An IoT-Powered Naval Defense against Bat Attacks in Indian Fruit Crops, an Effective Precaution against Nipah Virus

Tiji Tom

JPM Arts and Science College Labbakkada, Kerala, Idukki, Kerala, India

DOI: https://doi.org/10.51584/IJRIAS.2025.100500093

Received: 26 May 2025; Accepted: 02 June 2025; Published: 17 June 2025

ABSTRACT

Fruit bats, often known as flying foxes, are essential pollinators and seed dispersers in many environments. It is critical for ecological research and conservation efforts to study their behaviour and population dynamics. The article investigates the application of machine learning approaches to automate the detection and interpretation of fruit bats by using ultrasonic sound ranges of fruit bats, allowing for non-invasive monitoring and data collecting. Fruit bats can cause damage to fruit farms; however, we can employ IoT sensor networks and powerful machine-learning technologies to quickly identify and prevent fruit bat attacks in fruit plantations in India. Machine learning techniques can be used to identify and analyses ultrasonic (beyond the range of human hearing) noises. This is very significant in domains such as biology (for example, bat echolocation), industrial inspection (for example, identifying ultrasonic equipment abnormalities), and others. Developing an IoT network to identify fruit bats using ultrasonic noises includes several technologies, including IoT devices, ultrasonic sensors, data processing, and machine learning.

Keywords: Fruit Bats, Fruit bat attacks, machine learning, IoT, IoT sensor network, MFCC algorithm, Ultrasonic sensors, NIPA viruses Introduction

INTRODUCTION

Fruit bats are keystone species in many habitats, which means their presence or absence has a substantial influence on the general health and functioning of those ecosystems. Protecting fruit bat populations and habitats is critical not just for their survival, but also for the well-being of many other species and the overall ecological balance. Conservation activities focused at protecting these creatures are critical for sustaining biodiversity and ecological health. Bat attacks on fruit plantations can have serious ecological and economic consequences. While bats are important pollinators and pest controllers in ecosystems, they may also harm fruit crops under certain conditions. We cannot kill bats because they have a significant influence on biodiversity. As a result, we can only utilise non-harmful preventive methods to protect fruit crops from their attacks.

According to Juliet Pulliam, an epidemiologist at South Africa's Stellenbosch University. “Bats are very messy eaters, “They slobber everywhere and drop things while eating." They also urinate and defecate to lessen the weight before taking off[1]. These propagate dangerous viruses all throughout the world, particularly in South India. Following the 2018 outbreak, public health officials launched a campaign to discourage citizens from eating fruit with bite marks or doing anything else that would disrupt flying fox colonies [1]. Residents, though, claim the bats are becoming increasingly impossible to avoid. The Indian flying fox, like other fruit bats, may act as a natural reservoir for illnesses such as nipaviruses and flaviviruses [2]. These are fatal to both people and domestic animals. Nipah virus, a kind of nipavirus, has been found in Indian flying foxes in India and Bangladesh. Because of human encroachment on their habitats, there is a considerable chance of Nipah virus infection spreading from Indian flying foxes to people [3].

Fig. 1: Fruit bats eating various fruits commonly seen in Kerala [6][7][8][9].

LITERATURE REVIEW

According to research conducted in India, Indian flying foxes caused the most damage to mango, guava and Rambutan crops out of all orchard crops. However, an estimated 60% of the fruits destroyed by the flying foxes were ripe or overripe; overripe fruits are approximately half the value of ripe fruits.[4]. Fruit bats devastate fruit orchards, with 7-76% fruit loss per tree. Damage is more severe in taller lychee trees than in smaller ones[22].

The following are some of the most prevalent fruit bat damage in fruit crops.

- Fruit Damage: Bats that primarily feed on fruits and nectar can cause harm to fruit plantations by damaging or consuming a portion of the crop. This can result in fruits being left eaten or bruised making them unsuitable, for sale in the market.

