Prolonged Evaluation of the Automated Electric Rat Trap (AERT) in a Large Agricultural Storage Facility

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Approval Sheet

This research entitled, **PROLONGED EVALUATION OF THE AUTOMATED ELECTRIC RAT TRAP (AERT) IN A LARGE AGRICULTURAL STORAGE FACILITY**, prepared and submitted by **ACHILLES T. ABARY, CHARLES GODWIN S. AGUJA, LORI BELLE R. GAPASANGRA, DUSTIN AMIEL F. GARCIA, ARABHEL C. MONSERRAT,** and **JAMES DALE S. MOOG** in partial fulfillment of the requirements for the Senior High School Applied Research Course with the specialization on **SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM)** has been examined and is hereby recommended for approval and acceptance.

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Dedication

With heartfelt gratitude, this research is dedicated to:

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And to God, for His blessings and guidance

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"Trust in the Lord with all your heart and lean not on your own understanding;

in all your ways submit to him, and he will make your paths straight."

Proverbs 3:5-6

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Prolonged Evaluation of the Automated Electric Rat Trap (AERT) in a Large Agricultural Storage Facility

Abstract

This study investigates the effectiveness of the Automated Electric Rat Trap (AERT) as a humane solution for managing rat populations in agricultural environments. Employing a quasi-experimental pretest-posttest non-equivalent group comparison design, the research compared rat luring and damage to agricultural commodities with and without the AERT over a 10-day period. The study found that the AERT significantly reduced wheat sack damage, with the mean number of damaged sacks decreasing from 0.6842 (without AERT) to 0.3684 (with AERT). A paired t-test revealed a statistically significant difference in wheat sack damage ($t = 2.0513$, $p = 0.0275$, one-tailed), indicating the AERT's potential as an effective pest management tool. However, the impact on rat luring was not statistically significant ($p = 0.7990$). The AERT demonstrated predictable power consumption, with voltage dropping linearly from 11.84V to 10.42V over five days ($R^2 = 0.9721$). These findings highlight the importance of humane pest control methods that align with ethical standards and contribute to sustainable agricultural practices, while also emphasizing the need for further research to optimize the AERT's design and functionality.

Keywords*:* rodent infestation control, automated trapping systems, agricultural pest management, humane pest control, electric pest management, non-chemical pest control

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Chapter 1

Introduction

A comprehensive understanding of the widespread rat problems in both farms and homes, including indoor and outdoor areas, focused on the need for effective control measures. Globally, rodents were responsible for approximately 30% of annual crop damage, emphasizing the importance of addressing this issue (Wondifraw et al., 2021). The extensive damage rat caused to crops globally underscored the pressing need for more effective management strategies. Addressing the ecological and agricultural impacts of rats was essential for ensuring food security and mitigating losses. Community-based approaches to pest management played a crucial role in reducing health risks associated with rat infestations (Witmer, 2022).

Rats were the primary transmitters of leptospirosis, a dangerous bacterial disease that could infect both humans and other animals (Cleveland Clinic, 2022). The significance of rats in the spread and transmission of *Leptospira* was widely recognized globally. Rats were recognized for harboring various harmful serovars of *Leptospira spp*., which could infect both humans and animals (Boey et al., 2019).

Rat infestations had been proven in India and Southeast Asia to impair output by 25-30%, especially hurting rice and other key crops. Severe infestations in some regions could cause 80-100% damage, particularly to young plants and seedlings. Rodents were reported in Western Kenya to inflict 20% damage to maize crops, 34% to 100% damage to immature wheat, and 34% damage to barley. Rats have caused losses of 15-40% in oilseeds and pulses, 13-29% in root crops, 9-48% in coffee, and 21-60% in cotton in Ethiopia, where comparable disastrous repercussions had been observed.

While cereal yields in northern Ethiopia had dropped by 9-44%, maize crops in central Ethiopia had fallen by 26.4%. Furthermore, crop losses in Eastern Ethiopia had surpassed 50 percent. Rodents not only harmed numerous properties in rural areas, but they also impair agricultural goods in cities. Despite these issues, there was a notable lack of detailed studies identifying rodent pest species in many affected regions (Wondifraw et al., 2021).

Captive-bolt and electrocution traps were determined to provide the least amount of suffering, while anticoagulants and some other traps were linked to high levels of distress. Well-constructed snap traps, which caused quick death, were preferred over traps that caused prolonged suffering. These results emphasized the importance of incorporating humane principles in trap construction (Baert K. et al., 2023). There had been a noticeable change in pest management ethics over time, with growing awareness of the inherent worth of non-human animals and a heightened sense of duty to treat them with empathy. This shift reflected a broader understanding of the need for more compassionate techniques in dealing with pests (Wolf & Schaffner, 2019). Existing requirements for death traps, such as time to unconsciousness, were regarded inadequate and might have been considerably improved by the introduction of novel trap designs and materials (Proulx et al., 2020).

The design and intended use of most rat traps were geared toward household applications, making them inadequate for effectively managing larger rat populations on farms. Farm rats were bigger and more wary of traps than house rats. As a result, household traps did not work as well in agricultural settings because they were made for house rats, not the larger and more numerous farm rats. Most traps available were designed primarily for home use (Byers et al., 2019). Furthermore, the continuing problems caused by rats, such as their harmful effects on crops and forests, as well as their contribution to the spread of diseases like leptospirosis, emphasized the necessity for improved and compassionate pest management techniques. The ethical difficulties with ordinary rat traps, which caused extended suffering, underscored the need for kinder alternatives to be deployed. New electronic traps that allowed for a speedy, humane kill, as well as a desire for traps tailored for larger farm rats, reflected developments in pest control understanding.

This study aimed to demonstrate the critical need of incorporating humane and successful rat control tactics in domestic and agricultural settings, guaranteeing that pest management not only ensured public health and food security but also represented an increasingly important ethical duty toward animal welfare.

Background of the Study

Rats continuously grew their teeth; they gnawed on things such as plastics, wood, and even electrical wiring, resulting in the rats having strong and sharp teeth (AIWC Volunteer, 2023). Rats were susceptible to global food danger and health issues, resulting in nearly 280 million cases of malnutrition worldwide, and 400 million people each year were affected by diseases they carried. In sub-Saharan Africa, rats were the cause of crop losses, about 16% in the field and 8% during storage. Regardless of the potential of rodents to spread over 60 diseases to the human population, the public health risks associated with them were not well understood. Understanding how communities perceived and dealt with rats was essential for developing effective management strategies (Donga et al., 2022).

The regulation of rat populations, especially those impacting agriculture, was dictated by a blend of local and international legislation and ethical principles that sought to reconcile the need for pest management with the humane treatment of animals. The Philippine Animal Welfare Act of 1998 (Republic Act No. 8485) was a municipal regulation that demanded the humane treatment of all animals, potentially embracing the ethical handling of pests, such as rats. This regulation corresponded with international norms, particularly the Wildlife and Countryside Act 1981, which required the humane death of trapped animals, and Environmental Protection Agency (EPA) guidelines that prohibited the use of ecologically damaging rodenticides.

Rice was a staple food in the Philippines; hence efforts were made to cultivate enough of it to maintain the country's growth. One of the most difficult problems in achieving this goal was eliminating rat infestations generated by diverse species, such as black and brown rats, which lived in buildings, sewers, and agricultural regions in both urban and rural settings. According to Ronald Pacol, South Cotabato’s coordinator for integrated pest management control, data from 2018 to 2022 showed that rat infestations resulted in at least PHP 69 million in crop losses, predominantly impacting rice, corn, and valuable crops. The high breeding capacity of rats worsened the problem since just one pair could give birth to many babies, causing quick growth in population and more damage to crops. In many regions affected by the widespread issue, there was a lack of comprehensive studies that specified rat pest species (Rebollido, 2023).

Rats were adaptable omnivores that thrived near humans, living in large colonies and staying underground or hidden during the day. They reproduced rapidly, with females having up to seven litters per year and the young becoming independent within three to four weeks (Floyd, 2024). Every year, millions of rats and mice were killed worldwide because they were seen as pests. Methods like glue traps and using bait with anticoagulant poisons caused the most suffering and should have been the last option from an animal welfare viewpoint. However, these were some of the most commonly used ways to control rat populations. Cage traps, followed by a quick, forceful kill, were found to be less harmful. The effectiveness of snap traps varied depending on the type used, but high-quality snap traps, when used correctly, could have caused the least suffering. The large-scale killing of rats had the biggest human impact on the welfare of wild animals. Since rats were capable of feeling pain, it was important to reduce their suffering as much as possible when controlling their numbers (Baker, 2022).

Finding the most effective method for managing rat populations in agricultural settings was crucial for protecting crops, ensuring food safety, and maintaining economic viability. Rats were notorious pests in these environments, where they thrived due to the abundance of food sources such as grains, fruits, and vegetables. Their rapid reproduction rates and ability to cause significant damage made effective rat control imperative (Ultimate Pest Control, 2023). Farm rats often needed specialized trapping techniques due to their larger size and more cautious behavior, making standard household traps less effective (de Cock et al., 2024). This study aimed to evaluate the suitability of different trapping methods for agricultural settings, with a focus on improving both efficacy and animal welfare. Additionally, the researchers sought to identify more humane alternatives that minimized suffering and better addressed the needs of managing larger and more wary rat populations on farms with the use of electric shock.

Review of Related Literature

This foundational knowledge underscores the importance of maintaining rat populations for effective pest management in agriculture and cities to prevent crop destruction and health hazards. To address these challenges, multiple techniques have been created, ranging from physical traps such as the Trap Barrier System (TBS) in rice paddies to electronic traps and the implementation of baiting tactics in city settings. The efficiency of these tools in controlling rat populations can vary depending on the species, bait preferences, and environmental conditions. Furthermore, the increasing worry about the reliance on artificial pesticides emphasizes the necessity for sustainable and compassionate alternatives for pest control that safeguard both human health and the environment.

Crop Yield and Crop Damage

Rodent invasions represent a significant obstacle for agriculture, leading to considerable crop destruction and jeopardizing food safety. Efficient pest control methods are crucial to reduce these effects while maintaining environmental sustainability.

The Trap Barrier System (TBS) demonstrated its effectiveness by capturing 4,580 rats over a single planting season, significantly reducing rat populations, with adult males comprising the majority of the captures. The study was conducted on a one-hectare rice field using the Trap Barrier System (TBS), which included physical barriers and multiple live traps. (Afif et al., 2023). Although TBS reduced rat attacks on rice crops by 80%, the system doesn't address the entire rat life cycle, indicating the need for complementary pest control strategies (Garfansa et al., 2023). Despite current rat control methods, crop damage remains a serious concern, and the development of safer alternatives is essential to minimize risks to health and the environment (Witmer, 2022). Research also stresses the importance of sustainable pesticide use to mitigate environmental damage and improve food security (Rajak et al., 2023). In Asia, integrating ecologically-based rodent management (EBRM) with broader pest management strategies is vital for balancing food security and conservation (Singleton et al., 2021). Additionally, Taiwanese farmers report significant crop damage from rats, especially in rice and vegetables, highlighting the need for improved rat control methods to safeguard their livelihoods (Best et al., 2022).

Optimal Voltage for Humaneness

High voltage electric fields have emerged as a promising, humane method for rodent control, offering an alternative to chemical-based solutions. As research in sustainable pest management advances, these systems are gaining attention for their effectiveness, efficiency, and minimal environmental impact.

The utilization of high voltage in rodent control, particularly for the humane elimination of rats, can be considered both effective and ethical in certain contexts. Research has demonstrated that high voltage electric fields can induce electrostatic phenomena that effectively repel and capture pests, offering a non-chemical alternative to traditional pest control methods. For instance, the study "High Voltage Electric Fields Have Potential to Create New Physical Pest Control Systems" of Kusakari et al. (2020), illustrates how electric fields can be employed to humanely eliminate rodents by generating attractive forces that capture and immobilize them.

The effectiveness of high voltage electric fields in pest control has been supported by multiple studies. For example, additional research by Takikawa et al. (2019) explored the use of electrostatic forces in controlling pest populations in greenhouse environments, demonstrating substantial reductions in pest numbers with minimal impact on non-target species. Similarly, the findings of Panich and

Rukijkanpanich (2024) highlighted the potential of high voltage systems in reducing infestations in storage facilities, thereby preventing damage to stored commodities.

Moreover, the consistent and predictable power consumption rates observed in high voltage traps ensure sustained effectiveness over time. These systems reduce the need for frequent maintenance, thus minimizing operational costs and the risk of harm to non-target species. The ability to maintain high efficacy with low maintenance makes high voltage electric traps an attractive option for large-scale pest management in agricultural settings.

Furthermore, the ethical considerations of using high voltage electric traps cannot be overlooked. Unlike chemical-based methods, which often result in secondary poisoning and ecological disruption, high voltage traps provide a more targeted approach, ensuring that only the intended pest species are affected. This aligns with the principles of Integrated Pest Management (IPM) and Sustainable Pest Management (SPM), which prioritize environmentally friendly and humane pest control methods.

While further research is warranted to fully comprehend the long-term effects and optimize the use of high voltage in rodent control, existing evidence suggests that it can serve as a viable and humane strategy for managing rodent populations in agricultural and other settings. The continuous advancements in this field, coupled with the growing interest in sustainable pest management, underscore the potential for high voltage electric traps to play a significant role in future pest control strategies. These findings are reinforced by studies such as those conducted by Grady (2024) and Ali et al. (2024), which emphasize the integration of AI and IoT technologies in enhancing the effectiveness and efficiency of pest control systems. The automated nature of high voltage traps, combined with real-time data monitoring and intervention capabilities, positions them as a cutting-edge solution in the realm of smart farming and pest management. As research progresses, it is anticipated that high voltage electric traps will become even more refined, offering greater reliability and efficacy in various environmental conditions.

