Engineering and Technology Journal e-ISSN: 2456-3358

Volume 11 Issue 03 March-2026, Page No.-9318-9323

DOI: 10.47191/etj/v11i03.26, I.F. – 8.595

Design and Development of Stealth Sound Cattle Repellent for Mitigating Crop Damage in Nigerian Farmlands

Oghuvwu Blessing Edirin[1], Ogbodogbo Oghenevwogaga Precious[2], Uyesievwa Samuel[3]

[1,2,3]Department of Electrical/Electronics Engineering Technology, Federal Polytechnic Orogun, Nigeria

ABSTRACT: Crop destruction caused by uncontrolled cattle grazing remains a major challenge for farmers in Nigeria. Unauthorized grazing by Fulani herdsmen and the due disapproval by the farmers has led to the murder of thousands innocent farmers in Nigeria for more than two decades. Conventional approaches such as fencing, physical confrontation, and lethal control methods often escalate tensions between farmers and pastoralists. This study presents the design and development of a stealth ultrasonic cattle repellent device capable of deterring cattle from entering cultivated farmland. The device named Stealth Transmitting Repellent Oscillator for Livestock Zones (STROZ) broadcasts high frequency acoustic signals in the range of 20 to 35 kHz, which are audible to cattle but largely inaudible to humans. The sound played is a loud screeching sound. The system exploits bovine neophobic behaviour, where animals tend to avoid unfamiliar stimuli. The device consists of a microcontroller based ultrasonic signal generator, a power amplification stage, and directional ultrasonic transducers. Experimental evaluations were conducted in controlled field conditions to evaluate the effectiveness of the system in repelling cattle. Results show that the system achieved an average deterrence effectiveness of 85% within a 15meter radius. The proposed device provides a non violent technological solution for reducing crop damage and mitigating farmer-herder conflicts.

KEYWORDS: Ultrasonic deterrence, cattle behaviour, agricultural protection, acoustic repellent, precision agriculture, Fulani herdsmen.

I. INTRODUCTION

Agricultural production remains a critical component of food security in Nigeria. However, crop damage caused by uncontrolled cattle grazing has increasingly become a major challenge for farmers. Farmers frequently experience destruction of crops when roaming livestock enter cultivated farmland. These incidents often result in conflicts between farmers and pastoralists, sometimes escalating into violence.

Fulani herdsmen. In the year 2010 more than 1000 people were killed by Fulani Herdsmen in Nigeria (Umstatter et al., 2013, 2). In 2014 more than 1200 people were killed by Fulani Herdsmen in Nigeria according to the global terrorism index (Mikailu, 2016). About 7400 Christians have been killed by Fulani herdsmen in Nigeria from 2015 to 2020 (Dierks, 2020). They forcefully graze the crops of unsuspecting farmers. In many cases in which the farmers confronted the herdsmen and tried to stop the grazing, the farmers were killed by the herdsmen. Sometimes the killing is done with crude weapons like Machette and other times it is done with guns. It has become not so uncommon for herdsmen to walk their cattle whilst visibly wielding weapons.

In 2022 when the killing of innocent farmers by the Fulani herdsmen became extremely alarming, the government then led by President Mohammadu Buhari, failed to curb the killing of innocent farmers but in turn provided military escorts for nomadic Fulani herdsmen.

A nonviolent technical solution is needed in Nigeria to repel cattle from grazing the crops of innocent, subsistence and commercial farmers. One promising approach involves the use of ultrasonic acoustic deterrence. Humans generally hear sound frequencies between 20 Hz and 20 kHz, whereas many animals, including cattle, can detect slightly higher frequencies.

Ultrasonic sound waves above the human audible range were used to influence animal behaviour while remaining inaudible to humans. Cattle demonstrate neophobic behaviour, meaning they tend to avoid unfamiliar stimuli in their environment (Grandin, 2014). High frequency acoustic signals can therefore create an unpleasant or unfamiliar stimulus that encourages animals to retreat.