- Economic Losses: When bats damage fruit crops it leads to losses for fruit growers. The reduced yield and quality of the fruits can result in profits and increased production costs.

- Disease Transmission: Fruit bats are carriers of diseases like Hendra virus and Nipah virus, which can be transmitted to humans and other animals. This poses a health risk to both farmers and consumers.

- Stress on Fruit Trees: Frequent visits by bats to fruit plantations can cause stress to fruit trees. Bats may disrupt the trees by roosting in them resulting in damage to branches or leaves.

- Noise and Odor: Large bat colonies can generate noise and odors that may disrupt residents or workers, in fruit plantations making it an unpleasant experience.

Another most dangerous outbreak caused by fruits bats is theNipah virus . Nipah virus (NiV) outbreaks linked to fruit bats have previously been observed in the Indian state of Kerala. Fruit bats, notably the Indian flying fox (Pteropus medius), are recognised to be the Nipah virus's natural reservoir hosts.[27]In May 2018, the fear of bats grew in Kerala as 17 out of 19 infected individuals in Kozhikode and Malappuram districts succumbed to the Nipah virus. A year later, NiV reappeared in Ernakulam in June 2019. Recently, the virus was reported for the third time in Kozhikode and claimed the life of a 12-year-old boy[5]. However, all primary contacts of the boy tested negative for the virus. Despite this, people who have bats living around them still fear the possibility of infection[5].

[27]The Nipah virus was first discovered in Malaysia's Kampung Sungai Nipah in 1998. In 2001, it appeared in Bangladesh and infected 65 people in Siliguri, West Bengal, India, resulting in 45 fatalities. Some Nipah virus infections have also been recorded in Kerala in September 2023.As a result, precautions must be taken to avoid fruit bat attacks in impacted fruit farms[5].

METHODOLOGY

One of the topics discussed in this paper is how to prevent fruit bats from damaging fruit plantations. Mitigating the damage caused by fruit bats in orchards can prove challenging, but effective measures can be implemented to minimize their impact. Given that fruit bats are naturally attracted to orchards because of the abundance of ripe fruits, the key is to make the orchard less appealing and erect barriers to deter them.