Environment, Health, and Safety (EHS)

Pesticides are essential for boosting agricultural productivity. Research indicates that, without these chemicals, crop losses from pests and diseases could reach 30-50%. By managing rat and pest populations, farmers can increase their yields per hectare, which is crucial for feeding the expanding global population.

However, pesticides, while necessary for modern farming, can be harmful to human health through various exposure routes such as skin contact, breathing, and ingestion. Studies examine these routes and their health effects, including immediate poisonings and long-term diseases like cancer, asthma, and cognitive impairments, highlighting the need for better pesticide application and reduced use to protect human health (Tudi et al., 2022). Additionally, research reviews how pesticides spread through ecosystems, polluting water sources and degrading soil quality. Pesticides can persist in the environment, negatively impacting beneficial organisms like earthworms and soil microbes, which underscores the need for improved management practices to minimize these environmental effects (Pathak et al., 2022). Excessive use of man-made pesticides in farming is crucial but results in significant pollution of soil, water, and air, affecting unintended species and emphasizing the need for more sustainable farming practices to ensure food security for the growing global population (Rajak et al., 2023). Furthermore, studies highlight the importance of improving rat monitoring and control due to rats spreading new bacterial diseases

that can affect humans, stressing the need to prevent outbreaks and safeguard public health (Ame et al., 2023). The rise in global pesticide use has also exposed flaws in management practices, increasing risks to both
human health and the environment, which calls for better management strategies (van den Berg et al., 2020).

Bait Preferences

Effective rat control relies on selecting appropriate baits, with food-based lures playing a key role in attracting roof rats.

A study assessing the effectiveness of different baits for roof rats found that food-based lures, such as peanut butter and wax blocks, significantly increased visitation rates to monitoring devices compared to control setups without bait, highlighting that effective bait can enhance rat capture (Wales et al., 2021). Non-toxic baits, such as peanut butter, can be useful for pre-baiting and acclimatizing rats to bait stations before introducing toxic baits, helping to overcome neophobia (fear of new objects) and increasing the likelihood of rats consuming toxic baits later (Frankova et al., 2019). While non-toxic baits are effective for monitoring and acclimatization, anticoagulant baits remain the most effective tool for significantly reducing rat populations, as demonstrated in a controlled interrupted time series analysis in Singapore, where intensive anticoagulant baiting resulted in substantial reductions in rat activity and abundance (Soh et al., 2022). However, their use must be judicious to prevent resistance development. Similarly, a study on commensal small mammal species in urban areas of Penang Island found Bandicota bengalensis to be the dominant species in residential areas (19.20%) and Rattus norvegicus in commercial areas (14.93%), with Rattus norvegicus having the highest overall trapping success rate of 11.30%. High-protein bait, particularly fried chicken leftovers (FCL), proved to be the most effective for attracting commensal rats (Amni et al., 2019). Peanut butter and fried chicken can both serve as effective baits due to their scent and high protein content, respectively, making them versatile options for attracting various small mammal species in urban environments.

Studies show that the most effective results in rat control are achieved through a variety of tactics. The Trap Barrier System (TBS) has been successful in agricultural environments, notably decreasing rat numbers, but it does not cover the complete pest life cycle. In urban areas, selecting the right bait, like peanut butter and leftover fried chicken, is essential for attracting species like Rattus norvegicus and Bandicota bengalensis, highlighting the importance of customized approaches. Although non-toxic baits can assist in getting rats accustomed to bait stations, anticoagulant baits are still the most successful in reducing populations on a large scale, but caution must be taken to prevent the development of resistance. In conclusion, it is crucial to combine these diverse methods with eco-friendly pesticide use to achieve a balance between efficient rat management and concerns for the environment and public health.

Rat traps are the most well-known way to catch rats. However, baiting techniques used for the rodents are not similar to those used to catch mice because of their different preferences when it comes to food to which they get attracted and their mannerisms. They indulge in the higher protein counts in foods; the higher the protein, the better for the traps to fall for it. The most efficient bait to catch a rat is to use foods that rat could not resist, like nuts, bacon, dried fish, and peanut butter. Peanut butter is the most compatible bait for traps because of its stickiness, which has a high chance of not falling off, a great description for the trap. Rats do not get attracted to cheese as much as they do to peanut butter (Underwood, 2024).

Economic and Structural Impacts of Rat Infestations in Storage Facilities

Rodent infestations, particularly rats and mice, can have significant financial and structural consequences for storage facilities. Their presence is a common and pressing issue, especially in states like Arizona, where their destructive behaviors cause widespread damage.

They have powerful teeth that mark a gnaw in doors and baseboards, which is a possible telltale sign of rat infestation. Rats also make scratching noises and marks around the area. Rodents give a threat to the safety of an individual's home, business, or property (Woolf, 2023). The costs associated with rat infestations can be staggering, with average extermination expenses ranging from $150 to $1,200, and the national average around $475 (Rakesh, 2024). In cases of severe infestations, property owners may face costs exceeding $1,200 due to extensive removal and repair measures (Lacoma, 2024). The financial implications extend beyond extermination costs. Damaged goods, particularly in food storage facilities, can result in significant losses in inventory value. Rodents can contaminate stored products, rendering them unsellable. For instance, a study found that rodent-induced damage in food warehouses led to the loss of approximately 28.25 tons of rice in just 25 days, costing between €1,435 and €6,136 per warehouse (Dossou et al., 2020). In addition, rats consume about 25 grams of food per day and contaminate large quantities of stored produce with urine and feces, further compounding financial losses, as infested batches may need to be declared unfit for human consumption (IRRI Rice Knowledge Bank, 2024). These rodents gnaw on insulation, electrical wiring, and building materials, leading to costly repairs and increased fire hazards (Convesio, 2024). Furthermore, a study in Cotonou Harbor emphasized how rodent-induced damage in food warehouses resulted in substantial economic losses due to destroyed or contaminated food stocks, highlighting the importance of effective rodent management strategies (Dossou et al., 2020). In addition to direct damages, the costs of pest control services must be considered. Professional extermination services typically range from $145 to $572 for standard removal (Knight, 2023), and ongoing maintenance costs can add an additional financial burden. Monthly pest control visits can cost between $40 and $70 (Area Pest Control Services, 2022).

Pest Control Strategies for Agricultural Storage

Effective pest control in storage environments is critical to ensuring the quality and safety of stored goods, particularly in bulk cereal storage. The use of integrated strategies that combine prevention, active control measures, and sustainable practices is increasingly recognized as the most effective approach.

Research shows that combining various trap types, such as scented traps and snap traps for rodents, with sticky tape barriers can significantly reduce insect and rodent infestations, leading to minimal grain damage (Kljajić et al., 2021). Integrated Pest Management (IPM) focuses on holistic, sustainable methods, prioritizing improved storage facilities, environmental controls, and reduced chemical pesticide use (Mishra et al., 2024). However, organically approved chemicals may be needed for extended storage periods to maintain pest control effectiveness (Kljajić et al., 2021). Additionally, maintaining cleanliness and organization in storage units, along with using climate-controlled environments, can minimize rodent infestations (Buckman, 2022). In food and feed manufacturing, a comprehensive rodent control program that integrates sanitation, maintenance, and pest management is vital to prevent product damage and contamination (Nationwide Mutual Insurance Company, 2024).

Theoretical Framework

This study's theoretical framework is anchored in behavioral ecology, which explores how animals interact with their environments. Behavioral ecology sheds light on how animals modify their behavior in response to environmental stimuli, such as traps and barriers. Prior research has shown the efficacy of electric traps in controlling pest populations by capitalizing on behavioral patterns of attraction and avoidance. For example, Jobe et al. (2024) demonstrated the use of electric fields to manage insects, highlighting the potential of electrocution traps to control pest populations humanely, without the adverse effects associated with chemical pesticides. These findings support the idea that targeted electric traps can leverage pests' behavioral tendencies to improve control efficiency.

Ethical considerations are crucial in pest control, as underscored by the Career Navigator (2025), which emphasizes the humane treatment of animals during pest control operations. The ethical focus of this study is on ensuring that the Automated Electric Rat Trap (AERT) offers a humane pest control method by delivering quick and lethal electric shocks, minimizing prolonged suffering. Additionally, the study incorporates principles from electrical engineering, specifically the use of high voltage electric fields to develop effective pest control systems. Kusakari et al. (2020) demonstrated the potential of high voltage electric fields to generate electrostatic phenomena that can be used for pest control, including the attraction and repulsion of insects, as well as their destruction through arc discharge.

The AERT incorporates various electrical components, such as relays, diodes (1N4007), transistors (BC547), infrared (IR) sensors, batteries, switches, copper wires, and high voltage generators. These components work together to create a system that effectively delivers the necessary voltage to penetrate the dermal layers of pests like rats, ensuring the trap's efficacy. The AERT's design and construction aim to balance electrical performance with ethical responsibility. By integrating behavioral ecology insights with advanced electrical engineering principles, this study seeks to enhance the AERT's overall efficacy in pest management. The inclusion of IR sensors and relays allows for automated detection and activation of the electric trap, increasing operational efficiency and reducing the need for constant human oversight. The use of copper wires and high voltage generators ensures that the electric shock delivered is sufficient to cause immediate incapacitation or death in the target pests, thereby adhering to ethical standards of humane pest control.

Conceptual Framework

The subsequent conceptual framework served as a guide for the following research topic:

The researchers utilized an IPO model in their conceptual framework. In the input stage, the materials required for constructing the Automated Electric Rat Trap (AERT) were identified, including a perforated metal sheet/screen, stainless steel hinge, stainless steel handle, stainless steel plate, stainless steel rod with hook, motorcycle battery, electric switch, electric wire, DC-DC step down converter, 5V relay module, diode, transistor, high voltage generator, female to male jumper wires and plywood. The process stage outlines the procedure, which includes the assembly process and the device pre-testing, followed by data gathering through experimentation and statistical treatment. Finally, the output stage compasses the materialization of the AERT.

Figure 1

Paradigm showing the different processes used to conduct the study

Input	**Process**	**Output**
A. Materials a. Perforated metal sheet/screen b. Stainless steel hinge c. Stainless steel handle d. Stainless steel rod with hook e. Motorcycle battery f. Electric switch g. Electric wire h. DC-DC Step Down Converter i. 5V Relay Module j. Diode 1N4007 k. Transistor BC547 l. High Voltage Generator m. Female to Male Jumper Wires n. Plywood	A. Procedure a. Assembly b. Device Pre-Testing B. Data Collection a. Field testing b. Statistical Treatment and Interpretation	Automated Electric Rat Trap

Statement of the Problem

The goal behind this research was to evaluate how well the Automated Electric Rat Trap (AERT) functions as a humane solution for managing rat populations in agricultural environments. More precisely, this investigation aimed to explore these key inquiries:

1. What are the features of the Automated Electric Rat Trap (AERT)?
2. What is the operational performance of AERT in terms of:
   2.1. daily voltage consumption rate from the power source;
   2.2. number of rats lured with and without the presence of AERT's electricity; and
   2.3. number of wheat sack damage with and without the presence of AERT's electricity?
3. Is there a significant difference between the number of wheat sack damage along with rats lured with and without the presence of AERT's electrical component?

Research Hypothesis

To obtain a more comprehensive understanding of the capabilities of the Automated Electric Rat Trap, the following null hypothesis was tested.

H0: The implementation of AERT's electricity has no statistically significant difference in incidence of damaged wheat sacks and rats lured with and without AERT's electrical presence.

Significance of the Study

The study will provide benefits to the following stakeholders:

Local Farmers. This study will significantly benefit local farmers by offering a safer alternative to traditional rodenticides and reducing direct contact with potentially harmful rats. The proposed trap removes the necessity for chemical-based solutions, which can be dangerous. Moreover, its design allows for continuous operation without needing to be reset after each use, making it more convenient for farmers to monitor and maintain. This feature simplifies pest control efforts and enhances overall efficiency.

Nearby Residents. The study will help reduce the community's reliance on chemical solutions. The research aims to create a healthier and safer environment for all. It will offer residents a safer alternative, enabling the prevention of toxic pesticide use that can lead to harmful effects.

Electrical Engineering Industry. The research has the potential to impact the electrical engineering industry by demonstrating the practical application of electric traps. This study could pave the way for broader use of renewable energy sources in pest control technologies, highlighting an environmentally friendly alternative to chemical rodenticides.

Future Researchers. For future researchers, this study will serve as a valuable reference and guide. It provides insights into the development of non-toxic pest control methods and could inspire further research into innovative solutions that balance efficacy with environmental and health considerations.

Scope and Limitations

This study primarily aimed to advocate for the adoption of electric rat traps specifically within agricultural environments, emphasizing their utility and benefits in pest management. The researchers sought for the electrical rat trap to replace or work alongside traditional rat control. This study, conducted in the academic year 2024-2025, aimed to contribute to the understanding of the practicality and effectiveness of electric rat traps in agricultural pest management. The study focused on executing a single trap on a storage room experiencing rat infestation. The limited availability of existing local information regarding electric rat traps highlights the importance of this investigation.

In terms of assembly, the electric rat trap was far more complex and costly than the conventional traps, the researchers contended that the benefits justify this investment. These benefits include enhanced longevity, increased durability, user-friendly operation, and the ability for bulk trapping, all of which contribute to greater overall effectiveness in pest control.

This research delineated its scope by excluding external factors, particularly temperature change, and disturbance of noise, during the study’s timeframe. Additionally, the research setting was in a real-world warehouse environment where existing maintenance practices were already in place to deter rodents and pests. These pre-existing measures might influence the observable impact of the AERT.

Definition of Terms

The following terms that were used in this study was defined operationally and conceptually as follows:

AERT is the acronym for "Automated Electric Rat Trap."