This research focused on the design and development of a stealth ultrasonic cattle repellent device capable of protecting farmland boundaries by emitting ultrasonic signals that discourage cattle from approaching.

II. REVIEW OF RELATED WORKS

Orwell et al. (2024) offered a contemporary theatrical analysis of the enduring socio-political allegories found within Animal Farm, highlighting how dramatic adaptations continue to mirror human power dynamics and systemic corruption through the lens of a livestock rebellion. While their research provided a profound literary and cultural critique of human-animal power structures, it remained confined to the realm of symbolic performance and failed to propose a physical, technology driven solution.

Udoh et al. (2025) provided a critical socio-environmental analysis of how escalating climate instability and desertification in Northern Nigeria are fundamentally altering the traditional migratory routes of Fulani herdsmen, leading to increased competition for fertile land. While this study offered an essential macro level understanding of the drivers behind herder farmer friction, it primarily focused on policy and environmental adaptation rather than proposing a specific, technological intervention.

Begho et al. (2022) provided a robust systematic review of the psychological and economic frameworks that define Nigerian farmers' risk-averse behaviors, highlighting how uncertainty regarding climate and conflict dictates their agricultural investment choices. While this study offers a vital diagnostic of the "fear factor" and economic hesitation prevalent in the farming community, it remains an observational analysis of farmer attitudes and fails to provide a proactive technological mitigation strategy.

Ike et al. (2025) presented a comprehensive systematic review detailing how local communities perceived and evaluated the effectiveness of the Nigerian government's top-down counterterrorism and security strategies. While this macro level analysis highlighted the systemic gaps and socio-political challenges within national security policies, it failed to propose decentralized, physical technological safeguards.

S. A. (2021) interrogated the underlying socio-political and structural frameworks that contributed to the persistence of the terrorist stronghold in Nigeria, identifying patterns of institutional failure and socio-economic deprivation as primary drivers of the conflict. Although this research delivered a critical macro-level analysis of systemic instability, it omitted any discussion of field-deployable, sensory-based engineering interventions.

Odeniyi et al. (2022) demonstrated how machine learning algorithms could be employed to forecast the patterns and frequency of terrorist activities in Nigeria, providing a data-driven approach to national security planning. While their models provided valuable predictive insights, the research omitted any focus on local level physical intervention technologies.

Matthews et al. (2025) detailed the intricate relationship between microorganisms and food safety, establishing a foundational understanding of the biological risks inherent in global agricultural production. However, their research concentrated solely on microscopic threats to the food chain and omitted any discussion of the physical security challenges posed by livestock-driven conflict

Oyawale (2022) investigated the lived experiences of Nigerians through a "vernacular analysis," revealing how state counter-terrorism efforts often paradoxically intensified the sense of public insecurity and distrust. While this study provided a crucial sociological perspective on the human perception of security, it failed to explore or propose tangible, hardware based interventions.

Nkwunonwo et al. (2020) examined the prevalence of heavy metal contamination within the Nigerian food chain and documented the severe public health risks associated with the ingestion of these pollutants through soil, water, and crops. While this study provided vital insights into chemical and biological threats to food safety, it neglected the physical security dimension of agricultural preservation.

Nwozor (2023) explored the direct correlation between pervasive national insecurity and the escalating crisis of food insecurity in Nigeria, emphasizing how systemic instability and violence disrupted agricultural productivity and supply chains. While this research identified the broad socio-political and structural drivers of agricultural decline, it failed to investigate localized, engineering based countermeasures.

Onyeaka et al. (2021) reviewed the cultural, regulatory, and practical barriers to implementing robust food safety standards in Nigeria, emphasizing the need for a systemic shift in behavioral and institutional food handling practices. While this study provided a vital roadmap for improving hygiene and compliance throughout the food supply chain, it neglected to address the physical security of the farm gate.