Workflow

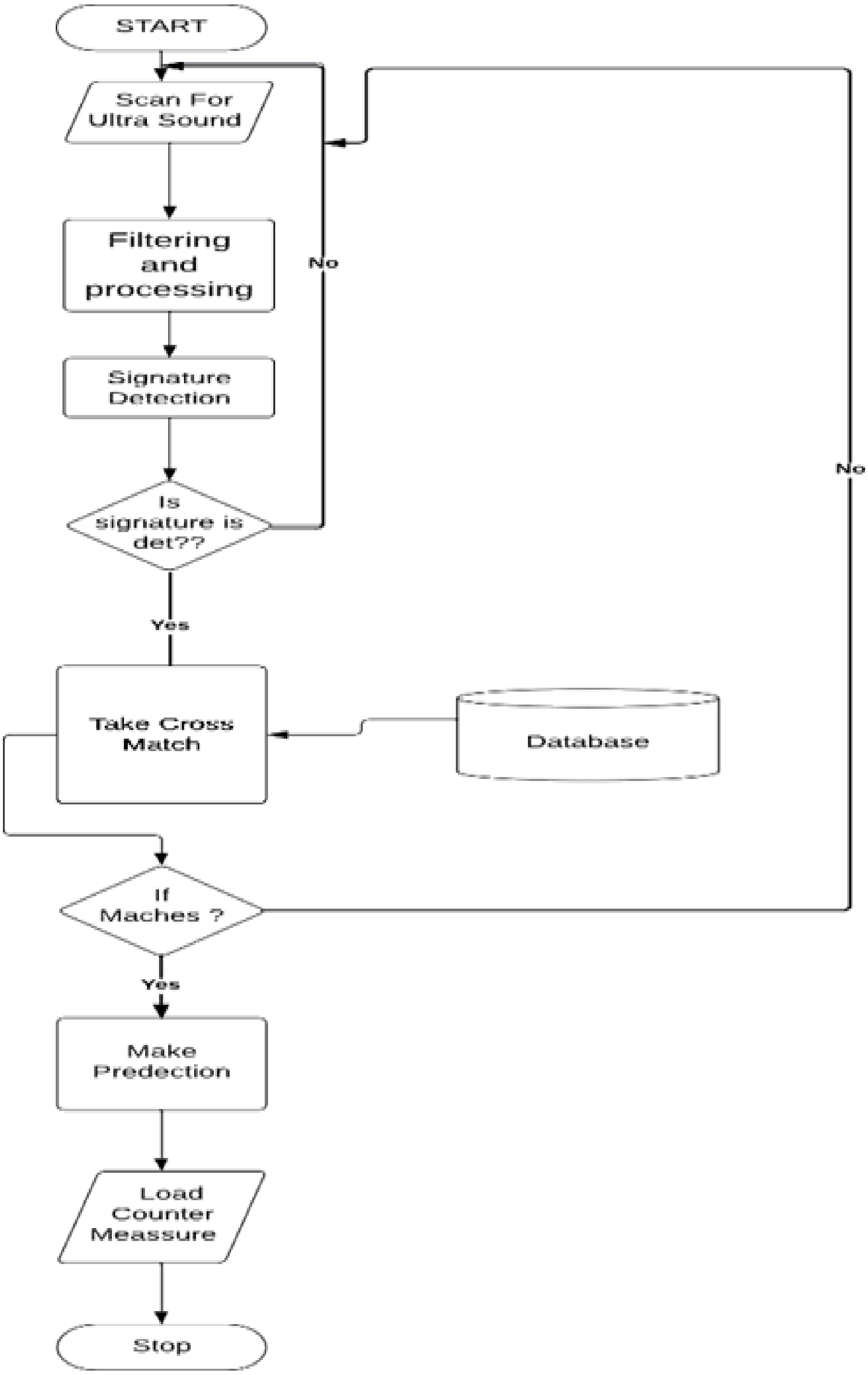

Fig. 2 Flowchart for the IoT model of Fruit bat prediction and prevention System

Echolocation call recording and analysis are key approaches for studying bat distribution, ecology, and behaviour. However, identifying bats in flight using echolocation sounds is not always achievable. In contrast to bird melodies, bat cries vary greatly, making identification difficult [13]. Because many birds are considerably more readily observable by sound than by eyesight or other signs, the audio modality is well-suited to bird monitoring[15]. The frequencies at which fruit bats make their echolocation sounds vary per species, although they commonly lie between 20 and 100 kHz (kilohertz). Humans can normally hear noises in the 20 Hz (hertz) to 20 kHz range, therefore fruit bat echolocation calls are generally above our hearing capabilities. Detecting bats through sound alone can be challenging, as they are difficult to spot visually. We recommend using acoustic sensors that can capture ultra-frequency sound to gain more accurate results. By applying machine-learning techniques to filter and analyse the recorded sound, we can accurately detect the presence of bats in the orchard. The IoT-based working model of the Fruit bat prediction and prevention system is demonstrated in Figure.

Several datasets are available for detecting fruit bat noises. Prat et al. give one dataset that contains continuously recorded vocalisations of Egyptian fruit bats in a laboratory context. The collection comprises around 300,000 files, each a few seconds long, reflecting the bats' entire vocal range. An estimated 90,000 files are annotated with information on the people engaged, their behaviours, and the context of their vocal exchanges [18]. Surlykke et al. report another dataset in which a Support Vector Machine (SVM) classifier was employed to categorise bat sounds from a two-month study of echolocating bats. [28]The collection was whittled down to 162 MiB of potential bat sounds, with an estimated accuracy of 96% for dry nights and 70% for wet nights [19]. Skowronski and Fenton investigated multiple algorithms for automated call detection in bat surveys and discovered that the links detector, a model-based analytical technique, was more accurate than other detectors [20]. Andreassen et al. also conducted research that used automated multi-channel surveys to categorise bat sounds and non-bat events, yielding a dataset of 162 MB of high-accuracy candidate bat calls [21].