Features are all the different parts that make up the device. These parts can be electrical or mechanical, and they all work together to make the device function.

Milliampere (mA) is a measurement unit of electric charge and is employed in this study as an electrical unit for assessing the flow of electric charge within a circuit.

Multimeter refers to the device that was utilized in the study to measure the output voltage and milliampere of the AERT.

Pest is an organism that is considered harmful to humans. In this study, it encompasses organisms that pose threats to humans, livestock, and agricultural crops.

Pesticides are specially crafted compounds designed to manage or remove unwanted organisms like bugs, invasive plants, and harmful molds. It can be used in crops, surfaces, or the environment to reduce the number of pests.

Rodents are a group of mammals characterized by continuously growing incisors. In this study, this term specifically refers to small to medium-sized mammals, such as mice and rats, which possess the ability for perpetual tooth growth in both the upper and lower jaws.

Voltage, expressed in volts (V), acts as the driving pressure that propels electric charge to move through a circuit. In this study, it represents the force of electric charges through the conductor.

Chapter 2

Methodology

This section outlines the study's structure, location, utilized tools and resources, procedural steps, and methods applied for data analysis.

Research Design

This research followed a quasi-experimental pretest-posttest non-equivalent group comparison design, suitable for evaluating interventions without random group assignment (Yang, 2023). Two groups were utilized: a control group, without the Automated Electric Rat Trap (AERT), and an experimental group, with the AERT. Initially, the rat population was measured before deploying the AERT (pretest). After the intervention period, the rat population was measured again (posttest) to assess the trap's effectiveness. This method involved collecting data both with and without the AERT. The control group comprised 19 sacks of wheat without the rat trap, while the experimental group included the same number of sacks but with the trap. The pretest measured the rat population in a specific area before the deployment of AERT, followed by a posttest after a specified period to determine whether AERT effectively reduced the rat population. The study aimed to provide detailed information on the accuracy and reliability of AERT in capturing and eliminating rats. By comparing pretest and posttest results, the research sought to evaluate the efficacy of AERT and identify potential improvements for practical rat control applications. This comprehensive assessment aimed to ensure reliable findings for future rat population management strategies.

Setting of the Study

The construction of the Automated Electric Rodent Trap (AERT) was carried out at two of the researchers' residences, with testing and data collection conducted at a third location. The first site, located at Sampaguita St., Brgy. I. Mendiola, Siniloan (N 14° 25' 40.151", E 121° 27' 6.623"), was selected for the assembly of the trap's body due to the presence of a professional skilled in safely constructing the trap, which minimized the risk of accidents during this phase. This task was completed in October. The second location, situated at Adricula St., Brgy. Pandeño, Siniloan (N 14° 24' 58.865", E 121° 26' 35.148"), provided the necessary materials and a suitable environment for constructing the electric circuit, which was completed in November. The third site, located in Brgy. Matalatala, Mabitac, Laguna (N 14° 24' 57.4808", E 121° 24' 34.4230"), was designated for testing and data collection. This site, encompassing an area of 500 m^2, housed a storage facility for rice and wheat, making it an ideal environment for evaluating the accuracy of the trap and gathering data. Consistent monitoring at this location allowed for effective data collection in January. These carefully chosen sites were essential to ensure practical field data could be gathered following the assembly and construction of the device.

Research Instruments

There were two sets of research instruments in the study. The first set are the materials, and the second set is the data review journal.

For the experiment’s conduction, the equipment that the researchers used is a multimeter. The multimeter was used to measure the electricity output of the automated rat trap’s power source or battery, ensuring that the electrical voltage being delivered is consistent and sufficient to eliminate rats effectively.

A. Materials

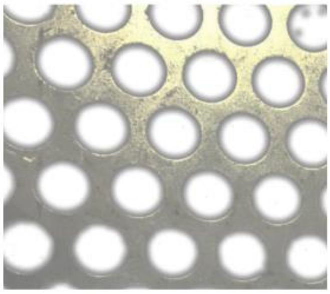
Materials	Description	Amount
 *Figure 2.1: Perforated Metal Sheet / Screen*	**Perforated Metal Sheet/Screen** A perforated metal sheet or screen is a thin metal sheet with a pattern of holes or openings. This study utilized a 14x30 cm with ⅝ hole perforated metal sheet that served as the walls of the trap.	Php 750.00
 *Figure 2.2: Stainless Steel Hinge*	**Stainless Steel Hinge** A stainless steel hinge is a durable, rust-resistant component that enables pivoting movement between two parts. In the rat trap, five stainless steel hinges were used: two for the top openings, two for the battery compartment at the back, and one for the front door.	Php 26.00 x 3 = Php 78.00
 *Figure 2.3: Fishing Hook with 8 Claw*	**Fishing Hook with 8 Claw** A fishing hook with 8 claw is a strong, rust-resistant rod used for hanging items. A hook was used to hold the bait, with the hook’s eight claws designed to attract rats.	Php 51.00

Figure 2.4: Electric Wire

Electric Wire Php 22.00

An electric wire is a conductor used to carry electrical current between different components in a circuit. A 1-meter-long wire connecting the circuit to the battery was used in this study.

Figure 2.5: Motorcycle Battery

Motorcycle Battery Php 800.00

A motorcycle battery is a rechargeable lead-acid battery designed to provide electrical power to the starting system and accessories of a motorcycle. It was attached to the back of the trap and has a voltage 12V.

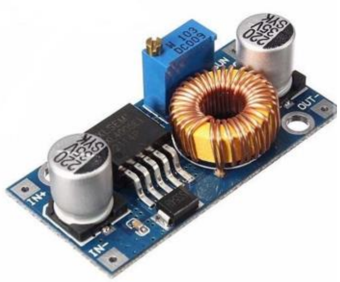


Figure 2.6: DC-DC Buck Converter

DC-DC Buck Converter Php 149.00

A DC-DC buck converter, is an electrical device designed to decrease a higher voltage down to a lower level while simultaneously boosting the output current. It ensured efficient energy transfer, especially for applications like a 12V motorcycle battery, to provide the correct voltage for sensitive components.

Figure 2.7: Infrared Sensor

Infrared Sensor Php 24.00

An infrared sensor is a gadget that senses heat energy emitted by objects. It served to detect the presence of a rat by monitoring changes in infrared levels.

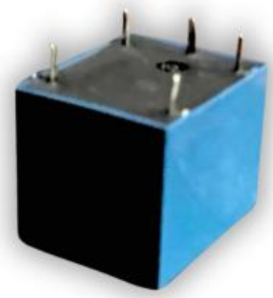


Figure 2.8: 5V Relay Module

5V Relay Module Php 15.00

A relay module is an electrically operated switch that allowed low-voltage signals to control high-voltage or high-current devices. It was used to activate and deactivate electrical circuits, controlling high-voltage systems.

Figure 2.9: Diode IN4007

Diode 1N4007 Php 3.00

1N4007 is a standard rectifier diode used primarily for converting AC to DC in power supply circuits, handling up to 1000 volts and 1 ampere. In this study, its function was to safeguard against voltage spikes produced when the relay coil is de-energized, ensuring the other components are not damaged.

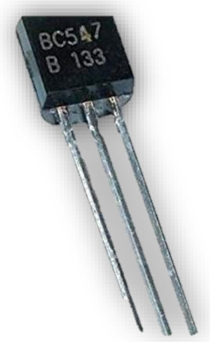


Figure 2.10: Transistor BC547

Transistor BC547 Php 6.00

BC547 is an NPN bipolar junction transistor commonly used for amplification and switching applications. It was integral to this study for the regulation and management of various sections of the circuitry.

Figure 2.11: High Voltage Generator

High Voltage Generator Php 73.00

A high voltage generator is a device that converted low voltage into high voltage. It was used in the trap to provide the necessary voltage to create an electric field.

Figure 2.12: Jumper Wires

Jumper Wires Php 45.00

Jumper wires are bendable conductors equipped with terminals at both ends, designed to facilitate connections in electrical circuits: one end has a socket and the other end has a pin. This facilitated easy connections between the sensor and relay module.

Figure 2.13: Multimeter

Multimeter Php 375.00

The instrument used to measure voltage is called a multimeter. In this study, the multimeter only measured voltage across different ranges of values. The voltage was measured in standard units of Volts. Although multimeters can measure other electrical quantities like current, for this experiment, it was used exclusively to measure the voltage.

Figure 2.14: On / Off Switch

On / Off Switch Php 9.00

The on/off switch is a control mechanism that allows you to turn a device or system either on (active) or off (inactive). An on/off switch was utilized in this study and attached at the back of the rat trap connecting to the battery.

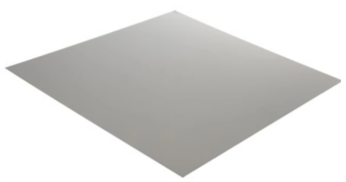


Figure 2.15: Galvanized Steel

Galvanized Steel Php 135.00

Galvanized steel refers to a type of steel that has been treated with a protective zinc coating to avoid rusting. A 0.1 cm thick galvanized steel was used in the trap for durability and corrosion resistance.

Figure 2.16: Electric Alligator Clip

Electric Alligator Clip Php 20.00

An alligator clip is a spring-loaded clip with a serrated jaw. Two alligator clips were used in the trap.

Figure 2.17: Electrical Tape

Electrical Tape Php 20.00

Electrical tape is a strong, adhesive tape used to insulate and protect electrical wires. It was used in the trap for insulation and to securely connect the wires.

Figure 2.18: Stainless Steel Door Handle

Stainless Steel Door Handle Php 12.00 x 3 = Php 36.00

A stainless steel handle is made from stainless steel, a durable, corrosion-resistant alloy. 3 steel door handle was applied to the door at the top, battery compartment, and poop container of the rat trap to ensure reliability and hygiene the study.

Figure 2.19: Galvanized Steel Square Tube

Galvanized Steel Square Tube

Php 250.00 x 2 = Php 500.00

Galvanized Steel Square Tube refers to steel that is shaped into hollow tubes, typically round, square, or rectangular in cross-section. Two pieces of 3/4 x 3/4 galvanized square steel were used for the trap's framing and structure, ensuring strength and durability.

Figure 2.20: Epoxy Primer

Epoxy Primer

Php 85. 00

Epoxy primer is a type of coating that provides a strong, adhesive base layer to protect surfaces from corrosion. It was mixed with thinner and applied outside of the trap to prevent rusting and enhance durability.

Figure 2.21: Lacquer Thinner

Lacquer Thinner

Php 30.00

Lacquer thinner is a solvent used to dilute or reduce the viscosity of paints and coatings. It was mixed with the epoxy primer to adjust the consistency and improve the application of the coating on the outside of the trap.

Figure 2.22: Plywood

Plywood Php 25.00

Plywood is a material made from thin layers of wood veneer bonded together. A 5mm thick plywood sheet measuring 30cm by 30cm was used as the flooring and partial wall in the trap. Holes each measuring 3/8 inch in diameter were drilled into it to allow waste to fall into the compartment.

Estimated Total Cost: Php 3, 251.00

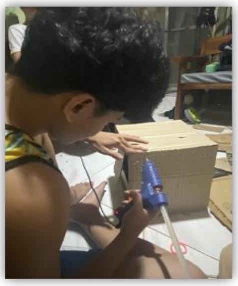
For the research, the researchers built an automated electric rat trap (AERT) using different materials. The total cost for these materials is Php 3,251.00.

B. Data Review Journal

This Data Review Journal provided a weekly overview of research on the development of an Automated Electric Rat Trap. Each entry detailed methodologies, experimental results, and technical challenges encountered during the design and testing phases. It included insights into circuit design, sensor integration, battery voltage, and efficiency of the trapping mechanism, supported by pictures and narratives. Any problems or changes made to improve how the trap works was clearly documented to encourage teamwork among the group.

Week Number	Activities/Progress of Research
Week 1: Material Acquisition	The first week of the research project, from October 7 to 11, 2023, was dedicated to material acquisition and prototype development. The team began by compiling a comprehensive list of necessary materials, carefully comparing prices and quality from various online and physical stores. Once the optimal materials were selected, funds were collected from team members. Orders were placed, and a prototype of the rat trap was constructed to visualize the design. Additionally, Mr. Domingo from Brgy. Burgos in Siniloan was identified as the welder responsible for assembling the final trap. These foundational steps laid the groundwork for the subsequent phases of the project.





Week Number	Activities/Progress of Research
Week 2: Material Completion and Assembly	The second week, from October 14 to 18, 2023, centered on procuring the necessary materials and initiating the construction process. A change in welding personnel occurred on Monday, with Mr. Julius, Moog's uncle, taking over due to Mr. Domingo's unavailability. Over the next two days, the team diligently shopped for additional materials at hardware stores, ensuring high-quality components. They visited various stores, comparing prices and selecting the best materials for the project. By Thursday, the blueprint was provided to the welder, and the construction of the rat trap began.

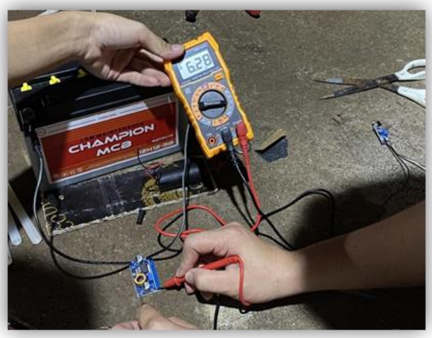



Week Number	Activities/Progress of Research
Week 3: Assembly Completion	The third week, from October 21 to 25, 2023, was dedicated to completing the structural aspects of the rat trap and initiating the preparatory steps for painting. On Monday, the perforated sheets were attached to the trap, and additional handles were installed to enhance its functionality. The following day, lacquer thinner and gray epoxy primer were purchased to protect the metal from rust and deterioration. While the team intended to begin painting the trap from Wednesday to Friday, unfavorable weather conditions hindered their progress.

