to endangered species and wildlife population. The number of deaths due to accidents rivals those due to poaching as a key threat to elephants in India.
- Vehicle damage
- Economic losses incurred (repairing vehicles, cleaning up, providing compensation to victims etc.)
- Accidents result in delay in time/schedule of train. The delay caused has a domino effect since schedule of other trains is also affected, resulting in gross inconvenience. For e.g., after the Chapramari Forest train accident in 2013, the track was closed for over 12 hours, delaying multiple passenger and freight trains.

VI. CURRENT METHODS BEING EMPLOYED AND PROSPECTIVE METHODS

The current methods being employed by the railways to prevent such accidents include: installation of warning signs to prompt the drivers to decrease speed near regions which thrive with wildlife and night patrols along the tracks to inform necessary authorities of any wildlife spotted nearby. However it has been reported that drivers go over the speed limit and are unable to stop the train in time to avoid the accident. Also, regular night patrols are very laborious and have not brought about the desired change.

Certain novel solutions proposed include using electrical fencing and motion sensors (being developed by IIT-Delhi) to warn drivers of any animals near the tracks. Both these proposals have mutual problems. In order to achieve the desired goal, innumerable sensors/fences will have to be used to cover hundreds of kilometres of railway tracks which is financially impractical. What's more, the maintenance will be painstaking and time consuming.

Another factor to consider here is human intervention. While the sensors can provide a warning, the train will be stopped by the driver. And it may so happen that the driver is unable to stop the train in time since wherever there is human intervention, there is a chance for error. Our proposed mechanism is void of any human intervention and hence void of chances for such errors.

VII. OUR PROPOSAL

VII.I WHAT WE INTEND TO ACHIEVE

We propose to use sound waves to repel elephants from the tracks of an approaching train and hence prevent such fatalities. Elephants have an audibility range of 12-12000 Hz and can hear infrasound. Through experimental means, a particular frequency can be determined at which the animal experiences minor irritation. A device emitting the sound of this frequency can be placed in trains and switched on when the train is passing through areas which abound with elephants. This can either be done manually or done automatically using a GPS which will work along with the device. The device itself will produce the sound using a java program that we have written.

Although the idea of repelling animals using sound waves has been floating around for quite some time, what makes our proposal unique is that we have taken into account various factors which will affect the emitted sound's frequency. Air temperature and the speed of the train will be taken into account and amendments to the emitted frequency will be made using the Doppler Effect formula (*see Fig.3)*.

$$f^\circ = \left(\frac{v - v_o}{v - v_s}\right) f'$$

$f^\circ = frequency\ of\ observed\ sound$

Kept constant=14Hz

$v = velocity\ of\ sound$

Calculated using the formula: $v = (331.3 + 0.606T) m/s$

T is taken as input

$v_o = velocity\ of\ observer/elephant$

Was taken to be zero

$f' = frequency\ of\ emitted\ sound$

Calculated using program

$v_s = velocity\ of\ source/train$

Taken as input

NOTE:

1. f° above denotes the value of the irritation causing frequency. Here we have assumed it to be 14Hz; actual value may differ.
2. The formula for velocity is derived from the Taylor expansion of the Newton-Laplace equation.

Fig.3 The formulae used

VII.II JAVA PROGRAM SOURCE CODE

Click here

In case the hyperlink is not working, please paste the following in your browser- https://drive.google.com/file/d/0B9AxKx4WpZ9acmJiY3IyQkdaZnc/view?usp=sharing

VII.III INFRASOUND AND ELEPHNATS

Elephants react to infrasound. This is one of the reasons they're so quick to react when a natural disaster is looming, such as an earthquake. Big storms such as hurricanes produce their own distinctive infrasonic signature. Similarly, earthquakes can produce several distinct infrasound pulses that can travel thousands of miles. Elephants, after hearing these waves, tend to run away even before the disaster strike.

