Ultrasonic Shield System

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ABSTRACT

This study aimed to develop and evaluate the Ultrasonic Shield System, a non-chemical pest control device designed to repel rice ear bugs through ultrasonic sound exposure under controlled laboratory conditions. A research and development (R&D) design combined with a one-shot case study approach was employed to establish baseline performance prior to field deployment. The system utilized a microcontroller-based ultrasonic transducer operating at calibrated frequencies and was tested in an isolated setup to minimize environmental interference.

Experimental trials were conducted by exposing rice ear bugs to programmed ultrasonic sound cycles, and pest response was measured through direct observation and video verification, focusing on behavioral disturbance and positional movement as indicators of repellency. Descriptive statistical tools were used to analyze pest reduction and consistency of system performance across trials. The findings revealed a measurable and consistent reduction in rice ear bug presence, indicating a moderate level of pest-control efficacy under controlled conditions.

Ultrasonic exposure induced observable changes in pest behavior, including movement away from the sound source, demonstrating that the system was capable of influencing rice ear bug activity without the use of chemical agents. Although complete pest elimination was not achieved, the results suggest that the Ultrasonic Shield System has potential as an eco-friendly alternative to conventional chemical pesticides. The controlled testing environment strengthened internal validity by isolating the effects of ultrasonic sound, providing reliable baseline data to support further system optimization, longer testing periods, and real-field validation for sustainable rice pest management.

Keywords: Ultrasonic Shield System, rice ear bugs, pest-control efficacy

INTRODUCTION

Rationale

Rice is one of the most important crops in the Philippines and in many other parts of Asia. However, pests in rice fields, especially rice ear bugs that attack during the important flowering stage, continue to threaten its production. Farmers often use chemical pesticides which can harm the environment and people's health (Ahmad et al., 2024). This growing concern over the long-term impacts of chemical pesticides has drawn attention worldwide, as the effects of pest-related crop losses and unsafe pest control methods extend beyond national borders.

Globally, studies report states that 10–30% of rice grains may become unfilled or discolored due to rice ear bug infestation, leading to reduced market value and compromised seed viability (Poudel et al., 2025). According to recent studies on sustainable control strategies, botanical insecticides have demonstrated strong potential as environmentally friendly substitutes, with high mortality rates (up to 85%) against rice ear bugs (Cano et al., 2025; Ponijan et al., 2023). However, chemical insecticides remain widely used, leading to a global trend toward

integrated pest management practices to effectively address the continuing threat of rice ear bugs to rice production and crop yield

In the Philippines, rice ear bugs remain a significant pest threatening rice production, particularly during the flowering to milky stage of the crop. Their feeding causes empty, shriveled, and discolored grains, resulting in reduced yield and poor grain quality.

Rice ear bug infestations can damage about 10–30% of rice fields, with losses reaching up to 40% or more in heavily infested and unmanaged areas (Grokipedia, 2023). PhilRice has identified rice ear bugs among the major rice pests that require close monitoring, emphasizing that delayed management during critical crop stages can lead to serious yield and quality losses (PhilRice, 2024).

These infestations increase production costs due to added pest control measures and reduce farmers' income, making rice ear bugs a continuing issue in national rice production.

In municipalities such as Ubay, Bohol, pest outbreaks have caused significant disruptions to rice farming. In early 2020, rice black bug infestations damaged portions of local rice fields, affecting several barangays in the municipality and prompting urgent calls for pest control assistance (Bohol Chronicle, 2020).

According to the Department of Agriculture in Sagbayan, the barangay San Agustin has about 30-40% of rice fields that have been damaged by pests.

This study proposed the development of an Ultrasonic Shield System specifically designed to repel rice ear bugs. A review of existing literature shows that there are no studies that specifically focus on an ultrasonic repellent system for controlling rice ear bugs.

Reviews and experiments also show mixed results—some insects are repelled in controlled tests while others show little effect or can become habituated to the sound—so effectiveness is still debated (Yanagisawa et al., 2023). Additionally, several strong studies target different pests rather than rice-field pests, as they cannot safely assume the same results hold for the rice ear bug in open paddy fields (Nakano et al., 2022).

This study aimed to develop and assess the performance of the Ultrasonic Shield System in repelling rice ear bugs under controlled isolation conditions.

The results provided empirical data on the efficiency and practicality of ultrasonic pest control in tropical agricultural settings by minimizing external influences, thereby serving as a reliable basis for further innovation.

Theoretical Background

Pest infestation remains a major challenge in rice farming, especially in rural areas with limited access to sustainable pest control. While chemical pesticides are widely used against rice ear bugs, they pose risks to health, soil, and the environment.

Existing studies on ultrasonic repellent devices primarily focus on household pests, with only limited research examining their effectiveness in rice field pests. This gap in localized research highlights the need to develop and assess the sonic shield system tailored for rice pests in rural communities.

This section outlines the relationships among the key variables involved in assessing the repellent response of rice ear bugs to ultrasonic sound exposure using the Ultrasonic Shield System.

The framework has been able to point out the independent variable, the mediating variable, the dependent variable, the moderating variable, and the control variables, which conceptualize how the use
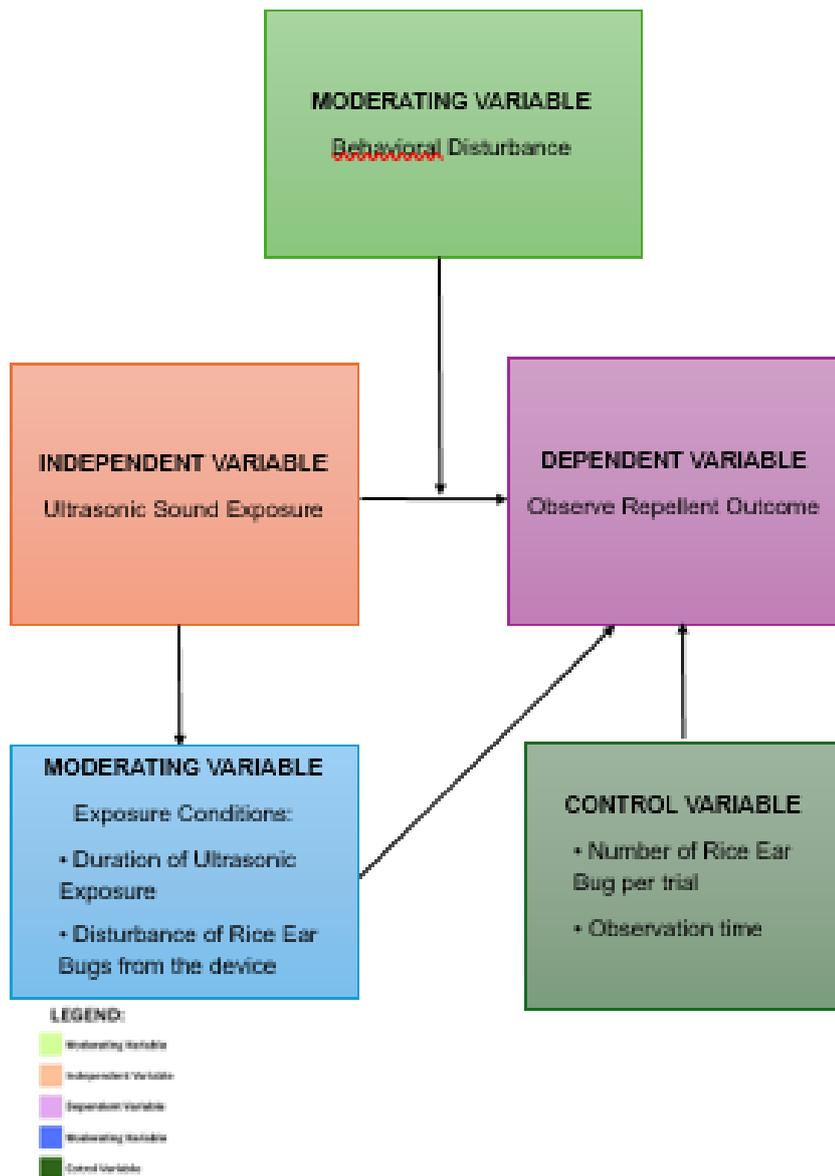
Figure 1. Conceptual Framework of the Study

of the ultrasonic technology can affect the behavior of the pest.