The most commonly used and most effective machine-learning algorithm for audio processing and feature extraction is the MFCC algorithm. Following input from the fruit garden's surroundings via a microphone, an audio analysis is performed. The system's architecture includes manipulating the input audio stream. The input signal is subjected to a number of procedures at different stages, including windowing, framing, pre-emphasis, Mel Cepstrum analysis, and matching (or recognition) of high-frequency audio disturbances[29].

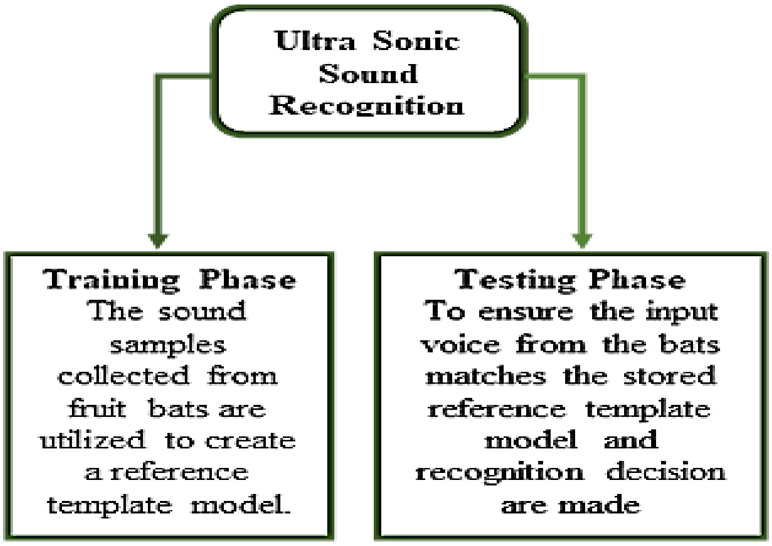

Fig. 3 Phases of Ultrasonic sound recognition algorithm

Training Phase

At this point, the system will be trained by producing training groups comprised of various sound samples taken from the fruit garden, from which the system will be able to develop its own sound database by picking samples with greater precision and purity as shown in Fig 4[10].

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

For training, at least 5 sample sounds from bat species, filtering the sample using the MFCC algorithm. Then take the sample with the highest match with more purity and store it in the system database.

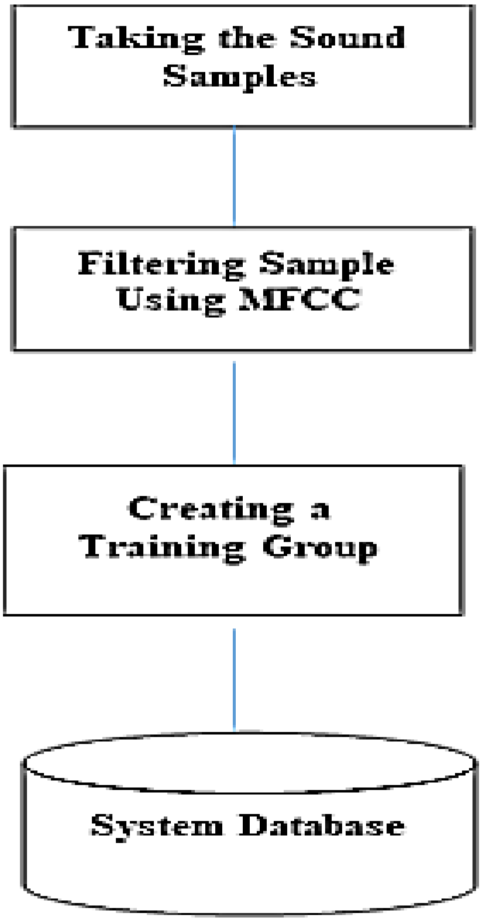

Fig 4. Training Phase

[11]MFCC is utilized in the feature extraction process to produce a more compact and less redundant representation of the representative voice from the input voice. [11]The DTW algorithm will be used to classify speech patterns. The DTW speech pattern classification module is crucial because it is utilized to find the best path between the input voice and the reference voice in the database [11].