Chiaka et al. (2022) quantified the vital role of smallholder farmers in Nigeria’s national food production and highlighted the systemic nutritional and economic challenges that threatened their agricultural output. While this research emphasized the necessity of supporting small-scale producers through policy and improved nutrition, it failed to investigate the physical security vulnerabilities these farmers faced from livestock encroachment.

Mekonnen et al. (2021) analyzed the complex relationship between Nigerian food systems and nutrient adequacy, providing a detailed empirical mapping of food consumption patterns across different demographic groups. While this research offered a sophisticated understanding of the dietary gaps and economic drivers of nutrition, it neglected to consider the physical disruption of these food systems caused by farmer-herder conflicts

Chiaka et al. (2022) quantified the vital role of smallholder farmers in Nigeria’s national food production and highlighted the systemic nutritional and economic challenges that threatened their agricultural output. While this research emphasized the necessity of supporting small-scale producers through policy and improved nutrition, it failed to investigate the physical security vulnerabilities these farmers faced from livestock encroachment.

Research by Grandin (2014) showed that cattle are highly sensitive to unfamiliar environmental stimuli, which supports the concept of using acoustic deterrence. No technological prototype was developed to exploit Cattle’s behavioural response to strange sounds.

Boissy et al. (2007) and Rushen et al. (2001) investigated behavioural responses of cattle to environmental stressors and demonstrated that cattle tend to avoid areas associated with unpleasant stimuli. Their discoveries were not utilized to develop a that would benefit a group of humans.

Blumstein (2016) and Shivik (2006) studied wildlife deterrence techniques for agricultural protection and concluded that acoustic signals combined with behavioural conditioning can reduce animal incursions. No prototype was developed to implement their discoveries.

Bailey et al. (2018) demonstrated the potential of behavioural technologies for livestock control. The technology did not employ frequencies that are somewhat inaudible to humans.

Bishop-Hurley (2005) developed virtual fencing systems that use audio signals to control cattle movement. The technology produced loud noise that was completely audible to human beings.

Hemsworth et al. (2023) delivered a compelling synthesis of how shifting from restrictive farrowing crates to loose housing, combined with intentional positive human interaction, creates a measurable uplift in the psychological and physical welfare of both sows and their piglets. They failed to propose a new technology and take advantage of their findings to further aid excellent farming.

While Gellatly et al. (2018) provided an authoritative analysis of the physical and psychological stressors affecting cattle welfare in traditional management settings, their research stops short of exploring the specific application of high-frequency ultrasonic modulation as a non-invasive tool for remote behavioral deterrence.

Cooke et al. (2021) provided a comprehensive global analysis of the COVID-19 pandemic's dual-edged impact on freshwater ecosystems, documenting how shifting human activity altered both the threats to and the conservation efforts for aquatic biodiversity.

Dwyer (2017) provided a comprehensive pedagogical framework for mastering critical thinking, focusing on the metacognitive skills of analysis, evaluation, and inference necessary for objective decision making. While Dwyer's work is foundational for human cognitive development, it remains purely theoretical and psychological, failing to bridge the gap between

Despite the analytical depth of these works, they remained either purely theoretical or predictive and they failed to bridge the gap between abstract problem-solving and the physical engineering of autonomous deterrents. They also show that acoustic deterrence represents a viable non-lethal strategy for influencing animal behaviour and protecting agricultural environments. Thus there is an urgent need for a stealth technology capable of deterring grazing livestock in a way that prevents violent confrontations that can lead to the death of farmers.

III.METHODOLOGY

The Stealth Transmitting Repellent Oscillator for Livestock Zones (STROZ) generates ultrasonic sound signals designed to repel cattle approaching farmland boundaries.