The independent variable of the study is ultrasonic sound exposure, which refers to the application of high-frequency sound waves generated by the Ultrasonic Shield System. This variable was identified as the independent variable because it is the factor deliberately introduced and manipulated by the researchers to examine its potential influence on the behavior of rice ear bugs. Serving as the primary intervention of the study, ultrasonic sound exposure functions as the initiating condition that may affect the behavioral response of the pests during the experimental process.

The effect of ultrasonic sound exposure on pest behavior Is explained through the mediating variable, which is behavioral disturbance. This variable accounts for the mechanism through which ultrasonic sound may influence rice ear bugs. Behavioral disturbance includes changes in movement, activity levels, and avoidance behavior exhibited by insects when exposed to ultrasonic frequencies, as demonstrated in laboratory studies where ultrasonic exposure induced escape responses and significantly reduced biological parameters such as survival rate, longevity, and fecundity (Kavousi et al., 2021). By focusing on behavioral changes rather than pest mortality, the study emphasizes an observational and non-chemical approach to pest management.

The dependent variable of this study Is the observed repellent outcome, which refers to the measurable behavioral response of rice ear bugs following exposure to ultrasonic sound waves. This variable is assessed in terms of the insects' presence, absence, and the degree of their activity within the designated observation area. By systematically recording these responses, the study aims to determine the effectiveness of ultrasonic sound as a repellent stimulus and to evaluate its potential influence on avoidance behavior among rice ear bugs. The observed repellent outcome thus serves as a critical indicator for understanding the behavioral modifications induced by the independent variable under controlled experimental conditions, providing empirical evidence to support or refute the hypothesized relationship between ultrasonic exposure and pest deterrence.

The study also Incorporates a moderating variable, defined as the exposure conditions, which may influence the magnitude or strength of the relationship between ultrasonic sound exposure and the observed repellent outcome. Exposure conditions encompass factors such as the duration of ultrasonic sound application and the distance of the rice ear bugs from the ultrasonic device. Variations in these conditions are expected to affect the intensity of the insects' behavioral responses, potentially amplifying or diminishing the repellent effect of the ultrasonic waves. By considering these moderating factors, the study seeks to provide a more nuanced understanding of how different exposure scenarios can impact the effectiveness of ultrasonic sound in eliciting avoidance behavior among rice ear bugs.

Lastly, the control variables of the study include the number of rice ear bugs per trial and the observation time, which are kept constant throughout the experiment. Maintaining these variables at consistent levels ensures that any observed changes in pest behavior can be attributed to ultrasonic sound exposure rather than external or uncontrolled factors. By controlling these variables, the study enhances the reliability and validity of the observed outcomes.

Overall, the conceptual framework provides a structured and systematic representation of how ultrasonic sound exposure may influence the behavior of rice ear bugs. It establishes a clear pathway from intervention to observed outcome while accounting for influencing conditions and controlled factors, thereby supporting the study's exploratory and performance-based approach to evaluating ultrasonic pest control technology.

The implementation of the Sonic Shield System is grounded not only in the key variables involved but also in national laws that promote sustainable agriculture, innovation, and environmental protection. This study responds to a growing concern in farming communities—particularly the overreliance on chemical pesticides, which can harm human health, damage the environment, and compromise food safety. By offering an eco-friendly, non-chemical alternative for pest control, the study aligns with existing legal mandates that encourage science-based and sustainable agricultural practices. The following laws provide a legal foundation that supports the study's goals of promoting innovation, ensuring food security, and modernizing pest management in rice farming.

Many farmers still rely on outdated, chemical-based methods that harm the environment and limit crop productivity. To address this, the Agriculture and Fisheries Modernization Act of 1997 (RA 8435) was enacted to modernize the agriculture and fisheries sectors through science, research, and technology. It highlighted the importance of adopting sustainable and cost-efficient solutions, including the integration of information and communication technologies into farming systems. The law recognized that innovation and technology are essential in achieving food security and rural development. This initiative was strengthened by the Philippine Innovation Act of 2019 (RA 11293), which established innovation as a key driver of national progress. RA 11293 encouraged collaboration among government agencies, academic institutions, and communities to develop science-based solutions for real-world challenges in agriculture, health, education, and the environment. The Ultrasonic Rice Bug Repellent System developed in this study supports the objectives of both RA 8435 and RA 11293 by providing a sustainable, low-cost, and technology-driven approach to pest management that reduces chemical dependence and improves rice productivity in Barangay Cabog, Clarin.

The Organic Agriculture Act of 2010 (Republic Act No. 10068) institutionalized the state's commitment to promoting, propagating, and developing organic agriculture as a sustainable farming practice. It underscored the importance of ecological balance, soil fertility enhancement, and avoidance of synthetic inputs such as pesticides and fertilizers. RA 10068 aimed to reduce farmer exposure to harmful chemicals, prevent environmental

degradation, and promote food safety by supporting natural pest control methods and biological agents. The law established the National Organic Agriculture Program (NOAP) to provide certification, research funding, training, and market support to farmers adopting organic principles.

Reinforcing this commitment, Executive Order No. 481 designated the Department of Agriculture to lead efforts in advancing organic agriculture through research and education. EO 481 highlighted the necessity of public-private partnerships and the development of appropriate technologies to empower farmers. The ultrasonic repellent system developed in this study fully supported both RA 10068 and EO 481 by providing an alternative pest control method that required no chemicals, thereby preserving organic certification and ensuring safe food production. It enabled rice farmers to adopt organic principles without sacrificing productivity or resorting to harmful fumigants.

Sustainable pest control is essential to guard against crop yields while reducing damage to the ecosystem and human health. In rice cultivation, overreliance on chemical pesticides has raised issues of pest resistance, ecological imbalance, and long-term food safety. With improving agriculture practices, there is an increasing demand to work on technology-based solutions that are effective as well as affordable for farming communities. Current research from different contexts points to innovative pest control methods ranging from integrated management systems to contemporary ultrasonic and IoT technology.

Technological advancements, particularly in microcontrollers and sensor-based systems, have transformed pest control into more precise and responsive processes. Chamara et al. (2022) examined the evolution of agricultural IoT technologies, observing how embedded systems and automation can substitute for manual monitoring and intervention. This technological revolution aligns with the architecture of the current ultrasonic repellent system, which utilizes microcontroller-based control for specific pest deterrence. Notably, Awal et al. (2025) developed a near-far ultrasonic system for Sitophilus oryzae, a major stored rice pest, achieving repellency rates of 29%, 54%, and 79% over 24, 48, and 72 hours, respectively. Their results demonstrate the potential of frequency-specific ultrasonic devices to significantly reduce pest presence—findings that directly inform the hardware and frequency optimization in the current study.

The role of smart technologies in pest management is further demonstrated by Rahman and Ravi (2023), who applied AI to enhance detection through smart traps and mobile applications, and by Shah and Razaq (2021), who discussed IoT-enabled devices for reducing chemical pesticide reliance. While these works emphasize detection rather than direct repelling, they highlight the growing movement toward affordable, automated, and eco-friendly pest control—a movement that the present study builds upon by integrating ultrasonic technology with accessible, locally adaptable designs.

The literature reviewed indicates that microcontrollers and sensors make possible accurate, automatic pest control systems that are effective and versatile. By making possible real-time monitoring and selective response, these technologies minimize labor requirements and enhance pest deterrence effectiveness. For this research, these observations inform the construction of a microcontroller-based ultrasonic system designed for stored rice pests with accurate frequency output and functional field performance.

Ultrasonic pest control operates by emitting high-frequency waves that interfere with pest behavior or physiology, though effectiveness varies with species. For example, Panthawong et al. (2021) found that nine commercial ultrasonic devices were ineffective against the Australian paralysis tick, suggesting that species-specific tuning is essential. In contrast, Agah-Manesh et al. (2021) identified optimal ultrasonic frequencies for the pink stalk borer in sugarcane, significantly reducing pest survival, reproduction, and activity. This demonstrates that correct frequency selection can produce strong repellency effects.

Similarly, Ammar et al. (2024) showed that exposure to 31 kHz and 38 kHz ultrasonic waves could significantly reduce egg hatchability, feeding activity, and adult longevity of Spodoptera frugiperda, demonstrating how carefully selected frequencies can disrupt pests' biological processes and provide an eco-friendly alternative to chemical pesticides.