Week Number	Activities/Progress of Research
Week 4: Protective Coating and Testing Consultation	The fourth week, from October 28 to November 1, 2023, focused on the initial painting process and consultations with experts. On Monday, the team began applying the first coat of paint, a mixture of lacquer thinner and epoxy primer. The following day, they ensured the trap was completely dry before proceeding to the second coat. While the remaining days were primarily dedicated to other academic commitments, the researchers also utilized this time to consult with Sir Jan Gabriel Bernardo regarding the Statement of the Problem (SOP) for conducting the upcoming testing phase.

Week Number	Activities/Progress of Research
Week 5: Trap Modification	The fifth week, from November 4 to 8, 2023, involved finalizing the physical structure of the rat trap and initiating the conceptualization of the research paper. On Monday, measurements were taken to determine the drilling points for electrical components. The following day, the welder drilled the necessary holes. Subsequently, the trap was transported to Mr. Garcia's house for advanced electrical work, and safety insulators were added to critical areas. In the latter part of the week, the team concentrated on brainstorming a title for the concept paper and began the preparation process for its submission.





Week Number	Activities/Progress of Research
Week 6: Trap Completion and Setup	During the week of November 11-15, 2024, the researchers focused on completing the electrical wiring of the rat trap. Soldering was employed to securely connect the wires. Additionally, the storage room, where the study would be conducted, was thoroughly cleaned and organized. To ensure the success of the experiment, the researchers procured necessary materials such as CCTV equipment, various feeds, wheat, and rice. These preparations laid the groundwork for the upcoming testing phase.

Week Number	Activities/Progress of Research
Week 7: Experimental Testing and Initial Data Analysis	The actual testing of the rat trap commenced on November 18, 2024, and continued for six days until November 23, 2024, within the designated storage room. The first three days of testing were conducted without the rat trap in place, while the subsequent three days involved testing with the rat trap in place. Throughout the testing period, the researchers closely monitored the CCTV footage to gather data that would be used to answer the research questions outlined in their Statement of the Problem (SOP). Following the completion of the testing phase on November 24, 2024, the researchers proceed into data analysis and made the Chapters 3 and 4 of their research paper.
Week 8: Task Division, Preparation, Consultation, and Trap Renovation	On January 27, 2025 the group divided into two teams to enhance productivity. One team focused on organizing and cleaning the storage area, ensuring that all materials for experimentation were in order, especially since the phase without the electric components had been completed. The second team inspected the trap's electric components and built a small prototype to test the planned upgrades, including increasing the voltage of the trap.

	On January 28, 2025 the group consulted with Sir Gab to present and get approval for their renovation plan. They then sought professional advice on the construction and execution of the changes. After successfully completing the renovations, the group conducted their second round of experimentation, incorporating the newly added electronic components into the trap.

Research Procedure

Phase 1: Blueprint Development

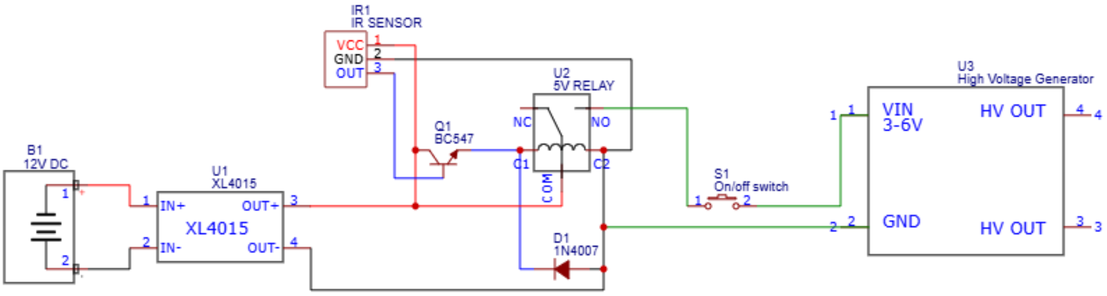
The researchers first conducted a cost analysis and the materials needed for the Automated Electric Rat Trap (AERT). They then proceeded to create a blueprint for the AERT. The blueprint included a framing of galvanized steel square tube and foundation made of stainless steel. The foundation measures 30 cm x 30 cm. The walls were made from perforated stainless-steel sheets and securely attached, while the flooring was constructed using plywood. The handles of the AERT were insulated using electrical tape. The entrance of the AERT featured a ramp that is 14.5 cm long and 10.5 cm tall. There was also a small compartment at the back of the AERT for setting up the wiring correctly and safely; this compartment measures 16 cm in length, 19 cm in width, and 14 cm in height. A partition, measuring 7 cm in height, was situated under the AERT floor facilitating convenient access to the rats' waste. In addition, handles and hinges were deliberately placed to meet the trap's functional requirements, with two handles on the top of the trap and one each for the battery and waste compartment.

Phase 2: Construction and Assembly of AERT

A copy of the finalized blueprint was sent to a welder to ensure the accurate construction of the trap's frame and foundation. Welding was done by a professional to prevent any mistakes. The entrance of the AERT incorporated a hinge designed to only open inwards to prevent rats from escaping. Upon completion of the welding process, the trap was treated with a mixture of grey epoxy primer and thinner to minimize rust formation. 10 pieces of straightened copper wires, each measuring 23 cm, were installed along the flooring of the rat trap. The handles were insulated with electrical tape to ensure safety. Subsequently, the construction of the electric circuit (see Figure 3) was completed at one of the researchers’ residences, followed by the battery which was connected to the wires in the compartment behind; this was done last to avoid accidents. A hook was then soldered inside the AERT to hang the bait. Once assembly was complete, testing of the AERT’s electric circuit was conducted with the use of a multimeter to ensure proper functionality. After the testing, the AERT was placed in a storage room to determine its effectiveness in capturing and neutralizing rats while enduring the elements.

Figure 3

Electrical Schematic Diagram of the AERT’s Circuitry

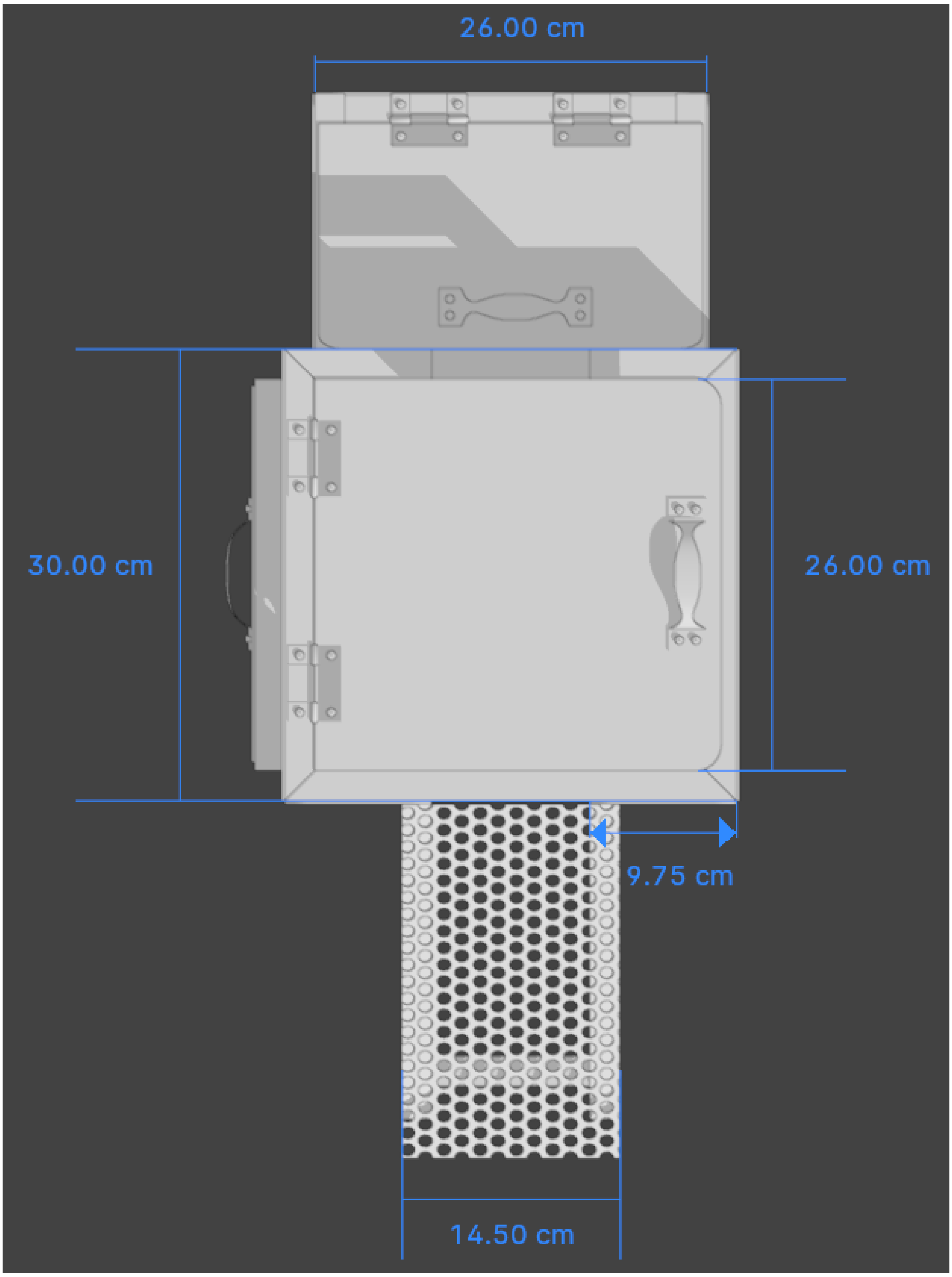


Phase 3: Preparation of the Experiment

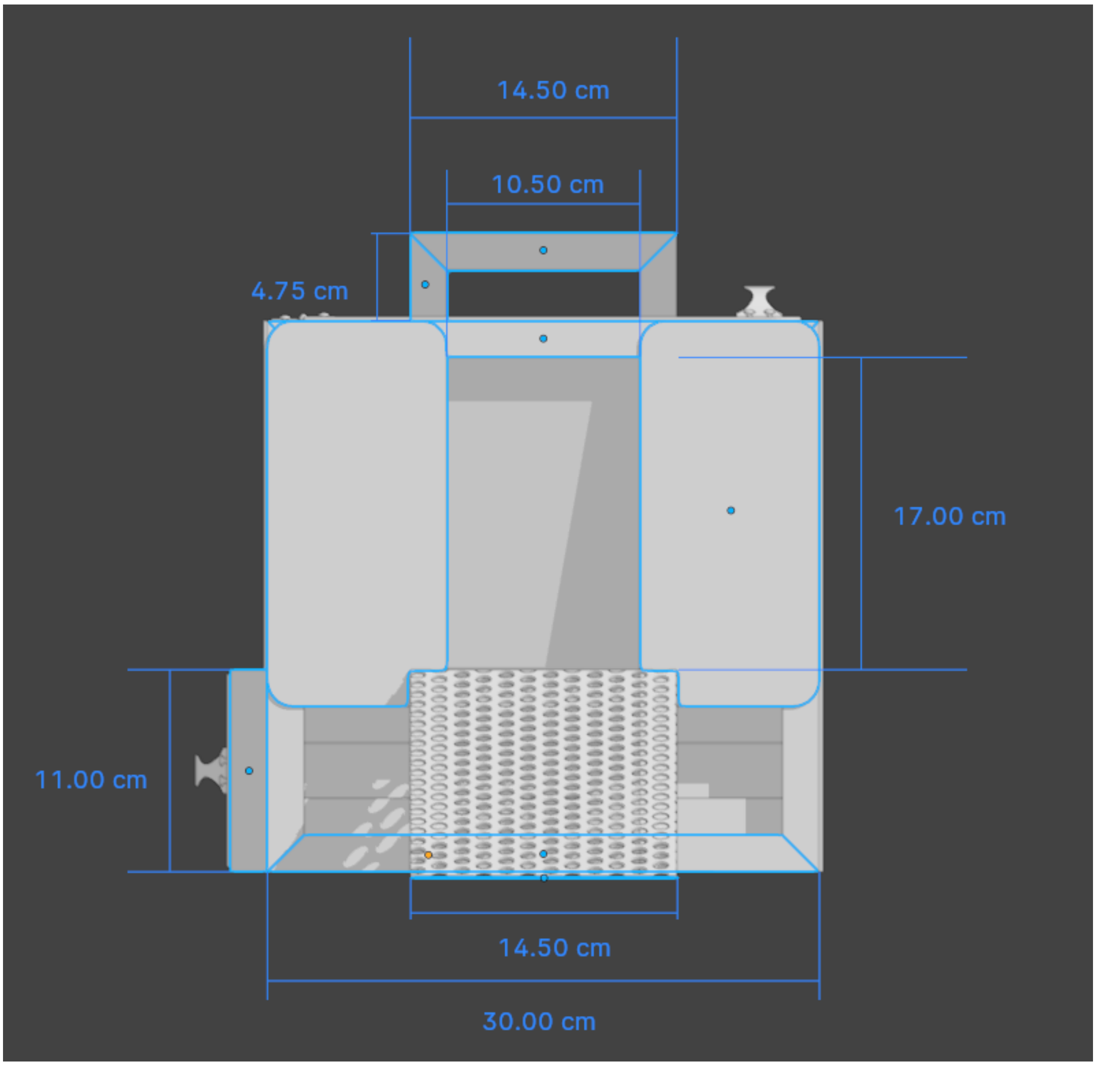
Before the experiment commences, the researchers visited the storage room equipped with necessary tools and materials, including extension cords, two cameras, 19 wheat sacks, and the Automated Electric Rat Trap. Upon arrival, the researchers meticulously installed the cameras to ensure comprehensive and uninterrupted monitoring of the entire storage area. They placed the 19 sacks of wheat around the storage room, ensuring an even distribution to create an environment that mimics typical storage conditions. Subsequently, the rat trap, along with the bait, was strategically positioned within the testing site, maintaining a sufficient distance to eliminate potential rat bias. Additionally, the trap door was left open, and the electrocution system remain inactive. Rats are naturally neophobic, meaning they fear new objects, which can make them cautious around traps. By leaving the trap inactive initially, this fear is mitigated, allowing rats to become familiar with the trap without associating it with danger (Stryjek et al., 2019). Allowing rats to explore the trap freely helps them develop trust in the environment, making them more likely to enter the trap when it is later activated. This preparatory strategy was implemented to mitigate rats' neophobia towards novel objects, aiding in their familiarity with trap locations and rapid learning processes.