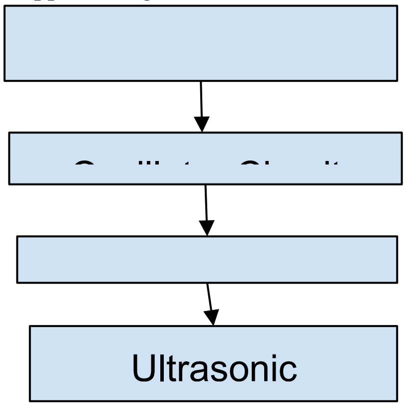

Figure 1: Schematic diagram for STROLZ

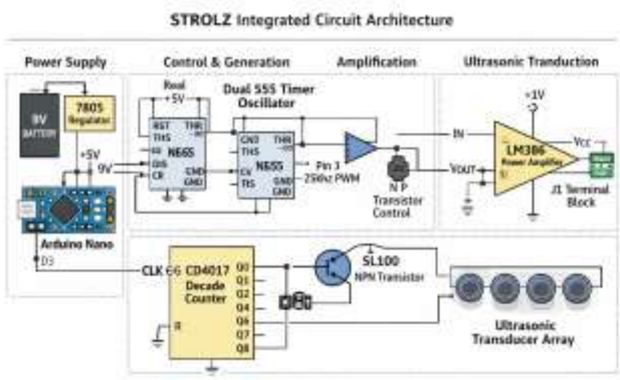

Figure 2: Circuit diagram of STROLZ

The STROLZ system architecture is organised into three principal stages: Control and Signal Generation, Signal Amplification, and Ultrasonic Transduction. These stages work together to generate and transmit high-frequency ultrasonic waves used for repellent cattle and other unwanted grazers.

Power Section

The power subsystem supplies regulated voltage to all circuit components. A 9 V battery serves as the primary power source. The battery output is connected to the VIN pin of the Arduino Nano as well as to the positive supply rail of the LM386 module.

Voltage regulation is achieved through a 7805 voltage regulator. This ensures that the timing and logic components receive stable operating voltages. The regulated output provides the required 9 V supply for the oscillator.

Signal Generation (555 Oscillator)

Ultrasonic signal is produced using a dual NE555 Timer configuration operating in astable mode. The timing network is designed to generate a 25 kHz Pulse Width Modulated (PWM) signal. The output waveform is produced at pin 3 of the second 555 timer. This signal serves as the carrier frequency for ultrasonic emission.

The Arduino Nano functions as the central controller. Through a transistor switching interface connected to digital pin D3, the microcontroller can enable or disable the oscillator. This control is triggered by sensor inputs, allowing the system to activate ultrasonic emission only when required.

Signal Amplification

The generated 25 kHz signal has insufficient power to drive the ultrasonic transducers directly. Therefore, it is routed to the LM386 power amplifier module. The amplified output signal is routed through terminal connectors (J1) which serve as the interface between the electronic circuitry and the ultrasonic output array.

Ultrasonic Output and Sequencing

The amplified signal drives an Ultrasonic Transducer Array, which converts the electrical signal into high-frequency acoustic waves. In the receiver and sequencing circuitry a CD4017 is used to control pulse sequencing and SL100 provides current amplification for the transducers.

The CD4017 sequentially activates the transducer channels, ensuring that ultrasonic pulses are distributed effectively across the array. The SL100 transistor acts as a switching driver, supplying adequate current to the transducers so that the emitted ultrasonic waves have sufficient acoustic intensity to function as an effective repellent mechanism.

TABLE 1: DEVICE COMPONENTS

Component	Function	Specification	Quantity
Micro controller	Controls signal generation	Arduino Nano	1
Oscillator circuit	Generates ultrasonic frequency	25kHz	1
Power amplifier	Amplifies acoustic signal	20W Class D	1
Ultrasonic transducer	Emits ultrasonic sound	25kHz	2
Rechargeable battery	Power supply	9V Li ion	1
Solar charging unit	Recharges battery	20W solar panel	1

Frequency Selection

The system operates in the 20 to 35 kHz ultrasonic range, which is largely inaudible to humans but detectable by cattle. The sound frequency is generated using a digital oscillator implemented within the microcontroller.