On the other hand, Sedlock et al. (2025) investigated whether ultrasonic choruses from meadow katydids influence the presence of arthropods in early-stage rice paddies in the Philippines. Their field experiments using a large speaker array found no significant attraction or deterrence among captured arthropod guilds, suggesting that natural ultrasonic sounds may have little impact on non-pest arthropods. However, they recommend testing more robust ultrasonic playback during crop stages with higher pest abundance, highlighting the importance of evaluating repellent performance under different growth conditions. Adding to the relevance, Balingbing et al. (2024) identified unique sound signatures of stored rice pests such as Rhyzopertha dominica and Sitophilus oryzae, using affordable acoustic sensors to distinguish them from secondary pests.

The reviewed studies show that ultrasonic pest control achieves the best results when frequencies are tailored to specific pests and environmental conditions. Studies demonstrate that targeted ultrasonic applications can disrupt pest survival, reproduction, and behavior, offering an eco-friendly alternative to chemical pesticides. However, inconsistent results in some trials highlight the need for precise calibration and species-specific tuning. For this research, these findings guide the development of a frequency-calibrated ultrasonic repellent integrated with acoustic detection to target stored rice pests in Barangay San Agustin.

Energy efficiency and sustainability are also significant factors to consider in the design of pest control devices. Puryono and Pangestu (2023) designed an IoT-based ultrasonic repellent device against rice pests such as leafhoppers and locusts, driven by an ESP32 microcontroller and smartphone connectivity, and effective within 3–6 meters. Also, Ali et al. (2024) integrated AI, infrared sensing, and ultrasonic emission to attain more than 98% efficiency in pest control, whereas Nurmalasari et al. (2023) evaluated a solar-powered ultrasonic device that decreased pest infestation by 60% and significantly increased rice yields.

Ramadhan et al. (2022) also developed a solar-powered pest management system using ultraviolet light and ultrasonic sound (UVUS) to enhance rice productivity, based on a location-allocation model to achieve the least untreated land area. While the majority of these studies focused on field pests, their concepts—efficient use of energy, smart integration, and efficient use of frequency—are directly transferable to stored grain pest management.

The literature on solar-powered and IoT-integrated pest control systems underscores the potential of combining renewable energy with smart automation for sustainable agricultural practices. These devices demonstrate that pest deterrence can be both energy-efficient and remotely managed.

Despite significant progress in ultrasonic and IoT-based pest control technologies, critical gaps remain in their application to rice ear bugs management. No existing study was found that specifically targets the rice ear bug using ultrasonic technology. Most related works focus on stored grain pests or other rice pests, leaving this species unaddressed. The effectiveness of ultrasonic repellents remains debated, resulting in only a small number of published studies. Current designs also fail to address the cost, energy efficiency, and durability needs of smallholder rice farmers. This study aims to fill these gaps by developing and testing a frequency-calibrated, energy-efficient ultrasonic repellent for rice ear bug control.

This conceptual framework establishes the scientific, technological, and legal foundations guiding the development of the Sonic Shield System. It integrated principles of Integrated Pest Management, ultrasonic technology, and sustainable agricultural laws to create an innovative, eco-friendly solution for pest control. Supported by recent studies on microcontroller-based and frequency-specific ultrasonic devices, the system is designed to be effective, affordable, and adaptable for rural farmers. By addressing existing gaps in rice ear bug management and promoting reduced chemical dependence, the Sonic Shield System aims to contribute to sustainable and modernized rice farming practices in Barangay San Agustin, Sagbayan, Bohol.

The Problem

Statement of the Problem

This study aimed to develop and assess the effectiveness of the Ultrasonic Shield System in repelling rice ear bugs during the school year 2025-2026.

Specifically, this study sought to answer the following questions:

1**. What is the technical profile of the Ultrasonic Shield System in terms of**:

1.1. circuit schematic;

1.2. prototype design; and

1.3. system flow?

2. **How effective is the Ultrasonic Shield System in repelling rice ear bugs in terms of pest-control efficacy?**

3. **What recommendations can be proposed based from the findings of the study?**

Significance of the Study

The results of this study aimed to provide valuable information to the following entities:

Local Farmers. The study provided local rice farmers with information on the potential use of ultrasonic technology as an alternative to chemical pesticides. It outlines the system's performance, usability, and limitations under local conditions, helping farmers make informed decisions about pest control methods suited to their needs and resources.

Local Government Unit (LGU). Findings assisted LGUs in evaluating non-chemical pest control options for agricultural programs. The results could inform localized policies and support systems that consider environmental safety and crop protection, while recognizing that further trials are necessary to confirm the system's effectiveness.

Local Community. Reduced reliance on chemical pesticides could benefit the community through improved environmental quality and lower chemical exposure. The study may also encourage awareness and participation in sustainable agricultural practices, although the actual long-term impact of the device still requires further study.

Innovators. The study provided innovators and agricultural technology developers with insights into the practical application of ultrasonic pest control in rice fields. The findings may serve as a foundation for improving device design, adaptability, as well as for developing cost-effective and sustainable pest management technologies.

Future Researchers. This study served as a reference for future work on sustainable pest control. Researchers could expand on the findings by examining economic viability, long-term effectiveness, or design improvements, addressing gaps such as cost-efficiency analysis and extended field trials.

Scope and Limitation

This study focused on the development and performance evaluation of the Sonic Shield System as a non-chemical pest control device designed to repel rice ear bugs using ultrasonic sound technology. The study was conducted during the school year 2025–2026 and emphasized isolated and controlled testing conditions to accurately assess the system's operational performance while minimizing external influences.

The scope of the study covered the design, construction, and functional testing of the Sonic Shield System, including its circuit schematic, prototype design, and system flow. Data gathering was conducted through isolated experimental trials, where rice ear bugs were observed under controlled exposure to ultrasonic sound emitted by the device. These controlled conditions allowed the researchers to focus on the direct behavioral response of rice ear bugs to ultrasonic exposure without interference from environmental variables such as weather, natural predators, crop variety, or surrounding agricultural activities.

The study utilized a research and development (R&D) design combined with a one-shot case study approach, wherein the system was tested through repeated isolated trials to determine pest-control efficacy based on observed pest reduction. Data were gathered solely through direct observation and measurement during the isolated testing sessions and analyzed using descriptive statistical tools such as mean and standard deviation. No farmer surveys, economic analysis, or long-term field deployment were included in the data collection process.

However, this study has several limitations. First, the testing was conducted under isolated and short-term conditions, which may not fully represent the complexity of real rice field environments. As such, the results may not account for long-term pest behavior, habituation effects, or seasonal variations. Second, the study focused exclusively on rice ear bugs, and the effectiveness of the system against other rice pests was not examined. Third, the limited number of test trials restricts the generalizability of the findings. Lastly, the study did not include large-scale field testing, farmer acceptability assessments, or cost-effectiveness analysis, which are important for real-world application.

Despite these limitations, the study provides a reliable baseline evaluation of the Sonic Shield System under controlled conditions. The findings serve as a foundation for future research involving extended testing periods, real field environments, and system optimization to enhance the effectiveness and applicability of ultrasonic pest control technologies in agriculture.

RESEARCH METHODOLOGY

Research Design

This study utilized a combination of Research and Development (R&D) design and Experimental Research using a One-Shot Case Study design to develop and evaluate the proposed intervention. The R&D approach is appropriate for studies that aim to create, test, and refine a product or system before full implementation. According to recent studies, R&D design is widely used in innovation-based research because it allows researchers to systematically design prototypes, conduct trials, gather feedback, and improve the developed output through iterative processes. This method ensures that the final product is both functional and relevant to the actual needs of users. Furthermore, R&D design has been proven effective in technology-related and educational research for validating newly developed tools and systems prior to large-scale application (Rahman et al., 2022). The structured stages of analysis, design, development, implementation, and evaluation help researchers produce reliable and well-tested innovations.

To measure the effectiveness of the developed system, the study employed an Experimental One-Shot Case Study design, which involves applying an intervention to a single group and measuring the outcomes afterward. This design is commonly used in exploratory and developmental studies where the main objective is to determine initial effectiveness in real-world settings (DocMcKee, 2020). Recent research confirms that the one-shot case study design is useful for preliminary testing of new interventions, particularly when the purpose is to gather immediate feedback and performance results without requiring complex control groups. Several studies conducted after 2020 have successfully applied this design to evaluate educational and technological innovations, demonstrating that it provides practical and valid evidence of an intervention's impact during early stages of implementation. Therefore, this design is appropriate for the current study because it allows the researchers to assess the outcomes of the developed system efficiently while providing empirical support for further improvement and future experimental research.