Figure 4

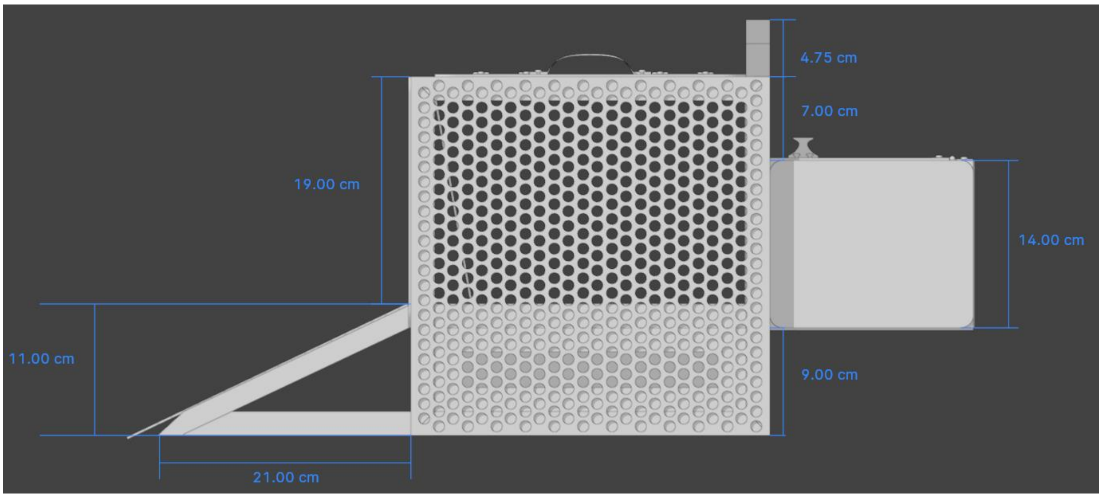
Blueprint showing Isometric Views of the AERT



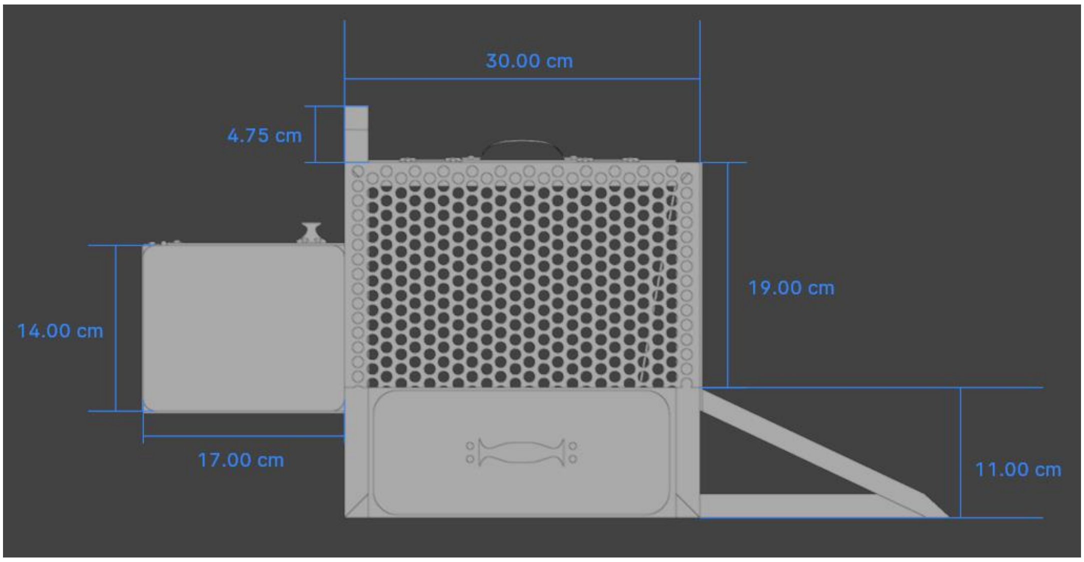
TOP VIEW



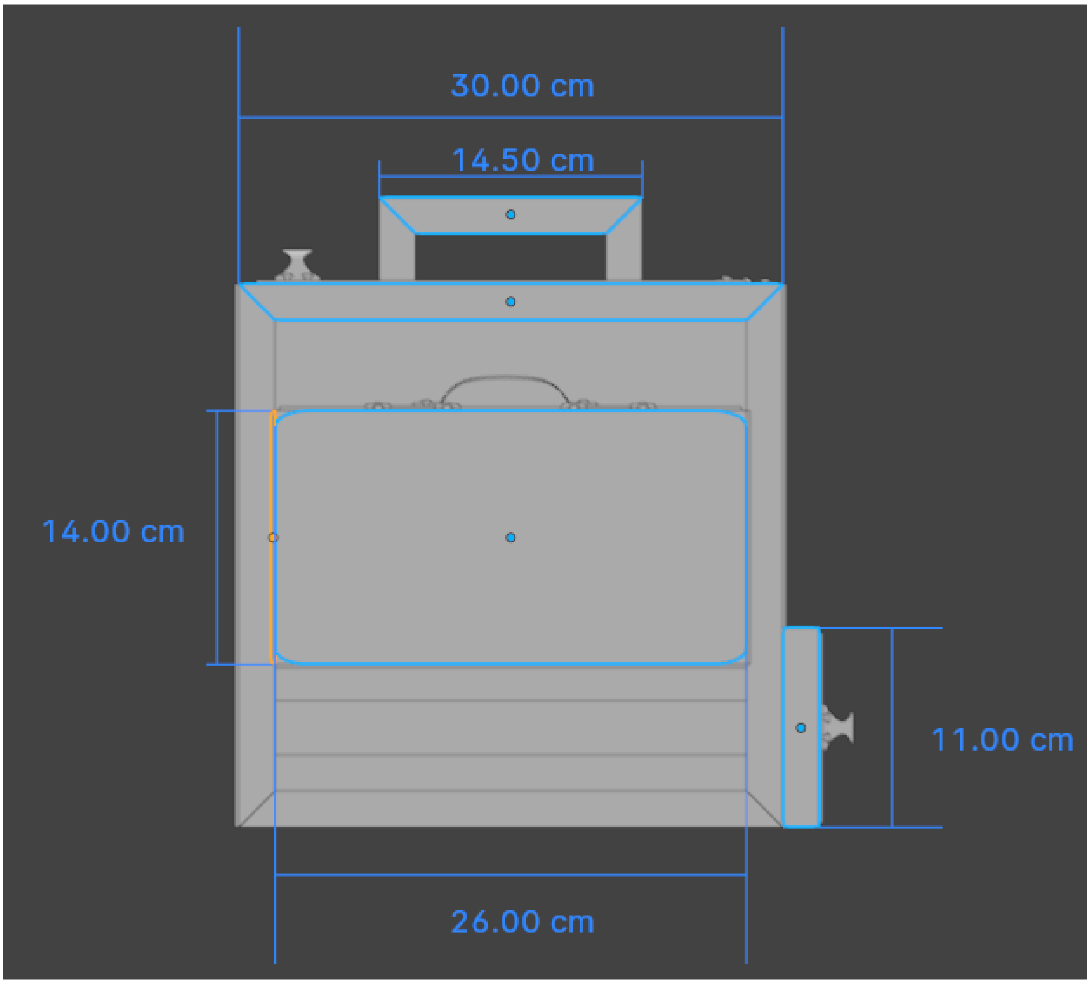
FRONT VIEW



RIGHT SIDE VIEW



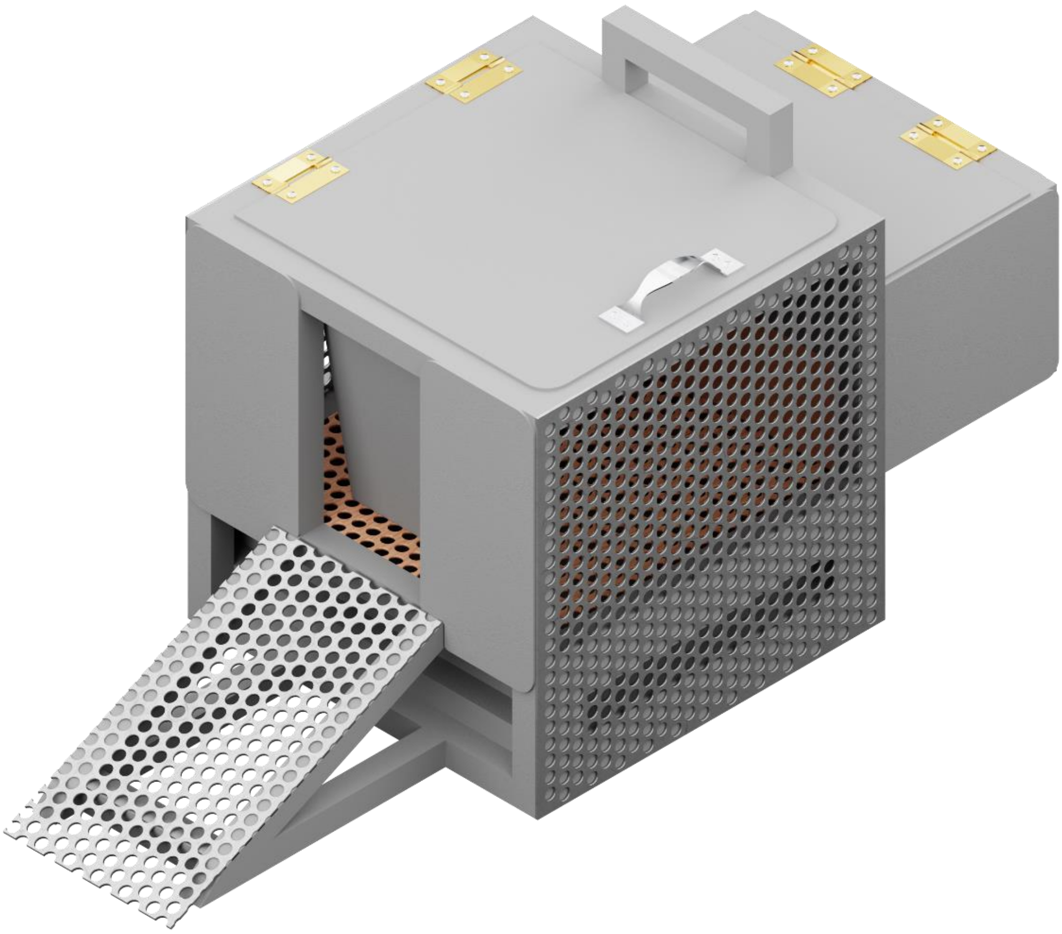
LEFT SIDE VIEW



REAR VIEW

Figure 5

Isometric projection of the fully assembled AERT



Phase 4: Experimentation

To initiate the experiment, an initial period of 5 days was allocated for the observation and analysis of the storage room without the activation of the trap's electric component. Following this, a subsequent period of 5 days was devoted to testing the trap with its electric component engaged. Researchers validated the correct positioning of the rat trap, ensuring the functionality of the electric circuit and the presence of bait. Daily monitoring of the trap was conducted via camera. At the end of each day, data was collected from the trap, recording the number of electrocuted and captured rats. Additionally, researchers utilized a multimeter to assess the depletion of energy or voltage from the battery throughout the experiment. This methodology was rigorously adhered to each day during the field-testing phase, which spanned a total of 10 days to evaluate the efficacy of the AERT in capturing and neutralizing rats.

Phase 5: Evaluation of Data

The collected data was systematically organized and compiled using Microsoft Excel. Within Microsoft Excel, the appropriate statistical treatments were employed to analyze the raw data, enabling the researchers to effectively address and answer the research questions.

Statistical Treatment of Data

This study utilized a multifaceted approach, integrating descriptive statistics, time-series analysis, and paired t-tests. Descriptive statistics were employed to calculate the mean and standard deviation for both the number of rats lured and the incidence of wheat sack damage. Additionally, the average daily rate of voltage consumption was measured. Time-series analysis was conducted to identify trends in daily voltage consumption over time. This comprehensive statistical approach provided a robust basis for concluding the differences in wheat sack damage and rat luring with and without AERT's electrical component.

Chapter 3

Results, Discussion, and Interpretation

The results and interpretations of the study, which aimed to assess the effectiveness of the Automated Electric Rat Trap (AERT) as a humane rat management strategy, were presented in this section. Each finding was discussed in order of appearance in the Statement of the Problem.

Mechanical Features

1. Foundation

The Automated Electric Rat Trap was constructed using galvanized steel square tubes with a thickness of 2 cm for the frame. The trap has dimensions of 30 cm in height, 30 cm in length, and 30 cm in width. The sides of the trap are covered with perforated sheets measuring 30 cm x 30 cm and 30 cm x 19 cm. The trap size was determined to be 30 cm x 30 cm to ensure robustness and increased capacity.