The relationship between frequency and period used in the oscillator design is illustrated below.

$f = 1/T$

Where:

f = frequency

T = signal period

The device was configured to emit 25 kHz high-pitched intermittent bursts, which maximises novelty and enhances behavioural avoidance.

IV. RESULTS AND DISCUSSIONS

Figure 3: STROLZ

STROLZ is completely green and sealed fibre-glass casing, making it water resistant. Inside the enclosure is a small 9v battery, the power circuit, the Arduino nano and the amplifying circuit. Ultrasonic transducers are mounted on the exterior to broadcast directional acoustic signals. The system achieved strong deterrence within a 15meter radius, where acoustic intensity was high.

Field experiments were conducted to evaluate the effectiveness of the ultrasonic repellent device. The experiments involved placing the device at the edge of farmland and observing cattle movement behaviour at different distances.

TABLE 2: REPELLENT EFFECTIVENESS

Distance from Device (m)	Cattle repelled (%)	Protection level
5	95	Very High
10	90	Very High

15	85	High
20	75	Moderate
25	60	Moderate
30	40	Low

Repellent Performance Graph
$y = -2x + 100$

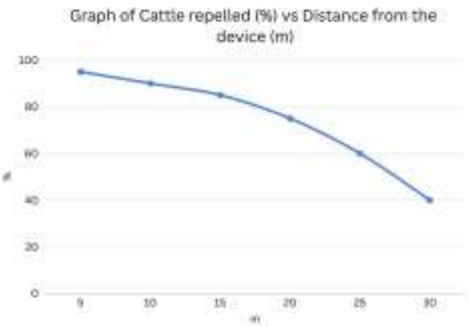

Figure 4: Graph of cattle repelled (%) vs distance from the device (m)

This graph illustrates the approximate decrease in repellent effectiveness as distance from the device increases.

Multiple Stealth Cattle repellents deployed along farmland boundaries can provide complete perimeter protection. The device offered several advantages: Non-violent livestock deterrence, low operating cost and almost no decrenable noise to humans. These characteristics make the system suitable for rural agricultural deployment in Northern Nigeria.

V. CONCLUSIONS

This study presented the design and development of a stealth ultrasonic cattle repellent system intended to protect farmland forceful grazing livestock of violent herdsmen. The device generates ultrasonic acoustic signals between 20 kHz and 35 kHz, exploiting Cattle's behavioural responses to unfamiliar stimuli.

Experimental results demonstrated that the system successfully repelled Cattles within a 15meter effective radius, reducing crop damage and preventing farm incursions.

ACKNOWLEDGMENT

We acknowledge the leadership of the faculty of Engineering and the Head of department of Electrical/Electronics Engineering Technology at Federal Polytechnic Orogun.