Problem Context and Design Rationale

There is still a significant lack of baseline laboratory data regarding the efficacy of ultrasonic technology, particularly against rice ear bugs, despite the growing interest in this alternative pest management approach. To ensure accurate and comprehensible results, it is essential to comprehend how rice ear bugs react to ultrasonic frequencies under controlled conditions before conducting field trials. By separating the system from environmental factors like wind, temperature swings, or other pests that could skew observations, laboratory

evaluation enables researchers to obtain a precise assessment of the system's performance. According to studies (Awal et al., 2021; Agah-Manesh et al., 2021), ultrasonic frequencies can successfully disrupt pests in laboratory settings, resulting in quantifiable movement and behavioral changes. In order to establish baseline data, optimize system parameters, and evaluate efficacy before field application, such controlled testing is essential.

Laboratory isolation has a quality assurance of the testing process, as it limits factors and external influences or standardises the process, which increases the accuracy and consistency of test results and improves the validity of the laboratory's outcome (Fung, 2025). In an ultrasonic repellent system, controlled sound exposure matters, as precise control of sound exposure is necessary to isolate the effects of frequencies and avoid noise-related health outcomes. Environmental noise can affect brain and neurological health through stress and inflammatory pathways (Hahad et al., 2022). Early validation and verification of system behaviour helps to detect design flaws and confirm that a system model meets requirements before implementation begins. Validating an ultrasonic repellent system's behaviour prior to real deployment ensures that its expected functions work correctly and prevents costly failures or unsafe behaviour in real-world conditions (Caderbladh et al., 2024).

Development of Innovation

The development procedure of the Sonic Shield System was carried out in three main phases: design and fabrication, interval testing, and refinement and optimization. In the design and fabrication phase, the prototype was constructed using only the fundamental components necessary for ultrasonic operation. The system was designed to focus primarily on the ultrasonic transducer and its corresponding control circuitry. The objective of this phase was to develop a functional device that could generate and transmit ultrasonic signals effectively. Careful planning and assembly were conducted to ensure that the prototype was properly built and capable of performing its intended function. This phase emphasized simplicity and practicality in order to evaluate the core performance of the ultrasonic system without the use of additional components.

In the interval testing phase, the operational performance of the fabricated prototype was evaluated using a structured time-based testing procedure. The duration of the time-activated ultrasonic burst was programmed into four cycles. In each cycle, the system operated for 5 minutes and automatically turned off for 3 minutes. During the deactivation period, the display showed the message "System Off," indicating that the ultrasonic transducer was not in operation. This on-and-off sequence was repeated continuously throughout the testing process to observe the behavior of the device under controlled intervals. The purpose of this phase was to determine the stability, consistency, and reliability of the ultrasonic system when subjected to scheduled activation and deactivation.

In the refinement and optimization phase, the results gathered from the
interval testing were carefully analyzed to identify areas that required improvement. Based on the findings, necessary modifications and adjustments were made to enhance the overall performance of the prototype. The efficiency of the activation cycles, the responsiveness of the system, and the effectiveness of the ultrasonic operation were all considered in implementing improvements. This phase ensured that the final version of the prototype was more reliable, functional, and aligned with the objectives of the study. The refinements conducted contributed to the development of a more stable and optimized ultrasonic system.

Performance Evaluation Design

The study uses a quantitative performance evaluation method since the study is measuring the pest count before and after of the system activation. The effectiveness of the system is measured using numerical data, specifically the number of rice ear bugs observed before and after exposure to the ultrasonic frequency. The criteria used in the evaluation is the change in the number of rice ear bugs' positions before and after system activation. The movement of rice ear bugs from the lower layer to the upper layer of the test setup is used as an indicator of disturbance caused by the ultrasonic frequency. The pest movement in the coverage area of the system is also considered in the observation. The performance of the system is conducted in a lab-controlled environment to ensure safety, accuracy, and consistent results.

To avoid uncontrolled external factors, the performance of the system is isolated in the laboratory during the evaluation. The system consists of two layers: a lower layer, where the rice ear bugs are initially placed, and the upper layer, where the rice ear bugs move once they are disturbed by the ultrasonic frequency. The evaluation consists three trials, with each trial lasting up to 30 minutes. In every trial, ten rice ear bugs are placed. During the first trial, five rice ear bugs moved from the lower layer to the upper layer. In the second trial, eight rice ear bugs moved to the upper layer. In the last trial, six rice ear bugs moved upward. These movements indicate the response of the rice ear bugs being disturbed to the ultrasonic frequency.

During the evaluation, two cameras are placed in the system, one on the lower layer and one on the upper layer to ensure accurate observation to the movements of the rice ear bugs and by this setup, it allows the researcher to get a clear data of the experiment. The data collected from each trial are recorded and compared. The number of rice ear bugs that changed position from the lower layer to the upper layer after system activation is analyzed as a measure of system effectiveness.

Data Collection Procedures

Data collection was conducted using the developed Ultrasonic Rice Bug Repellent System as the primary experimental instrument of the study. The system was utilized to generate ultrasonic sound waves intended to influence the behavior of rice ear bugs, while pest activity was continuously observed and documented through a camera. The use of video recording allowed for objective observation, minimized human interference during the experiment, and provided a reliable reference for verifying pest movement, presence, and behavioral changes throughout the data collection process.

Prior to the actual data gathering, the testing area was carefully prepared to ensure controlled and consistent experimental conditions. The ultrasonic repellent system was properly assembled, positioned, and tested to confirm its operational stability. Rice ear bugs were collected from a rice field and transferred into a designated observation box.

To reduce the effects of capture-related stress that could alter natural behavior, the pests were allowed an acclimatization period before exposure to ultrasonic sound. After this resting period, the initial number of rice ear bugs was recorded. A fixed sample size of ten (10) pests was used in each trial to maintain uniformity and comparability of data across all experimental runs.

Following the initial pest count, the ultrasonic system was activated for a total exposure period of thirty (30) minutes. During this time, the system operated in programmed cycles consisting of five (5) minutes of ultrasonic sound emission followed by three (3) minutes of cooldown.

This operational pattern was designed to prevent system overheating while maintaining consistent sound exposure. Throughout the activation period, pest behavior was continuously monitored using the camera, allowing the researchers to observe changes in activity levels, movement patterns, and possible avoidance responses associated with ultrasonic sound exposure.

After the completion of the exposure period, the number of rice ear bugs remaining active or present within the observation area was recounted and recorded. All observations and numerical data from each trial were systematically documented in a prepared data table to facilitate analysis and comparison. The entire data collection procedure was repeated for three (3) trials under identical conditions to enhance the reliability and validity of the results.

To ensure data accuracy and integrity, a data verification process was implemented through double counting of pests. The recorded pest counts were cross-checked by reviewing the camera footage obtained during each trial. This verification process minimized potential counting errors and strengthened the credibility of the collected data, ensuring that the recorded outcomes accurately reflected the effects of ultrasonic sound exposure on rice ear bug behavior.

Data Analysis

The data gathered from the three test trials were analyzed using descriptive statistics to evaluate the performance of the developed Sonic Shield System. Since the study employed a one-shot case study research design, the analysis focused on summarizing observed pest reduction outcomes rather than testing for statistical significance.

The mean was computed to determine the average pest count and average pest reduction observed across the test trials. The mean provides a measure of central tendency that summarizes the overall performance of the system during the isolated test runs.

$$\bar{x} = \frac{\Sigma x}{n}$$

Where:
$\bar{x}$ – mean
x – observed value per test trial
n – number of test trials

To assess the consistency of system performance, the standard deviation was calculated. This measure indicates the extent to which the observed pest reduction values varied across the three test trials, showing whether the system performance was stable or fluctuating.

$$sd = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n - 1}}$$

Where:
sd – standard deviation
x_i – observed pest reduction per test trial
$\bar{x}$ – mean pest reduction
n – number of test trials

Table 1. Scale for Interpreting Pest-Control Effectiveness

Mean Pest Reduction	Level of Effectiveness	Interpretation
8 – 10 pests	Very Effective	The system shows a high level of pest-control efficacy and is highly effective in repelling rice ear bugs.
6 – 7 pests	Effective	The system shows a moderate to high level of effectiveness in reducing pest presence.
4 – 5 pests	Slightly Effective	The system shows a limited but noticeable effect in pest reduction.
2 – 3 pests	Less Effective	The system has minimal impact on pest control.
0 – 1 pest	Not Effective	The system shows no significant pest-control effect.