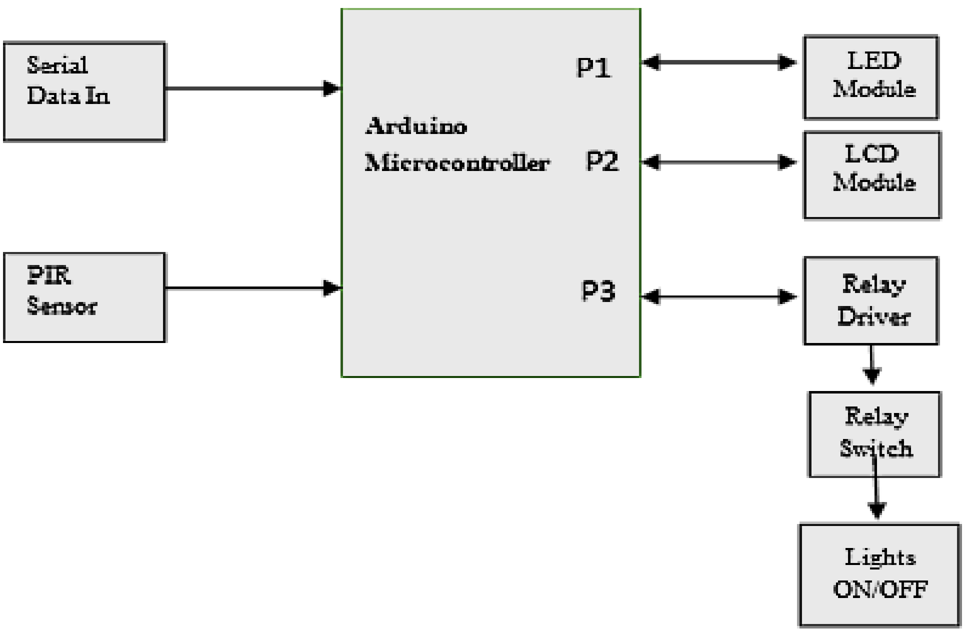

Fig.5 Bat Prevention Module

RESULT AND DISCUSSION

Previous research has concentrated on detecting and preventing zoonotic infections transmitted by fruit bats. Pteropus fruit bats, notably Pteropusgiganteus, were identified to be possible carriers of Salmonella enterica serotype Typhi in one investigation done in Bangladesh [23]. Another research looked at the olfactory detection and tracking behaviour of crawling northern yellow-shouldered bats (Sturniraparvidens) and discovered that they could find a reward-based only on odour cues [24]. Furthermore, research on the dangers of pesticides to bats has been conducted, with one study in an apple orchard finding that bat activity was high and pesticide residues on bat-specific food items varied depending on the arthropod type and mechanism of action of the pesticide [25]. A research in India showed the presence of Nipah viral RNA in Pteropusgiganteus bats, indicating a probable involvement in Nipah virus transmission [26].

Most recent research has concentrated on locating just particular species of bats. Some preventative actions were also mentioned. This study looks at the prediction of fruit bats that may be found anywhere in the world, as well as the use of massive datasets to detect different kinds of bats. The technique mentioned in this study is exclusively advised for using nonpesticide measures to prevent the presence of bats in fruit orchards. As a result, this approach is not dangerous to humans. Some of the prior research discussed above proposes using insecticides to decrease fruit damage caused by bats.