Figure 6

Foundation of the AERT

2. Entry Way

The entrance of the trap was constructed using galvanized steel. The dimensions of the entrance are 16 cm in length and 10 cm in width, while the door measures 16 cm in length and 11.5 cm in width. This design allows rats to enter the trap while preventing them from escaping. The ramp leading to the main entrance has dimensions of 24.5 cm in length, 14.5 cm in width, and 10.5 cm in height, sloping upward to guide the rats toward the trap. The ramp was made from a perforated sheet reinforced with squared steel tubing, creating a non-slip surface to effectively attract rats into the trap.

Figure 7

Entry Way of the AERT

3. Waste Compartment

The compartment was constructed from galvanized steel, with a square steel frame for added support and durability. The dimensions of the compartment are 21 cm in height, 26 cm in width, and 11 cm in. The compartment door was hinged and insulated with electrical tape to allow for safe handling. The door measures 26 cm in width and 11 cm in height.

Figure 8

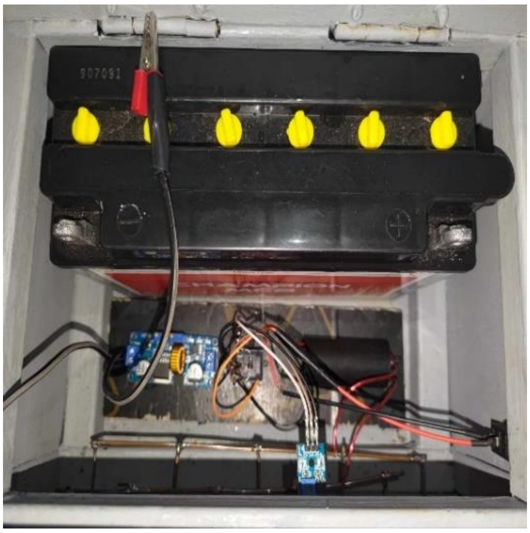
Waste Compartment of the AERT

4. Battery Compartment

The battery compartment was constructed from galvanized steel, ensuring durability and protection. Its dimensions are 16 cm in length, 14 cm in height, and 19 cm in width. The compartment features a top-mounted door with a hinge, which was insulated with electrical tape to ensure safe handling and operation.

Figure 9

Battery Compartment of the AERT

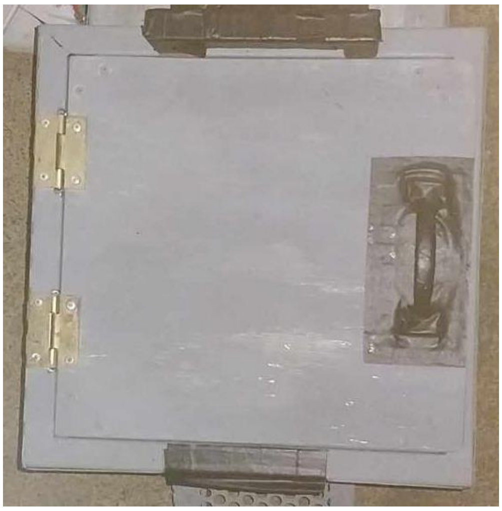


5. Hatch

The hatch door measures 26 cm by 26 cm and was equipped with a handle to facilitate easy opening. It was secured to the trap with two hinges, ensuring stability and durability. A slip knot hook was installed beneath the hatch door to securely hold the bait in place.

Figure 10

Hatch of the AERT

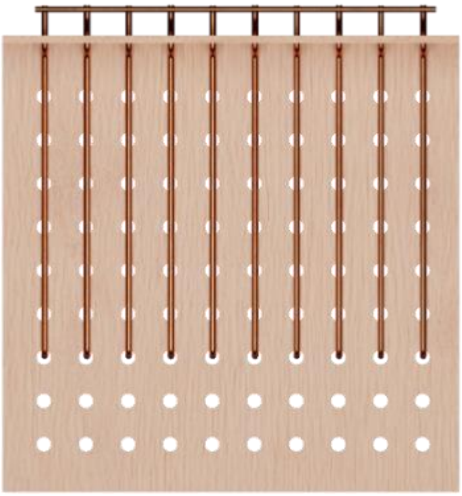


5. Copper Wires

The trap's flooring was equipped with ten copper wires. These wires are straightened and laid parallel across the flooring inside the trap. They are connected to a high-voltage generator, with the wires alternately assigned to positive and negative terminals. This configuration facilitates the flow of current across the trap's floor.

Figure 11

Copper Wires of the AERT

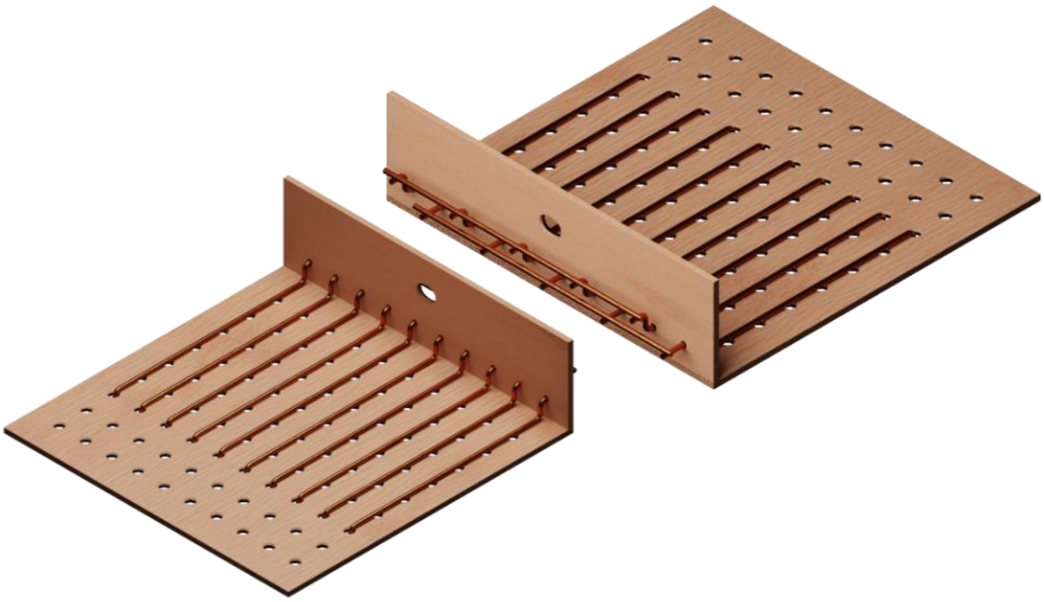


6. Flooring

The flooring was constructed from 5mm thick plywood measuring 30cm by 30cm. The material was chosen to prevent the flow of electrical current to other parts of the trap. Holes were added to mimic the perforated sheet, allowing rat feces and urine to pass into the compartment below.

Figure 12

Isometric Projection of the AERT's flooring



Electrical Features

1. 12V Motorcycle Battery

The 12V motorcycle battery was the main power source for the trap, providing the necessary voltage to kill the rats. It was mounted at the back of the trap within a designated compartment (Figure 2.5, p. 37).

2. DC-DC Step Down Converter

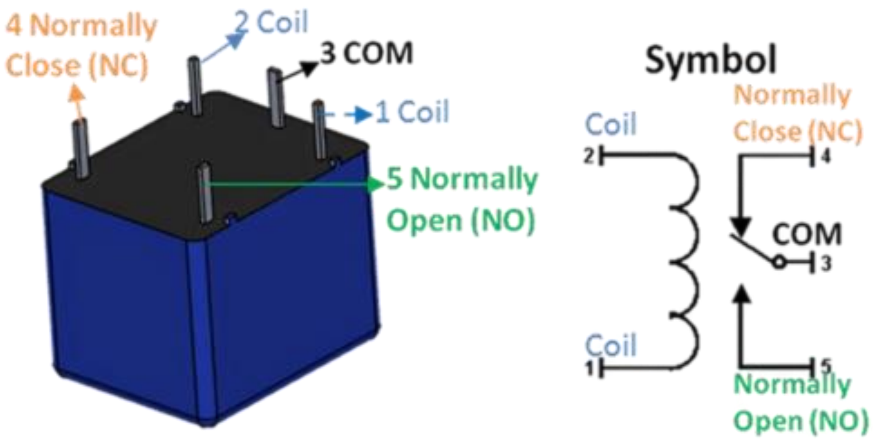
The DC-DC step-down converter, lowers the supplied voltage from the 12V battery configured to output 5.50V. It reduces the voltage to a lower level while allowing for a higher flow of current. This ensures that sensitive components receive the appropriate voltage for optimal operation (Figure 2.6, p. 37).

3. 5V Module Relay

The 5V relay module is an electrically operated switch that enables low-voltage signals to control high-voltage or high-current devices. This relay provided an electrical isolation between the low voltage control circuit, which includes components such as the IR sensor and the BC547 transistor, and the high voltage circuit that includes the high voltage generator. By isolating these circuits, the relay protects the low voltage components from potential damage caused by high voltage spikes.

Figure 13

5V Relay Pinout



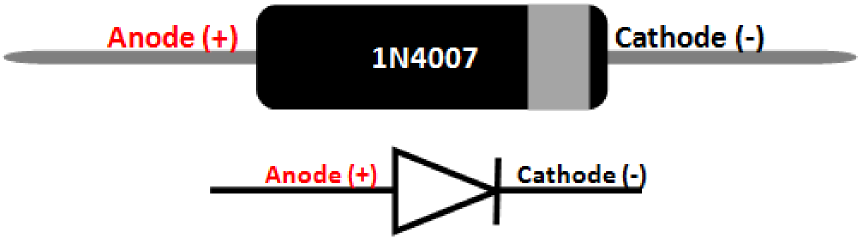
Note. From *5V Relay: Pinout, Description, Working & Datasheet*, by Components101, 2017 (https://components101.com/switches/5v-relay-pinout-working-datasheet). Copyright 2023 by Components101.

4. Diode IN4007

A 1N4007 diode was used to ensure current flows in the correct direction and protect the circuit from potential voltage spikes. The cathode of the 1N4007 diode was connected to the positive terminal of the relay module, and the anode was connected to the negative terminal of the relay module.

Figure 14

1N4007 Pinout



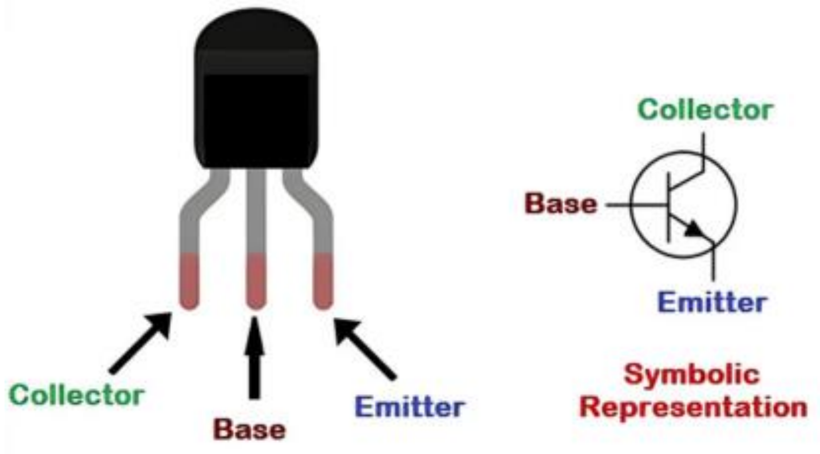
Note. From *1N4007 Diode: Pinout, Equivalents, Description & Datasheet*, by Components101, 2020 (https://components101.com/diodes/1n4007-diode). Copyright 2023 by Components101.

5. Transistor BC547

The BC547 transistor acted as a switch, controlled by an infrared (IR) sensor that detects the presence of a rat. When the IR sensor is triggered, the BC547 transistor activates the relay module, allowing the high voltage generator to produce a lethal shock. The emitter of the BC547 is connected to the positive terminal of the relay module, the base is connected to the output positive of the IR sensor, and the collector is connected to the VCC of the IR sensor.

Figure 15

BC547 Pinout



Note. From *Introduction to BC547 - The Engineering Projects*, by D. Watson, 2017 (https://www.theengineeringprojects.com/2017/06/introduction-to-bc547.html). Copyright 2020 by TheEngineeringProjects.com.

6. High Voltage Generator

The high voltage generator converts the low input voltage into high voltage, providing the necessary electrical energy to create an electric field inside the trap (Figure 2.11, p. 39).

7. On / Off Switch

The on/off switch is a simple control mechanism that allows the user to activate or deactivate the system. It was connected to the relay and high voltage generator mounted at the back of the rat trap (Figure 2.14, p. 40).

8. Electrical Wires

The electrical wires are conductors that carry electrical current between components in the circuit. For this setup, a 1-meter-long wire was used to connect the on/off switch to the battery (Figure 2.4, p. 37).