Ethical and Technical Considerations

The researchers have ensured that the study adhered to the ethical considerations. This study upheld ethical research guidelines even though it did not involve human participants. The feasibility testing was done openly and transparently, ensuring all procedures and measurements were carried out honestly and without manipulating data. All secondary data, standards, and references used in the study were cited correctly to prevent plagiarism. The materials, tools, and processes used in the feasibility testing did not harm the environment, equipment, or property. The results of the study were reported reliably and were intended only for academic and research purposes. The study employed a quantitative research design to evaluate the feasibility of the proposed project. Feasibility testing used measurable criteria such as performance efficiency, effectiveness, and adherence to established standards. Data were gathered through repeated trials, measurements, and numerical analysis of test results to confirm reliability. Appropriate mathematical and statistical methods, including the calculation of mean values and comparisons to feasibility measures, were used to interpret the data. Standard tools and testing methods were applied to ensure the consistency, accuracy, and validity of the results. Kindness was shown by making sure the study positively contributed to knowledge and practice, while avoiding harm through safe engineering practices and responsible device operation. The data collected was all well documented and accurately portrayed in this study. The authors limitations in the study were well portrayed and avoided all unproven claims on the devices efficacy. By following these guidelines and protocols in this study, it was ensured that the results produced in this study were done in an ethical and scientific way.

DEFINITION OF TERMS

The following operational definitions are provided to have a common understanding of the terms used in the study:

Ultrasonic Shield System

This refers to the ultrasonic rice bug repellent device developed by the researchers, which emits high-frequency sound waves to deter rice ear bugs and was tested under isolated conditions to minimize external interference during operation.

Pest-Control Efficacy

The effectiveness of the pest control method in reducing the number of rice ear bugs present after treatment. It is calculated by determining the observed reduction in rice ear bug count in each test trial, obtained by subtracting the number of pests after system activation from the number recorded before activation. The average pest reduction across the three test trials was then calculated to represent the overall pest-control efficacy of the system.

PRESENTATION, ANALYSIS, FINDINGS, AND INTERPRETATION OF DATA

This chapter presents, analyzes, and explains the data collected from the development and testing of the Ultrasonic Shield System. The first section outlines the system's profile, divided into four key parts: the components used, circuit schematic, prototype design, and system flow. The second section presents the performance evaluation of the Ultrasonic Shield System based on observed pest reduction results obtained from the three isolated test trials.

Profile of the Sonic Shield System

Materials and Specification. This section summarizes the specifications of the materials used in developing the Ultrasonic Shield System.

Table 1 presents the specifications for the various components of the Ultrasonic Shield System. A solar panel (12W, 6V, 2A) serves as the main renewable and sustainable energy source for the system. It makes the operation

of the system sustainable as it is the best for outdoor use. Solar-powered embedded systems have been widely adopted in environmental monitoring due to dependability and low operational cost (Hasan et al., 2023). The generated energy is stored in 3 18650 lithium-ion rechargeable batteries (3.7 V, 2200 mAh), which ensure continuous system operation in low solar irradiance or night conditions. Rechargeable Li-ion batteries are widely used in off-grid IoT and solar powered embedded systems, thus providing more efficient, long-lasting, and less expensive options than lead-acid batteries in total (Rosenfeld, 2025).

Table 2. Materials and Specification of the Ultrasonic Shield System

ITEMS	SPECIFICATION
POWER SUPPLY	
Solar Panel (1x)	Maximum power (Pmax): 12W Maximum power supply voltage (Vmp): 6V Maximum power current (Imp): 2A Size: 35x23.5x1.7cm
Battery (3x)	18650 3.7V 2200mAh Rechargeable
Battery Charger (1x)	TP4056 Lithium Battery Charger
Booster Module (1x)	XL6009 DC-DC
Buck Converter Module (1x)	XL6009 DC-DC
Switch (1x)	2 Pins SPST Red
Fuse (2x)	Current Rating: 3A
Fuse Holder (2x)	5x20mm 18AWG
Schottky Diode (1x)	1N5822 40V 3A
ELECTRONIC COMPONENTS	
Arduino Uno (1x)	Arduino Uno R3, 7-9V
LCD (1x)	2x16 with I2C Module
Ultrasonic Transducer - Transmitter (3x)	16mm TCT40-16 40kHz
MOSFET (1x)	IRLZ44N
Resistor (3x)	100 ohms (1pc), 10k ohms (2pcs)
Jumper Wires	M-M (Male-to-Male), M-F (Male-to-Female), F-F(Female-to-Female)
Electrical Wires	20AWG

The TP4056 lithium battery charger module is integrated to manage safe battery charging, preventing overcharging and deep discharge, which are known to reduce battery lifespan. Proper battery charge management significantly improves the durability and safety of lithium-ion energy storage systems in solar-powered devices (Du et al., 2022). The XL6009 DC–DC boost(increase) and buck(decrease) converter modules are used to regulate voltage levels based on system requirements to maintain voltage stability across different components (Dumalag et al., 2025).

Protective components such as a fuse (3A), are to provide protection. The fuse holders feature 5x20mm and operate at 18 AWG, used to securely mount the fuse in the circuit. The 1N5822 Schottky diode (40V, 3A), is used to prevent reverse current. The switch (2pins SPST Red) allows manual control. It incorporated to safeguard the system against overcurrent, reverse polarity, and short circuits. Electrical protection devices are essential in renewable energy systems to ensure operational safety and prevent component damage (Sharma et al., 2021).

The system is controlled by an Arduino Uno R3 microcontroller, operating 7-9V, which acts as the central processing unit. It is responsible for data acquisition, signal processing, and execution of control logic. Arduino-based platform is an effective and widely used microcontroller for environmental monitoring systems because it reliably collects, processes, and controls sensor data with simple implementation (Rudavskyi et al., 2023).

A 2x16 LCD with I2C module is employed to display real-time system information which is to enhance monitoring and system feedback. The I2C interface minimizes wiring complexity and improves communication efficiency between the display and the microcontroller. The 40 kHz ultrasonic transducer transmitters (TCT40-16) feature 16mm is to generate ultrasonic waves intended for deterrence applications. Ultrasonic frequencies in this range are commonly used in animal deterrent and distance-based sensing systems due to their effective propagation characteristics (Qiu et al., 2023).

An IRLZ44N MOSFET is used as a switching device to control high-current loads using low-voltage signals from the Arduino. Logic-level MOSFETs are preferred in embedded systems for efficient power switching with minimal energy loss. The supporting passive components that ensure stable and reliable circuit connections , such as resistors (100 ohms, 10k ohms), jumper wires (M-M, M-F, F-F) ensure flexible, reliable connections, and electrical wiring (20 AWG).

Circuit Schematic. This section summarizes the electrical connections and component configuration used in developing the Ultrasonic Shield System.
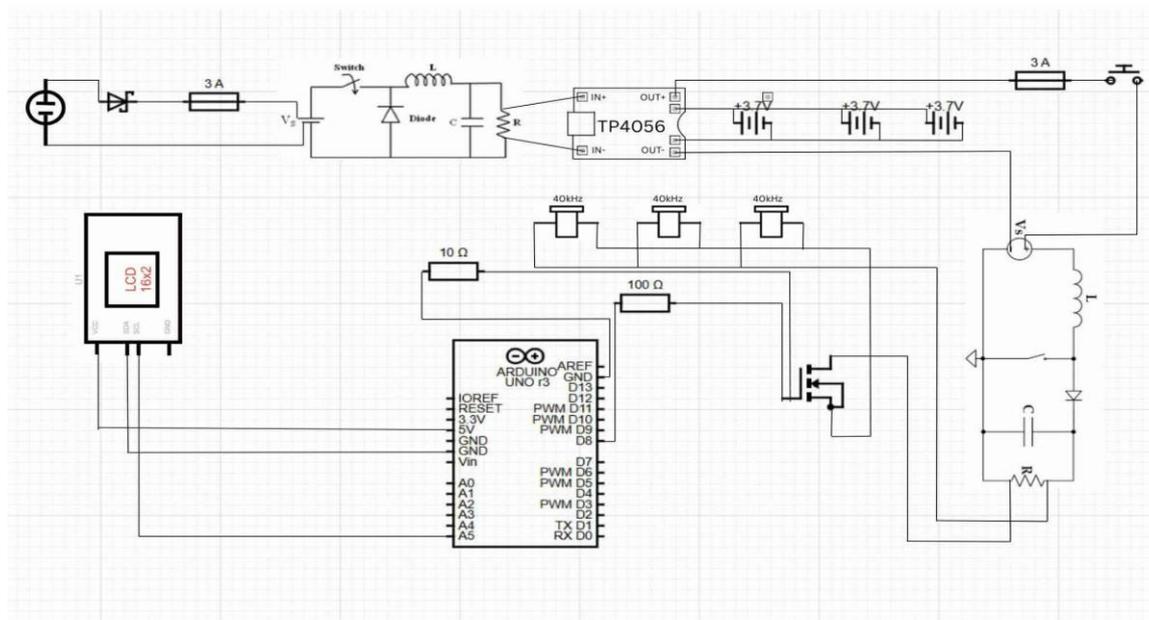
**Figure 2. Circuit Schematic of the Ultrasonic Shield System**

Figure 2 illustrates the schematic diagram of the Ultrasonic Shield System, an Arduino based pest repellent system. The system is supplied by a solar panel that charges a rechargeable lithium battery through a TP4056 battery charging module.