CONCLUSION

Finally, the findings show that IoT and machine learning can be used to identify and forecast fruit bat behaviour as a preventative step against Nipah virus (NiV) epidemics. We demonstrated that it is feasible to monitor fruit bat activity, analyse their motions, and anticipate probable regions for NiV transmission using data from IoT sensors and powerful machine learning algorithms. This novel technique might be beneficial in avoiding NiV epidemics and minimising their public health consequences. As we develop and expand our methods, the integration of IoT and machine learning can play an important role in protecting communities against future NiV threats.

REFERENCES

1. How a deadly bat virus found new ways to infect people. (2023b, May 16). Reuters. https://www.reuters.com/investigates/special-report/global-pandemic-bats-spillover/
2. Epstein JH, Quan PL, Briese T, Street C, Jabado O, Conlan S, Ali Khan S, Verdugo D, Hossain MJ, Hutchison SK, Egholm M, Luby SP, Daszak P, Lipkin WI. Identification of GBV-D, a novel GB-like flavivirus from old world frugivorous bats (Pteropusgiganteus) in Bangladesh. PLoSPathog. 2010 Jul 1;6(7):e1000972. doi: 10.1371/journal.ppat.1000972. PMID: 20617167; PMCID: PMC2895649.
3. Epstein JH, Prakash V, Smith CS, Daszak P, McLaughlin AB, Meehan G, Field HE, Cunningham AA. Henipavirus infection in fruit bats (Pteropusgiganteus), India. Emerg Infect Dis. 2008 Aug;14(8):1309-11. doi: 10.3201/eid1408.071492. PMID: 18680665; PMCID: PMC2600370.
4. Singaravelan, N., Marimuthu, G., &Racey, P. A. (2009). Do fruit bats deserve to be listed as vermin in the Indian Wildlife (Protection) & Amended Acts? A critical review. Oryx, 43(04), 608. https://doi.org/10.1017/s0030605309990391.
5. Haritha John, & Haritha John. (2021). Can bats spread Nipah virus? Experts allay concerns. The News Minute. https://www.thenewsminute.com/kerala/can-bats-spread-nipah-virus-experts-allay-concerns-155234
6. Nuisances of Bats - Bats Of Kerala. (2021, January 29). Bats of Kerala. http://batsofkerala.com/2020/09/04/welcome-bats-of-kerala/
7. fruit bat eating - shop14920.etjrdc.org. (n.d.). https://shop14920.etjrdc.org/?from=cpnmestadio3.com&c=fruit%20bat%20eating
8. Rowett, K. M. (2023, May 30). Fruit Bat - The Amazing Flying Nocturnal Species. WAF. https://worldanimalfoundation.org/animal_encyclopedia/params/category/173341/item/995150/
9. 79,900+ Fruit bat eating stock photos, pictures & Royalty-Free Images - iStock. (n.d.). https://www.istockphoto.com/photos/fruit-bat-eating