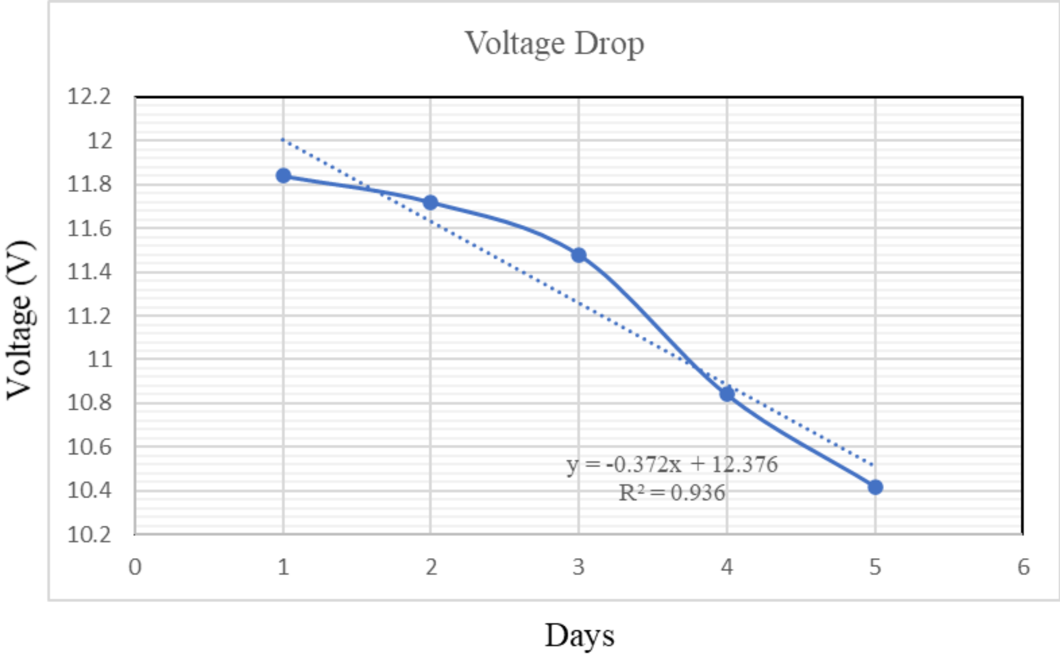
Operational Performance of the Automated Electric Rat Trap

Voltage Over Time Analysis

Figure 16 depicts the variation in battery voltage (y-axis) over a five-day period (x-axis). The data points represent voltage measurements taken on each of the five days, showing a consistent decline in voltage over time.

Figure 16

Daily Voltage Consumption for Five Consecutive Days



The analysis of the voltage consumption for the Automated Electric Rat Trap (AERT) over a five-day period reveals a clear and consistent decrease in voltage, highlighting a predictable power consumption rate. The voltage readings, beginning at 11.84V on Day 1, steadily declined to 10.42V by Day 5. The linear trend observed in this data is represented by the equation $y = -0.372x + 12.376$, indicating that the voltage drops by approximately 0.372 volts per day. The high R-squared value of 0.936 signifies a strong correlation between time and voltage drop, explaining about 93.6% of the variance in the voltage readings. This strong linear relationship suggests the AERT's energy consumption is reliable and foreseeable, emphasizing the need for regular monitoring and timely replacement or recharging of its power source to ensure optimal functionality in managing rodent populations. Additionally, this performance aligns with studies demonstrating the efficacy of high-voltage electric fields in pest control (Kusakari et al., 2020). Research further supports that non-chemical pest control methods, like the AERT, can provide greater economic benefits over the long term in intensively cropped systems (Balaska et al., 2023). The economic implications reinforce the value of such systems, with potential long-term advantages outweighing initial investment costs.

Rat Luring Analysis

Table 1 presents the descriptive statistics for rat luring before and after the implementation of the Automated Electric Rat Trap's electricity (AERT). The first column shows the condition, the second column shows the mean number of rats lured, while the third column provides the standard deviation. These values represent the impact of AERT on the rat population.

Table 1

Descriptive Statistics for Rat Luring With and Without AERT's Electricity

Condition	Mean	Standard Deviation
With AERT's Electricity	0.8	0.8367
Without AERT's Electricity	1	1

The analysis of rat luring data collected over a ten-day period demonstrated variability in the number of rats lured with and without AERT's usage of electricity. Data on the number of rats lured were recorded during the first five days, while the subsequent five days focused on mortality, due to electricity usage. The data indicates a slight reduction in the mean number of rats lured when AERT's electricity is utilized, decreasing from 1 to 0.8. This reduction, although modest, suggests that the activation of AERT has a positive effect on controlling the rat population. The standard deviation values indicate that the variability in the number of rats lured is reduced when AERT's electricity is employed, with a decrease from 1 to 0.8367, suggesting more consistent performance of the device.

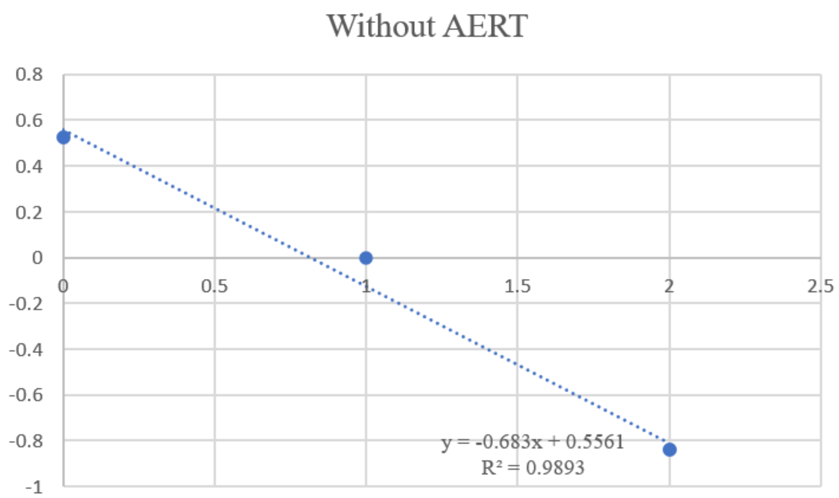
The mean number of rats lured is a critical indicator of the device's effectiveness in attracting and potentially deterring rats. The lower mean with AERT suggests that the device might act as a deterrent, reducing the number of rats entering the area. The decreased standard deviation with AERT further indicates that the results are more consistent, providing a reliable measure of the device's performance. These findings are essential for developing effective integrated pest management strategies, particularly in agricultural and urban settings where rat control is crucial.

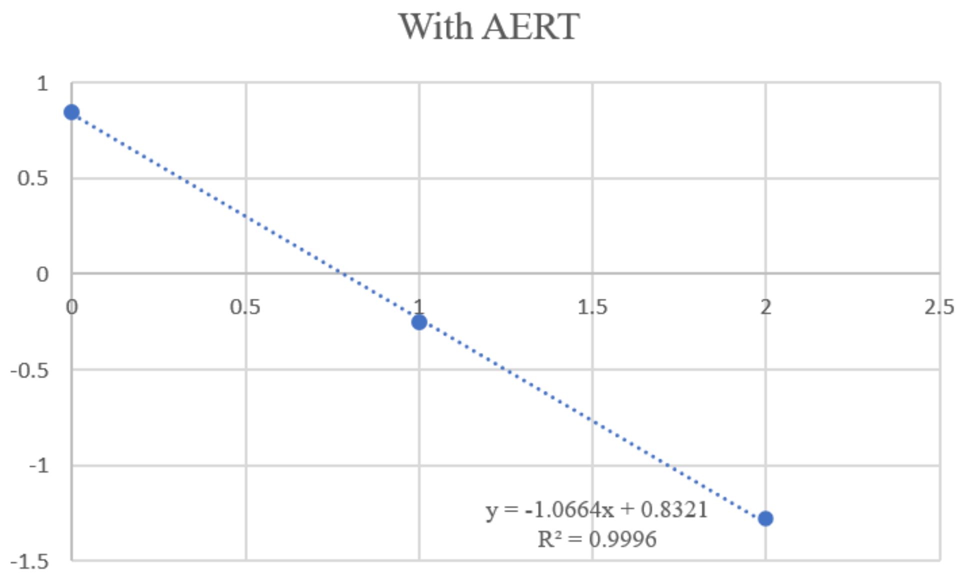
Normality Assessment

The normal distribution of the data for the number of rats lured before and after implementing the Automated Electric Rat Trap (AERT) electricity was evaluated using Q-Q plots. These plots visually depict how well the data conforms to a normal distribution, which is a crucial assumption for conducting parametric tests like the paired t-test.

Figure 17

Q-Q Plots for Rats Lured With and Without AERT's Electricity





Both Q-Q plots show very high R^2 values (0.9893 and 0.9996), indicating that the data points closely follow the theoretical normal distribution. The R^2 value for the post-implementation data (0.9996) is particularly close to 1, suggesting an almost perfect fit to the normal distribution. These results strongly support the assumption of normality for both pre- and post-AERT implementation data, justifying the use of paired t-tests for our analysis.

Analysis of Wheat Sack Damage

Table 2 presents the descriptive statistics derived from the raw data on wheat sack damage, both with and without of the Automated Electric Rat Trap's electricity (AERT). The first column shows the condition, the second column provides the standard deviation., while the third column provides the standard deviation. These values represent the effectiveness of AERT in reducing wheat sack damage.

Table 2

Descriptive Statistics for Wheat Sack Damage With and Without AERT's Electricity

Condition	Mean	Standard Deviation
With AERT's Electricity	0.3684	0.5973
Without AERT's Electricity	0.6842	0.8852

The data reveals a significant reduction in the mean number of damaged wheat sacks from 0.6842 without AERT to 0.3684 with AERT. This substantial decrease indicates that AERT is effective in minimizing wheat sack damage. Furthermore, the standard deviation without AERT is 0.8852, and with AERT, it is reduced to 0.5973. This reduction suggests that the variability in wheat sack damage is less when AERT is employed, indicating more consistent protection against damage.

The mean number of damaged wheat sacks was a critical measure of the device's effectiveness in protecting stored agricultural products. The significant reduction in the mean with AERT indicates that the device is highly effective in minimizing damage caused by rats. The lower standard deviation with AERT further supports the consistency of the device's performance, providing reliable protection for stored products. These findings have important implications for improving crop protection and food security, particularly in regions prone to significant rat infestations.

Test of Difference on the Number of Rat Lured and Wheat Sack Damage

Paired T-Test Results for Rat Luring

Table 3 presents the results of the paired t-test for the rat luring data, comparing the means with and without AERT's usage of electricity. The t-statistic and p-value (two-tail) are included, along with a decision and interpretation of the significance.

Table 3

Paired T-Test Results for Rat Luring With and Without AERT's Electricity

Statistic	Value	Decision	Interpretation
T-statistic	0.2722	-	-
P-value	0.7990	Failed to Reject Ho	Not Significant

Note: Confidence level: 95%

The paired t-test results indicate that the difference in the number of rats lured with and without AERT is not statistically significant (t-statistic = 0.2722, p-value = 0.7990). This implies that, based on the sample data, there is no evidence to suggest that AERT significantly reduces the number of rats lured. The high p-value indicates that any observed difference is likely due to random variation rather than a real effect of the AERT.

The non-significant results suggest that while there may be a reduction in the mean number of rats lured, the change is not substantial enough to be considered statistically reliable. This finding highlights the importance of considering sample size constraints in statistical testing, the need for further investigation into the factors influencing rat behavior, and the potential modifications to enhance the effectiveness of AERT.

Paired T-Test Results for Wheat Sack Damage

Table 4 presents the results of the paired t-test for the wheat sack damage data, comparing the means without and with AERT's electricity usage. The t-statistic and p-value (two-tail and one-tail) are included, along with a decision and interpretation of the significance.

Table 4

Paired T-Test Results for Wheat Sack Damage With and Without AERT's Electricity

Statistic	Value	Decision	Interpretation
T-statistic	2.0513	-	-
P-value (Two-tail)	0.0551	Failed to Reject Ho	Marginally Significant
P-value (One-tail)	0.0275	Reject Ho	Significant

Note: Confidence level: 95%

The paired t-test results for the number of damaged wheat sacks revealed a marginally significant difference (t-statistic = 2.0513, p-value (two-tail) = 0.0551), suggesting that AERT might positively impact reducing wheat sack damage. Notably, the one-tail p-value (0.0275) was below the significance level of 0.05, providing significant evidence to support the hypothesis that AERT reduces wheat sack damage. Despite not reaching conventional statistical significance, the substantial reduction in mean damage and the near-significant p-value indicated a trend towards AERT's effectiveness in mitigating wheat sack damage. The larger sample size for wheat sack damage (n = 19) compared to rat luring increased confidence in these findings. This reduction in damage holds practical significance in agricultural pest management, as even small reductions can have meaningful economic implications for farmers. The results suggested that AERT effectively mitigated wheat sack damage, likely due to its ability to deter or eliminate rats more efficiently.

AERT aligns well with Integrated Pest Management (IPM) and Sustainable Pest Management (SPM) principles by reducing reliance on insecticides, a key goal in sustainable agriculture (Grady, 2024). Its automated nature and high efficiency also meet the growing need for smart farming solutions, providing real-time data and enabling timely interventions, as highlighted by recent studies on AI and IoT integration in pest control (Ali et al., 2024).

These findings suggest that AERT may reduce agricultural damage; however, further research with larger sample sizes and extended testing periods is needed to draw more definitive conclusions. The importance of considering sample size and appropriate alpha levels in statistical testing to ensure valid conclusions is highlighted.

Nonetheless, the data analysis reveals a mixed impact of AERT between the conditions. For instance, the paired t-test for rat luring yielded a t-statistic of 0.2722 with a two-tailed p-value of 0.7990, indicating that the presence of AERT does not significantly affect the number of rats lured. In contrast, the evaluation of wheat sack damage produced a t-statistic of 2.0513 and a one-tailed p-value of 0.0275, underscoring a statistically significant reduction in damage when AERT's electricity is applied. Hence, the null hypothesis is rejected solely for wheat sack damage, suggesting that AERT holds promise for mitigating agricultural losses even though it does not appear to influence rat luring.