This power configuration enables autonomous and sustainable operation, ensuring continuous system functionality in outdoor agricultural environments (Guruswamy, 2022). The regulated battery output provides stable power to the Arduino Uno, ultrasonic transducers, and LCD display.

In this simplified setup, the Arduino Uno directly controls the ultrasonic transducers according to the programmed operational sequence. The transducers emit high-frequency ultrasonic waves in controlled burst cycles, consisting of alternating ON and OFF intervals over a predefined period. Burst-based ultrasonic emission has been shown to improve pest deterrence efficiency while minimizing power consumption and reducing thermal stress on electronic components.

The LCD display provides real-time updates on system status, including the activation cycles of the ultrasonic transducers. After completing the programmed number of burst cycles, the ultrasonic system is automatically deactivated. This configuration allows for isolated data collection on the performance and efficiency of the ultrasonic deterrence mechanism.

Prototype Design. This section describes the structural design and arrangement of the components in the Ultrasonic Shield System.
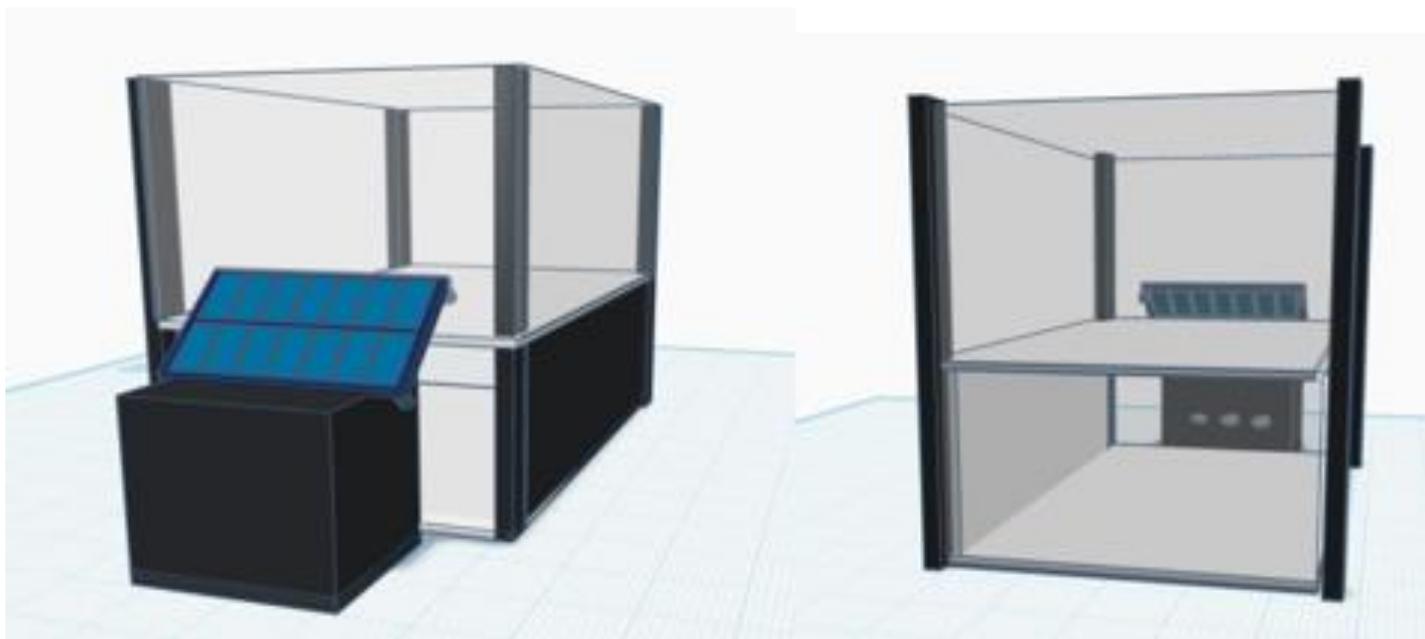
Figure 3. Prototype Design of the Ultrasonic Shield System

Figure 3 presents the prototype design of the Ultrasonic Shield System. The system is a solar-powered, automated device developed to repel rice ear bugs through the emission of ultrasonic sound waves. Solar energy harvested by the integrated panel charges onboard batteries, allowing the device to function independently of external power sources.

A microcontroller manages signals from the ultrasonic transducers and controls the emission of specific ultrasonic frequencies aimed at disturbing and repelling rice ear bugs from the rice crops. This design prioritizes sustainability, self-sufficiency, and low operational cost, making it particularly suitable for agricultural areas, including remote or off-grid rice fields.

The system operates on a 30-minute monitoring cycle to balance effectiveness and energy efficiency. Within this cycle, the ultrasonic emitters are activated for 5 minutes and then 3-minute cooldown phase, pausing emission to prevent excessive power consumption and allow the components to reset. This cycle repeats automatically throughout the 30-minute duration, ensuring periodic monitoring, targeted pest deterrence, and prolonged operational life.

Moreover, the prototype design was developed and evaluated under controlled conditions to assess its functional performance and system reliability prior to field implementation.

The enclosed structure serves as a protective housing for the electronic components while allowing proper placement and alignment of the ultrasonic transducers and solar panel for efficient operation.

Testing in an isolated setup enabled consistent monitoring of power consumption, signal emission patterns, and timing accuracy of the monitoring cycle. These controlled evaluations are essential for identifying design limitations and optimizing system parameters before future deployment in rice field environments.

System Flow. This section presents the system flow of the Ultrasonic Shield System. This is also how the code written in the microcontroller works.
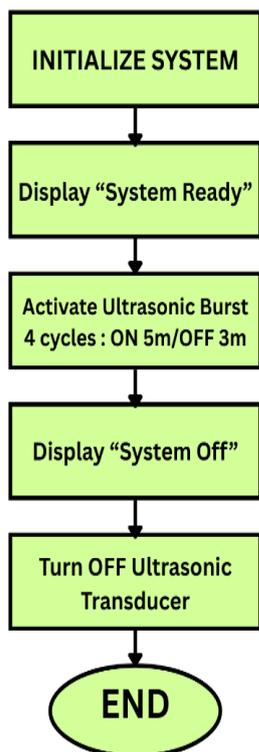
Figure 4. System Flow of the Ultrasonic Shield System

Figure 4 presents the system flow of the Ultrasonic Shield System. This flow illustrates how the system operates and how the program written in the Arduino microcontroller functions during actual use. The system starts at the Start point, where the device is powered on. Once power is supplied, the system proceeds to Initialize System, during which the microcontroller activates and prepares all connected components, including the LCD display and the three ultrasonic transducers. System initialization is a critical step in embedded systems, as it configures hardware peripherals, prepares memory, and ensures that all components are synchronized before normal operation begins.

After initialization, the system displays "System Ready" on the LCD, indicating that the device is active and ready to begin operation. The system then activates the ultrasonic repellent mechanism based on a predefined time-controlled sequence. The ultrasonic transducers operate in controlled bursts consisting of four cycles with a five-minute ON and three-minute OFF pattern, as shown in the system flow. Time-based control is commonly used in automated systems to limit continuous operation, reduce power consumption, and prevent excessive stress on electronic components.

Once the ultrasonic burst cycles are completed, the system displays "System Off" and automatically disables the ultrasonic transducers, ending the operation. This automated shutdown mechanism helps conserve energy and prolong the lifespan of the system components. The system then reaches the End state, completing one full operational cycle. Through this simplified, time-based control flow, the Sonic Shield System ensures consistent ultrasonic emission for pest deterrence while maintaining energy efficiency and operational reliability.