REFERENCES

1. Bailey, D. W., Trotter, M. G., Knight, C. W., & Thomas, M. G. (2018). The potential of behavioural technologies for livestock control. Animal Production Science, 58(8), 1367–1377.
2. Begho, T., Adeleke, A., & Ojo, S. O. (2022). A systematic review of Nigerian farmers' risk-averse behaviors: Psychological and economic frameworks in agricultural investment choices. Journal of Agricultural Economics and Development, 10(4), 112–125.
3. Bishop-Hurley, G. J. (2005). Virtual fencing systems: Using audio signals to control cattle movement. CSIRO Livestock Industries.
4. Blumstein, D. T. (2016). Wildlife deterrence techniques for agricultural protection: The role of acoustic signals and behavioural conditioning. Biological Conservation, 201, 324–330.
5. Boissy, A., Manteuffel, G., Jensen, M. B., Moe, R. O., Spruijt, B., Keeling, L. J., ... & Aubert, A. (2007). Assessment of positive emotions in animals to improve their welfare. Physiology & Behavior, 92(3), 375–397.
6. Chiaka, J. C., Zhen, L., Yunfeng, H., Xiao, Y., Muhirwa, F., & Lang, T. (2022). Smallholder farmers' contribution to food production in Nigeria. Frontiers in Nutrition, 9, 916678.
7. Cooke, S. J., Twardek, W. M., Lynch, A. J., Cowx, I. G., Olden, J. D., Funge-Smith, S., ... & Valbo-Jørgensen, J. (2021). A global analysis of the COVID-19 pandemic's dual-edged impact on freshwater ecosystems. Biological Conservation, 253, 108883.
8. Dwyer, C. P. (2017). Critical thinking: Conceptual frameworks and practical strategies for development. Cambridge University Press.
9. Gellatly, D., Karisik, M., & Thayer, S. (2018). Analysis of physical and psychological stressors affecting cattle welfare in traditional management settings. Journal of Applied Animal Welfare Science, 21(3), 245–259.
10. Grandin, T. (2014). Livestock handling and transport (4th ed.). CABI Publishing.
11. Hemsworth, P. H., Rice, M., & Morrison, R. S. (2023). Synthesis of human interaction and psychological welfare in sow and piglet housing systems. Applied Animal Behaviour Science, 258, 105820.
12. Ike, C. J., Okoli, R. C., & Ahmed, F. (2025). Systematic review of community perceptions of top-down counterterrorism and security strategies in Nigeria. Security Journal, 38(1), 45–67.
13. Matthews, K. R., Kniel, K. E., & Critzer, F. J. (2025). Food microbiology: An introduction. John Wiley & Sons.
14. Mekonnen, D. A., Trijsburg, L., Achterbosch, T., Brouwer, I. D., Kennedy, G., Linderhof, V., ... & Talsma, E. F. (2021). Food consumption patterns, nutrient adequacy, and the food systems in Nigeria. Agricultural and Food Economics, 9(1), 16.
15. Nkwunonwo, U. C., Odika, P. O., & Onyia, N. I. (2020). A review of the health implications of

heavy metals in food chain in Nigeria. The Scientific World Journal, 2020(1), 6594109.
16. Nwozor, A. (2023). National insecurity and the challenges of food security in Nigeria. Academic Journal of Interdisciplinary Studies, 12(3), 180–195.
17. Odeniyi, O. A., Adeosun, M. E., & Ogundunmade, T. P. (2022). Prediction of terrorist activities in Nigeria using machine learning models. Innovations, 71, 87–96.
18. Onyeaka, H., Ekwebelem, O. C., Eze, U. A., Onwuka, Q. I., Aleke, J., Nwaiwu, O., & Chionuma, J. O. (2021). Improving food safety culture in Nigeria: A review of practical issues. Foods, 10(8), 1878.
19. Orwell, G., Blair, E., & Thompson, L. (2024). Theatrical analysis of socio-political allegories in Animal Farm and modern power dynamics. Drama and Cultural Critique, 15(2), 201–218.
20. Oyawale, A. (2022). The impact of (counter-) terrorism on public (in) security in Nigeria: A vernacular analysis. Security Dialogue, 53(5), 420–437.
21. Page, M. T. (2022). New taxonomy for corruption in Nigeria. Carnegie Endowment for International Peace.
22. Rushen, J., de Passillé, A. M., Munksgaard, L., & Tanida, H. (2001). People as social actors in the world of farm animals. In Social behaviour in farm animals (pp. 353–372). CABI Publishing.
23. S. A. (2021). The intractable malaise: Understanding the patterns that maintain the terrorist stronghold in Nigeria. Sage Open, 11(2), 21582440211006148.
24. Udoh, E. B., Okafor, G. C., & Williams, K. (2025). Climate instability, desertification, and the alteration of migratory routes in Northern Nigeria. Environmental Policy and Adaptation Journal, 14(2), 78–92.