10. Mansour, A. H., Salh, G. Z. A., & Mohammed, K. A. (2015). Voice Recognition using Dynamic Time Warping and Mel-Frequency Cepstral Coefficients Algorithms. International Journal of Computer Applications, 116(2), 34–41. https://doi.org/10.5120/20312-2362.
11. Che Yong Yeo, S. A. R. Al-Haddad and C. K. Ng, "Animal voice recognition for identification (ID) detection system," 2011 IEEE 7th International Colloquium on Signal Processing and its Applications, Penang, Malaysia, 2011, pp. 198-201, doi: 10.1109/CSPA.2011.5759872.
12. Spoelstra, K., Van Grunsven, R. H. A., Ramakers, J. J. C., Ferguson, K., Raap, T., Donners, M., Veenendaal, E., & Visser, M. E. (2017). Response of bats to light with different spectra: light-shy and agile bat presence is affected by white and green, but not red light. Proceedings of the Royal Society B: Biological Sciences, 284(1855), 20170075. https://doi.org/10.1098/rspb.2017.0075
13. Russo, D., Ancillotto, L., & Jones, G. (2018). Bats are still not birds in the digital era: echolocation call variation and why it matters for bat species identification. Canadian Journal of Zoology, 96(1), 63-78.
14. Clement, M. J., Bishop, J. M., Wilkinson, G. S., &Waldick, R. C. (2008). The role of call frequency and duration in mediating dominance relationships among male and female big brown bats. Behavioral Ecology and Sociobiology, 62(7), 1047-1055.
15. Stowell, D., Plumbley, M. D., & Wood, M. (2016). Bird detection in audio: A survey and a challenge. In Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2016.
16. Kirschel, A. N., Blumstein, D. T., & Smith, T. B. (2009). Characterizing the distribution and diversity of anuran calls using an autonomous audio recording network: a collaboration between the national park service and the university of California, Los Angeles. Remote Sensing, 1(3), 577-595.
17. Putrada, A. G., Abdurohman, M., Perdana, D., &Nuha, H. H. (2022). CIMA: A Novel Classification-Integrated Moving Average Model for Smart lighting intelligent control based on Human Presence. Complexity, 2022, 1–19. https://doi.org/10.1155/2022/4989344
18. Prat, Y., Taub, M., Pratt, E., &Yovel, Y. (2017). An annotated dataset of Egyptian fruit bat vocalizations across varying contexts and during vocal ontogeny. Scientific Data, 4(1). https://doi.org/10.1038/sdata.2017.143
19. Surlykke, A., Andreassen, T., & Hallam, J. (2014). Long-term acoustic surveying of bats. Journal of the Acoustical Society of America, 135(4_Supplement), 2241. https://doi.org/10.1121/1.4877335
20. Skowronski, M. D., & Fenton, M. B. (2009). Detecting bat Calls: An analysis of Automated Methods. Acta Chiropterologica, 11(1), 191–203. https://doi.org/10.3161/150811009x465811
21. Andreassen, T., Surlykke, A., & Hallam, J. (2014). Semi-automatic long-term acoustic surveying: A case study with bats. Ecological Informatics, 21, 13–24. https://doi.org/10.1016/j.ecoinf.2013.12.010
22. Oleksy, R. Z., Ayady, C. L., Tatayah, V., Jones, C. G., Froidevaux, J. S., Racey, P. A., & Jones, G. (2018b). The impact of the Endangered Mauritian flying fox Pteropusniger on commercial fruit farms and the efficacy of mitigation. Oryx, 55(1), 114–121. https://doi.org/10.1017/s0030605318001138
23. Islam, A. B. M. S., Mikolon, A., Mikoleit, M., Ahmed, D., Khan, S. U., Sharker, M. a. Y., Hossain, M. J., Islam, A., Epstein, J. H., Zeidner, N. S., &Luby, S. P. (2013). Isolation of Salmonella Virchow from a Fruit Bat (Pteropusgiganteus). Ecohealth, 10(4), 348–351. https://doi.org/10.1007/s10393-013-0866-y
24. Brokaw, A. F., &Smotherman, M. (2021). Olfactory tracking strategies in a neotropical fruit bat. The Journal of Experimental Biology, 224(4). https://doi.org/10.1242/jeb.231829
25. Stahlschmidt, P., &Brühl, C. A. (2012). Bats at risk? Bat activity and insecticide residue analysis of food items in an apple orchard. Environmental Toxicology and Chemistry, 31(7), 1556–1563. https://doi.org/10.1002/etc.1834
26. Pragya, D, Yadav., CG, Raut., Anita, M., Shete., Akhilesh, C., Mishra., Jonathan, S., Towner., Stuart, T., Nichol., Devendra, T., Mourya. (2012). Short Report: Detection of Nipah Virus RNA in Fruit Bat (Pteropusgiganteus) from India. University Science, 1989.
27. Raju, N. (n.d.). The News Minute | South News | latest breaking news and headlines from South India. The News Minute. https://www.thenewsminute.com/
28. Tethys | Environmental Effects of Wind and Marine Renewable Energy. (n.d.). https://tethys.pnnl.gov/
29. SlideShare. (n.d.). SlideShare.net. www.slideshare.net. https://es.slideshare.net/