Performance Evaluation. This section presents a statistical analysis of the performance of the Sonic Shield System based on the observed pest reduction results from three test runs. The analysis is based on descriptive statistics, which evaluate the system's effectiveness through the computation of the mean pest reduction and standard deviation, reflecting both the magnitude and consistency of performance.

Table 2. Performance of the Ultrasonic Shield System

Test Run	Pest Count Before	Pest Count After	Reduction	Mean	Standard Deviation
1	10	5	5	6.33	1.53
2	10	2	8		
3	10	4	6		

Table 2 presents the statistical analysis of the performance of the Sonic Shield System based on the observed pest reduction across three test runs. The analysis focuses on the mean pest reduction and the standard deviation, which determine the system's overall effectiveness and the consistency of its results.

The mean pest reduction was computed by dividing the total reduction across the three test runs by the number of trials. A mean value of 6.33 indicates that, on average, the Sonic Shield System was able to reduce approximately six pests per test run. This demonstrates that the system achieved a measurable reduction in pest population during each activation period.

To assess the stability of the system's performance, the standard deviation was calculated. The obtained value of 1.53 indicates that the reduction results were relatively close to the mean, showing that the system produced consistent outcomes across the three test runs. A lower standard deviation suggests minimal variation in performance, which implies that the ultrasonic repellent mechanism operated reliably under the same testing conditions.

Overall, the results show that the Sonic Shield System demonstrated a consistent and observable pest reduction effect across all test runs. With a mean reduction of 6.33 pests and a standard deviation of 1.53, the system exhibited stable performance under controlled conditions. These findings suggest that the Sonic Shield System shows a moderate to high level of effectiveness in repelling rice ear bug in a controlled set-up.

From an agricultural perspective, the findings imply that ultrasonic-based pest control may help reduce farmers' dependence on synthetic pesticides. Although this study no longer includes a control group, the measurable reduction in pest presence demonstrates that the system produces tangible effects under controlled conditions.

This is especially important for small-scale farmers who seek safer and more affordable pest management options. By minimizing chemical exposure, the Ultrasonic Shield System supports healthier working conditions for farmers and helps reduce potential contamination of crops and surrounding ecosystems.

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of the whole research study. This final chapter includes the statement of the problem, findings, limitations, conclusions, and recommendations.

Summary

To reiterate, this study aimed to develop and assess the effectiveness of the Ultrasonic Shield System in repelling rice ear bugs during the school year 2025-2026.

Specifically, this study sought to answer the following questions:

1. What is the profile of the Ultrasonic Shield System in terms of:

1.1. circuit schematic;

1.2. prototype design; and

1.3. system flow?

2. How effective is the Ultrasonic Shield System in repelling rice ear bugs in terms of pest-control efficacy?

3. What recommendations can be proposed based from the findings of the study?

FINDINGS

After a thorough analysis and interpretation of data, the researchers arrived at the following findings:

1. Profile of the Sonic Shield System

The Sonic Shield System consist of a solar-powered ultrasonic pest control device designed to repel rice ear bugs in rice fields. The system is powered by a 12W solar panel connected to rechargeable 18650 lithium-ion batteries through a TP4056 charging module, allowing continuous and off-grid operation. It is controlled by an Arduino Uno R3 microcontroller, which manages system logic and ultrasonic activation. The system utilizes 40 kHz ultrasonic transducers driven by a MOSFET circuit to emit high-frequency sound waves that disturb and repel rice ear bugs without harming crops or the environment. The system operates in a programmed cycle that includes ultrasonic activation, cooldown intervals, and automatic shutdown after a fixed operating duration, ensuring energy efficiency and preventing pest habituation.

2. Performance Evaluation

Pest-Control Efficacy

The study revealed a mean reduction of 6.33 pests and a standard deviation of 1.53, which suggest that it shows a moderate to high level of effectiveness in repelling rice ear bug in a controlled set-up and exhibit stable performance under controlled conditions.

CONCLUSION

This study successfully developed and tested the Sonic Shield System, an Arduino-based ultrasonic pest control device designed to repel rice ear bugs using sound frequency technology and solar power. The system demonstrated a consistent and observable pest reduction effect across all test runs and showed moderate to high level of effectiveness in repelling rice ear bug in a controlled set-up. These findings indicate that the Sonic Shield System is a viable alternative to conventional pest control methods for managing rice ear bugs. Future research and development efforts should focus on improving system precision, optimizing ultrasonic frequency patterns, and evaluating long-term effectiveness under varying field conditions. Further studies may also explore the integration of advanced sensors and intelligent control mechanisms to enhance automation and overall system performance.

RECOMMENDATIONS

Based from the results of the study, the following recommendations are made.

1. Assessment of the acceptability of the Sonic Shield System among local rice farmers to determine its practicality, ease of use, safety, and overall effectiveness under actual field conditions.
2. Optimization and testing of different ultrasonic frequency ranges and emission patterns to enhance the repellency effect of the Sonic Shield System against rice ear bugs.

3. Evaluation of the system's detection accuracy and operational reliability to ensure proper functionality, minimize false detections, and enhance the consistency of pest monitoring and ultrasonic activation.

4. Extension of the data collection and testing period to assess the long-term effectiveness, durability, and sustainability of the Sonic Shield System across multiple cropping seasons. A longer observation period may provide more reliable data, reveal seasonal pest behavior patterns, and allow a more comprehensive evaluation of the system's sustained impact on crop protection.

5. Replication of the study in other rice-growing areas and under different field conditions to further validate the findings, improve system performance, and strengthen the generalizability of the results.

LIST OF ABBREVIATIONS

ABBREVIATION	DEFINITION
FWM	Farm Waste Management
WMT	Waste Management Theory
MINLP	Mixed-Integer Nonlinear Programming model
MILP	Mixed-Integer Linear Programming model
LARP	Location-Assignment-Routing-Problem
CADM	Comprehensive Action Determination Model
SEM	Structural Equation Modelling
LGU	Local Government Units
FAO	Food and Agriculture Organization
DA	Department of Agriculture
IPM	Integrated Pest Management
NAOP	National Organic Agriculture Program
AI	Artificial Intelligence
IoT	Internet of Things
PVC	Polyvinyl Chloride
LED	Light Dependent Resistor
PCB	Printed Circuit Board
PhilRice	Philippine Rice Research Institute

ACKNOWLEDGMENTS

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APPENDICES

Republic of the Philippines

Department of Education

SAN AGUSTIN NATIONAL HIGH SCHOOL

December 15, 2025

Nilo C. Lanoy EdD
Office of the School Principal
San Agustin NHS Campus
San Agustin, Sagbayan, Bohol

Dr. Lanoy:

We hope this letter finds you well. We, the undersigned Grade 12 students, are writing to formally request permission to conduct a research study as part of our Practical Research 2 class requirement. The study, titled **"SONIC SHIELD SYSTEM"**, will be conducted under the supervision of our research adviser, **Mr. Vincent Edward Cirunay.**

Due to the nature of our topic, we kindly request permission to conduct the study outside the classroom setting. We believe that an open and practical environment is essential for the accuracy and effectiveness of our data collection.

We assure you that we will strictly adhere to all safety protocols and guidelines provided by the school. Additionally, we are willing to coordinate with school administrators to ensure that our study aligns with the institution's regulations and academic goals.

We appreciate your time and consideration of this request. We look forward to your approval and guidance in facilitating this valuable learning experience.

Thank you very much for your support.

Sincerely,
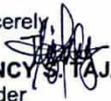
NANCY S. TAJALE
Leader

Noted:

JOSELITO Y. BULABOS
Teacher, Practical Research 2

Approved:

NILO C. LANOY EdD
School Principal II
School Head

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APPENDIX A. TRANSMITTAL LETTER

APPENDIX B. RESEARCH INSTRUMENT

PERFORMANCE TESTING RECORD SHEET

Test Run	Pest Count Before	Pest Count After	Reduction	Mean	Standard Deviation
1					
2					
3					

Computation Guide:

Reduction = Pest Count Before – Pest Count After

Mean = (Reduction / no. of Test Run)

Standard Deviation = $\sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$

APPENDIX C. DECLARATION OF ANTI-PLAGIARISM

Republic of the Philippines
Department of Education
Region VII, Central Visayas
Schools Division of Bohol
District of Sagbayan
SAN AGUSTIN NATIONAL HIGH SCHOOL
RESEARCH AND DEVELOPMENT CENTER
Senior High Department
San Agustin, Sagbayan Bohol

DECLARATION OF ANTI-PLAGIARISM
(DepEd Research Management Guidelines)

A. We, Nancy S. Tajale, Jamaica Dee C. Dominguez, Althea Faye Fernnadez, Trisha Eve R. Lapuja, Marjun Noah P. Polinar, Saiha Mae B. Repana, Fritz Leanne T. Requierme, Frederick A. Soreño, understand that plagiarism is the act of taking and using another person's ideas and works and passing them on as one's own. This includes explicitly copying the whole work of another person and/or using some parts of such work without proper acknowledgement and referencing thereof.