VII.IV BACKGROUND NOISE

Since we plan to emit low frequency sound, a difficulty which may arise is the signal to noise ratio. In the lower frequencies, there tends to be a higher level of background noise, which, in this case, may be the noise produced by a moving train. But animals that specialize in low frequency hearing have adapted in such a way that they can distinguish the signal from noise. The amount of sound energy collected by the tympanic membrane increases with increase in membrane area; thus, enhancing the signal to noise ratio at the level of the inner ear and enabling the animal to hear better.

Such is the case in elephants and hence they are able to communicate with one another using infrasonic sound. The relatively larger ossicles (middle ear bones) are able to withstand the great force produced by vibrations of the tympanic membrane. Hence, any noise produced by the train itself while moving on the tracks will not affect the final outcome.

VII.V REVERSE SQUARE LAW

Sound travelling through air diminishes by the reverse square law at 6 decibels (dB) for every doubling of the distance from the source. Thus, for example, a sound measuring 100 dB at one meter from the source will be reduced to 94 dB at 2 meters, 88 at 4 meters, 82 dB at 8 meters, and so on.

But elephants have an excellent ability to pick up even the faintest of sounds. Some elephant-produced calls are exceedingly powerful and may reach up to 112 dB at 1 meter from the source. Using the reverse square law we can estimate that a call of 112 dB at 1 m would be around 46 dB at 2,048 m from the source. It has been shown that elephants are able to both detect these infrasonic calls and recognize the voices of particular individuals up to 2.5 km from the source.

The infrasonic waves we propose to emit will be detected by the animal from large distances; hence, the animal will have sufficient time to move away from the tracks when a train is approaching.

VII.VI ADVERSE EFFECTS

One may have apprehensions whether infrasound will have negative consequences on other species. Honey bees, in particular, are known to be sensitive towards sound waves. But after extensive research, we have found that bees serve as a natural repellent to elephants. Hence the elephant population and the bee population are completely segregated. Since the device emitting the sound will be switched on in particular areas only, (as mentioned previously) bees will not be adversely affected.

As far as other wildlife species are concerned, it is evident from *Table 1 (below)* that the audibility range of commonly found animals in the North-East area of India does not include frequencies as low as12-15Hz; hence, there will no affect on these animals.

Animal	Frequency (Hz)
Dog	67-45,000
Horse	55-33,500
Sheep	100-30,000
Rabbit	360-42,000
Hedgehog	250-45,000
Raccoon	100-40,000
Ferret	16-44,000
Opossum	500-64,000
Cow	23-35,000
Cat	45-64,000
Tiger	20-65000

Table 1: The audibility range of certain animals

If we talk about elephants, since the infrasound will only cause momentary irritation, it will have no adverse effect on the animal's natural feeding or breeding ground.

VIII. CONCLUSION

Studies have shown that wild animals known to hear infrasound are becoming desensitized to low frequency sounds. Researchers hypothesize that this may be due to the increased exposure of animals to infrasound, a direct consequence of urbanization of deforested land. Therefore, to overcome this hindrance, our device can be made to emit sounds that elephants make to alert other members of the heard of an impending danger. While this sound lies in the infrasonic region as well, it is not as low as 12-15Hz. *ElephantVoices*, an organization dedicated to studying social behaviours of elephants had documented that the warning call of elephants consists of "*a sharp snort or snort-rumble"*. Immediately following a snort given in this context, a number of soft, medium length rumbles may then be heard.

The next step will be to test our program on elephants. We have contacted the Delhi Zoo seeking permission to perform our tests.

PRESENTAION

To view our presentation on this project, please click here.

In case the hyperlink is not working, please paste the following in your browser- http://prezi.com/k6w2rrkoilkm/?utm_campaign=share&utm_medium=copy&rc=ex0share

ACKNOWLEDGEMENTS

We wish to express our most sincere gratitude and appreciation for our teachers, Ms. Monika Sen Chaudhury and Ms. Priyadarshinee Ghose for their guidance and relentless support.

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