B. We understand that violation of this declaration and commitment shall be subject to consequences and shall be dealt with accordingly by the Department of Education.

C. We hereby attest to the originality of this report and has cited properly all the references used. We further commit that all deliverables and the final research emanating from this study shall be original content. We shall use appropriate citations in referencing other works from various sources.

Name	Signature
Nancy S. Tajale	
Jamaica Dee C. Dominguez	
Althea Faye Fernandez	
Trisha Eve R. Lapuja	
Marjun Noah P. Polinar	
Saiha Mae B. Repana	
Fritz Leanne T. Requierme	
Frederick A. Soreño	

APPENDIX D. CERTIFICATE OF PLAGIARISM TEST

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APPENDIX E. DECLARATION OF ABSENCE OF INTEREST
Republic of the Philippines
Department of Education
Region VII, Central Visayas
Schools Division of Bohol
District of Sagbayan
SAN AGUSTIN NATIONAL HIGH SCHOOL
RESEARCH AND DEVELOPMENT CENTER
Senior High Department
San Agustin, Sagbayan Bohol

DECLERATION OF ABSENCE OF INTEREST
(DepEd Research Management Guidelines)

We, Nancy S. Tajale, Jamaica Dee C. Dominguez, Althea Faye Fernandez, Trisha Eve R. Lapuja, Marjun Noah P. Polinar, Saiha Mae B. Repana, Fritz Leanne T. Requierme, Frederick A. Soreño, understand that conflict of interest refers to situation in which financial or other personal considerations may compromise out judgement in evaluating, conducting, or reporting research.

We hereby declare that we don't have any personal conflict of interest that may arise from the submission of this research report.

We, hereby attest to the originality of this report and has cited properly all the references used. We further commit that all deliverables and the final research emanating from this study shall be original content. We shall use appropriate citations in referencing other works from various sources.

Name	Signature
Nancy S. Tajale	
Jamaica Dee C. Dominguez	
Althea Faye Fernandez	
Trisha Eve R. Lapuja	
Marjun Noah P. Polinar	
Saiha Mae B. Repana	
Fritz Leanne T. Requierme	
Frederick A. Soreño	

APPENDIX F. COMPUTATION

Pest-Control Efficacy

Test Run	Pest Count Before	Pest Count After	Reduction	Mean	Standard Deviation
1	10	5	5	6.33	1.53
2	10	2	8		
3	10	4	6		

APPENDIX G. ETHICS RESULT

Research Design R&D and quasi-experimental design are appropriate, but **risk protocols** for handling electrical devices outdoors are not detailed.	*SUGGESTION:* Add a list of safety measures: waterproofing of components, secure casing, ground stability, PPE use, and emergency shutdown.
Conflict of Interest No conflict is declared, but the researchers belong to the same community and may rely on farmers' cooperation.	*SUGGESTION:* Add that the participation of any farmers providing field access is voluntary and will not affect their relationship with the school or LGU.
Research Environment/Participants/Sampling The environment is established clearly, but authorization procedures need strengthening. Accurately describes device components. However, multiple modules such as **ESP32-CAM** raise privacy implications.	*SUGGESTION:* *Obtain* **written permission** *from landowners and LGU/agriculture office for field testing; place warning signs around test plots.* Clarify that the camera does **not** capture identifiable persons and is strictly used for pest-detection only; images will not store personal data.

APPENDIX H. DESIGN/FEATURES OF THE SYSTEM

APPENDIX I. DOCUMENTATION

CURRICULUM VITAE

Personal Data		
Name	:	Nancy S. Tajale
Nickname	:	Nanz
Age	:	17
Contact Number	:	09104816315
Address	:	Cabog, Clarin, Bohol
Date of Birth	:	October 08, 2008
Place of Birth	:	Catigbian District Hospital
Civil Status	:	Single
Religion	:	Iglesia Ni Cristo
Motto	:	*"Nothing's New"*
Education Background		
Elementary	:	Cabog Elementary School Cabog, Clarin, Bohol
Junior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

CURRICULUM VITAE

Personal Data		
Name	:	Jamaica Dee C. Dominguez
Nickname	:	Maica
Age	:	17
Contact Number	:	09305531543
Address	:	Katipunan, Sagbayan, Bohol
Date of Birth	:	January 30, 2008
Place of Birth	:	Tagbilaran City Provincial Hospital
Civil Status	:	Single
Religion	:	Roman Catholic
Motto	:	*"Everything happens for a reason."*
Education Background		
Elementary	:	Sagbayan Central Elementary School School Site, Sagbayan, Bohol
Junior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

CURRICULUM VITAE

Personal Data		
Name	:	Althea Faye Fernandez
Nickname	:	Theang
Age	:	17
Contact Number	:	09651457372
Address	:	Cambitoon, Inabanga, Bohol
Date of Birth	:	November 20, 2008
Place of Birth	:	Mapinalanggaon, Bacolod, Negros Occidental
Civil Status	:	Single
Religion	:	Baptist
Motto	:	*"In His Time"*
Education Background		
Elementary	:	Cambitoon Elementary School Cambitoon, Inabanga, Bohol
Junior High School	:	San Jose National High School San Jose, Inabanga, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

CURRICULUM VITAE

Personal Data		
Name	:	Trisha Eve R. Lapuja
Nickname	:	Trish
Age	:	17
Contact Number	:	09702529186
Address	:	Sagbayan Sur, Sagbayan, Bohol
Date of Birth	:	January 03, 2008
Place of Birth	:	Catigbian District Hospital
Civil Status	:	Single
Religion	:	Roman Catholic
Motto	:	*"Carpe diem"*
Education Background		
Elementary	:	Sagbayan Sur Elementary School Sagbayan Sur, Sagbayan, Bohol
Junior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

CURRICULUM VITAE

Personal Data		
Name	:	Marjun Noah P. Polinar
Nickname	:	Jun
Age	:	17
Contact Number	:	09364541048
Address	:	Sitio Capitol, Poblacion, Sagbayan, Bohol
Date of Birth	:	June 22, 2008
Place of Birth	:	Catigbian District Hospital
Civil Status	:	Single
Religion	:	Roman Catholic
Motto	:	*"Always Positive."*
Education Background		
Elementary	:	Sagbayan Central Elementary School School Site, Sagbayan, Bohol
Junior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

CURRICULUM VITAE

Personal Data		
Name	:	Saiha Mae B. Repana
Nickname	:	saé
Age	:	17
Contact Number	:	09759121942
Address	:	Canmaya Diot, Sagbayan, Bohol
Date of Birth	:	May 16, 2008
Place of Birth	:	Tagbilaran City
Civil Status	:	Single
Religion	:	Roman Catholic
Motto	:	*DASIG lang sa KANUNAY"*
Education Background		
Elementary	:	Nahawan Elementary School Nahawan, Clarin, Bohol
Junior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

Personal Data		
Name	**:**	Fritz Leanne T. Requierme
Nickname	**:**	Yan
Age	**:**	18
Contact Number	:	09929600412
Address	:	San Jose, Inabanga, Bohol
Date of Birth	:	November 27, 2007
Place of Birth	:	Lapu-lapu City
Civil Status	:	Single
Religion	:	MCGI
Motto	:	*"If it's meant to be, it'll be."*
Education Background		
Elementary	:	Gun-ob Elementary School Gun-ob, Lapu-Lapu, Cebu, City
Junior High School	:	San Jose National High School San Jose, Inabanga, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol

CURRICULUM VITAE

Personal Data		
Name	**:**	Frederick A. Soreno
Nickname	**:**	Fred
Age	**:**	17
Contact Number	:	09305531543
Address	:	Cabog, Clarin, Bohol
Date of Birth	:	January 21, 2008
Place of Birth	:	Cabog, Clarin, Bohol
Civil Status	:	Single
Religion	:	Roman Catholic
Motto	:	*"Focus on improving, not proving."*
Education Background		
Elementary	:	Cabog Elementary School Cabog, Clarin, Bohol
Junior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol
Senior High School	:	San Agustin National High School San Agustin, Sagbayan, Bohol