Chapter 4

Summary of Findings, Conclusions, and Recommendations

Summary of Findings

The following are the findings drawn out from the study:

1. The Automated Electric Rat Trap (AERT) incorporated various mechanical and electrical features to enhance its efficiency in capturing and eliminating rats. Key features include galvanized steel construction for durability, a non-slip entry ramp, a waste compartment for safe disposal, a battery compartment for power management, a hatch for easy bait placement, and copper wiring to facilitate electrical current flow.
2. The study aimed to evaluate the effectiveness of the Automated Electric Rat Trap (AERT) in managing rat populations within agricultural environments. The research employed a quasi-experimental pretest-posttest non-equivalent group comparison design, collecting data over a 10-day period. The primary focus was on assessing the AERT's impact on wheat sack damage and rat luring effectiveness.
3. A significant reduction in wheat sack damage was observed with the implementation of the AERT. The mean number of damaged wheat sacks decreased from 0.6842 without the AERT to 0.3684 with the AERT, representing a 46.2% reduction in damage. This finding was supported by a paired t-test, which yielded a t-statistic of 2.0513 and a one-tailed p-value of 0.0275, indicating a marginally significant reduction in wheat sack damage.
4. The impact of the AERT on rat luring, however, was less pronounced. The mean number of rats lured decreased slightly from 1 rat/day without the AERT to 0.8 rats/day with the AERT. The paired t-test for rat luring yielded a t-

statistic of 0.2722 and a p-value of 0.7990, suggesting no statistically significant difference in the number of rats lured with and without the AERT's electricity activated.

5. The AERT demonstrated consistent and predictable power consumption over the testing period. Voltage readings showed a linear decline from 11.84V on Day 1 to 10.42V on Day 5, following the equation $y = -0.355x + 12.167$, with an R^2 value of 0.9721. This predictable power consumption pattern indicates reliable performance, which is crucial for maintaining the trap's effectiveness in agricultural settings where constant monitoring may not be feasible.

Conclusions

From the Summary of Findings, the following conclusions are deduced:

1. The findings of this study underscore the potential of the Automated Electric Rat Trap (AERT) as an effective and humane solution for managing rat populations in agricultural environments. The significant reduction in wheat sack damage demonstrates the AERT's capability to protect stored agricultural products, addressing a critical aspect of food security and economic viability for farmers.
2. While the AERT did not significantly reduce the number of rats lured, its effectiveness in minimizing damage suggests that it functions primarily as a deterrent or elimination tool rather than an attractant. This characteristic aligns well with the principles of Integrated Pest Management (IPM) and Sustainable Pest Management (SPM), offering a non-chemical alternative to traditional pest control methods.

3. The consistent performance of the AERT, as evidenced by the predictable power consumption pattern, indicates its reliability as a long-term pest management solution. This feature is particularly valuable in agricultural settings where constant monitoring and maintenance of pest control devices may be challenging.
4. The AERT's design, which delivers quick and lethal electric shocks, addresses ethical concerns associated with pest control by minimizing prolonged suffering for the target pests. This approach supports the growing emphasis on humane pest management practices in agriculture and aligns with broader sustainability goals.
5. The study's findings highlight the complex nature of pest control dynamics and underscore the importance of considering both statistical and practical significance when evaluating pest management solutions. While some results were marginally significant, the practical implications of reduced crop damage could translate to substantial economic benefits for farmers.

Recommendations

As outlined in the preceding section, the researchers formulated the following recommendations:

1. Since the study focuses on the effectiveness or the accuracy of the trap, future researchers may seek for significant difference between the effectiveness of the traditional rat trap and the AERT.
2. To ensure safety during research involving the automated electric rat trap (AERT), future researchers must prioritize appropriate protective gear.
3. Since the AERT is bigger and larger that traditional rat traps, future researchers may seek for the average cubic meter per rat captured in the traditional rat trap and the AERT. For example, the measurement of the volume of the trap divided by the rats captured in it.
4. To improve the automated electric rat trap (AERT) practicality, future research should focus on finding alternative lightweight materials that maintain its performance.
5. Given the previous limitations in testing the automated electric rat trap (AERT) outdoors, future researchers should expand their evaluations to encompass a range of outdoor environments, ensuring more reliable data collection, to assess the device's performance and reliability under varied conditions.

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Appendices

Appendix A (Turnitin Certification of Plagiarism and AI)

Document Viewer

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Prolonged Evaluation of the Automated Electric Rat Trap (AERT) in a Large Agricultural Storage Facility Achilles T. Abary, Charles Godwin S. Aguja, Lori Belle R. Gapasangra, Dustin Amiel F. Garcia, Arabhel C. Monserrat, James Dale S. Moog Senior High School Department, Siniloan Integrated National High School Research Capstone Project - Science, Technology, Engineering and Mathematics Icy Princess A. Trencio, PhD March 14, 2025 i Field Expansion and Prolonged Evaluation of the Automated Electric Rat Trap (AERT) in a Large Agricultural Storage Facility ABSTRACT This research evaluates the Automated Electric Rat Trap (AERT) as an advanced, ethical solution for mitigating rodent infestations in agricultural environments. Designed to address the persistent challenges posed by rat infestations—including crop damage and disease transmission—the AERT integrates technological innovation with humane pest management principles. Employing a quasi-experimental pretest-posttest design, the study assessed the device's effectiveness in reducing agricultural commodity losses and rodent population control. Results showed a statistically significant reduction in crop damage, with the number of damaged sacks halved following AERT implementation. Voltage consumption patterns were analyzed, revealing consistent power stability, further supporting the system's reliability. The integration of high-voltage technology, infrared sensors, and optimized trap design underscores the AERT's potential as a sustainable and non-toxic alternative to conventional pest control measures. This study provides a pathway for future advancements in ethical and effective pest management systems tailored to agricultural applications. Keywords: automated electric trap systems, agricultural pest management, humane pest control, rodent control technology, sustainable pest solutions ii Chapter 1 Introduction The persistent rat infestation issue in both agricultural and residential areas necessitate effective control measures. Rodents are accountable for significant annual crop damage globally, accounting for about 30% of losses (Wondifraw et al., 2021). This highlights the urgent need for enhanced management strategies to mitigate ecological and agricultural impacts, ensuring food security. Community-based pest management approaches are crucial in minimizing health risks associated with rat infestations (Witmer, 2022). Furthermore, rats are primary vectors for leptospirosis, a serious bacterial disease that affects both humans and animals (Cleveland Clinic, 2022). The global role of rats in spreading Leptospira spp., harboring harmful serovars, emphasizes the necessity of addressing this issue (Boey et al., 2019). In regions like India and Southeast Asia, rat infestations have reduced crop yields by 25-30%, with severe infestations causing up to 100% damage to young plants. Significant crop losses due to rats have also been reported in Western Kenya and Ethiopia, affecting major crops such as maize, wheat, barley, oilseeds, pulses, root crops, coffee, and cotton. Crop losses in Ethiopia are particularly severe, with cereal yields in the north dropping by 9-44%, maize crops in the central region falling by 26.4%, and overall crop losses in the east exceeding 50%. Rodents also cause damage to agricultural goods in urban settings. Despite these widespread issues, detailed studies identifying specific rodent pest species in affected regions are lacking (Wondifraw et al., 2021). The ethical implications of rat control methods are gaining importance. Research shows that captive-bolt and electrocution traps, which cause minimal suffering, are preferable to anticoagulants and other traps linked to high levels of distress. Well-constructed snap traps, resulting in quick death, are favored over those causing prolonged suffering (Baert K. et al., 1 2023). This shift reflects an increasing awareness of the ethical duty to treat non-human animals with empathy (Wolf & Schaffner, 2019). The inadequacy of most commercially available rat traps, primarily designed for household use, poses a significant challenge in agricultural settings. Farm rats are larger and more cautious than house rats, necessitating traps specifically designed

turnitin Page 2 of 58 - AI Writing Overview Submission ID trn:oid:::3618:82538369

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Appendix B (Raw Data)

	Day 1	Day 2	Day 3	Day 4	Day 5
Number of Rats Lured	0	2	2	0	1

Table 5. Total Number of Rats Lured Without the Automated Electric Rat Trap's (AERT) Electricity

	Day 1	Day 2	Day 3	Day 4	Day 5
Number of Rats Lured	1	0	1	2	0

Table 6. Total Number of Rats Lured with the Automated Electric Rat Trap's (AERT) Electricity

Sack Number	Agricultural Commodities	Without Intervention	With Intervention
1	Wheat	3	2
2	Wheat	1	0
3	Wheat	0	1
4	Wheat	1	0
5	Wheat	0	0
6	Wheat	2	1
7	Wheat	0	0
8	Wheat	1	0
9	Wheat	0	0
10	Wheat	0	1
11	Wheat	1	0
12	Wheat	1	0
13	Wheat	2	1
14	Wheat	0	0
15	Wheat	0	0
16	Wheat	1	1
17	Wheat	0	0
18	Wheat	0	0
19	Wheat	0	0
Total		13	7

Table 7. Number of Damaged Sacks Containing Wheat

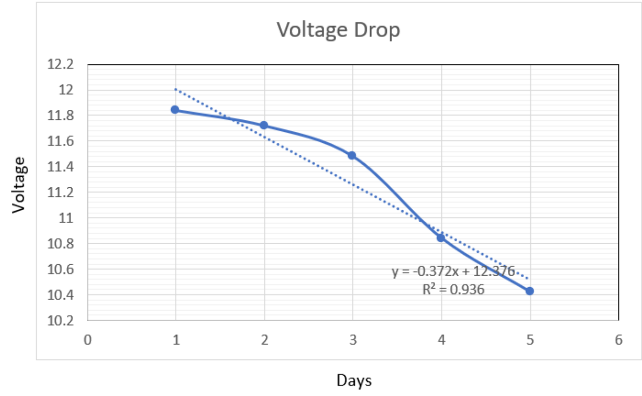
Day	Voltage (V)
1	11.84
2	11.72
3	11.48
4	10.84
5	10.42

Table 8. Daily Voltage for Five Consecutive Days

Appendix C (Sample Calculations)

A. Applying the statistical treatment on the raw data using Microsoft Excel application.

Day	Voltage Drop
1	11.84
2	11.72
3	11.48
4	10.84
5	10.42



Day	Lured	Mortality
1	0	1
2	2	0
3	2	1
4	0	2
5	1	0

t-Test: Paired Two Sample for Means

	Without AERT	*With AERT*
Mean	1	0.8
Variance	1	0.7
Observations	5	5
Pearson Correlation	-0.597614305	
Hypothesized Mean Difference	0	
df	4	
t Stat	0.272165527	
P(T<=t) one-tail	0.39948293	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.798965859	
t Critical two-tail	2.776445105	

	Without AERT	*With AERT*
Standard Deviation	1	0.83666

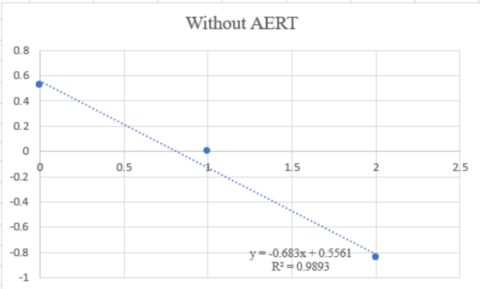
	Without Intervention	With Intervention
1	**Without Intervention**	**With Intervention**
2	3	2
3	1	0
4	0	1
5	1	0
6	0	0
7	2	1
8	0	0
9	1	0
10	0	0
11	0	1
12	1	0
13	1	0
14	2	1
15	0	0
16	0	0
17	1	1
18	0	0
19	0	0
20	0	0

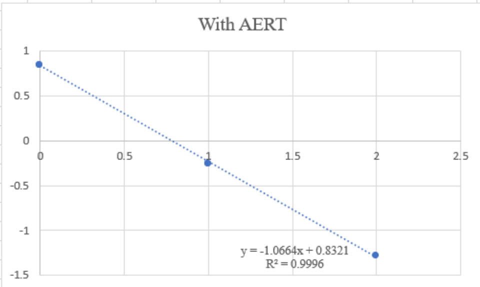
t-Test: Paired Two Sample for Means

	Without AERT	*With AERT*
Mean	0.684210526	0.368421053
Variance	0.783625731	0.356725146
Observations	19	19
Pearson Correlation	0.652581406	
Hypothesized Mean Difference	0	
df	18	
t Stat	2.051290376	
P(T<=t) one-tail	0.027541317	
t Critical one-tail	1.734063607	
P(T<=t) two-tail	0.055082635	
t Critical two-tail	2.10092204	

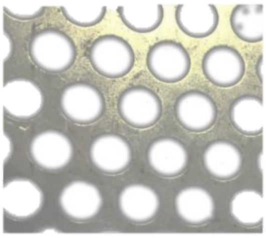
	Without AERT	*With AERT*
Standard Deviation	0.885226373	0.59726472

	A	B	C	D
1	0		4	0.524401
2	0		4	0.524401
3	1		3	0
4	2		1.5	-0.841621
5	2		1.5	-0.841621
6	BEFORE TRAP			
7				
8	after trap			
9	0		4.5	0.841621
10	0		4.5	0.841621
11	1		2.5	-0.253347
12	1		2.5	-0.253347
13	2		1	-1.281552





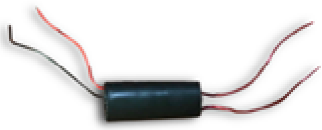
Appendix D (List of Materials and Equipment)

Pictures	Materials/Equipment
	Perforated Metal Sheet / Screen
	Stainless Steel Hinge
	Fishing Hook with 8 Claws
	Electric Wire
	Female to Male Jumper Wires

Motorcycle Battery

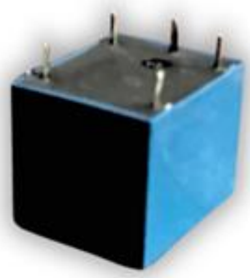
DC-DC Buck Converter

Infrared Sensor



High Voltage Generator

Galvanized Streel Square Tube



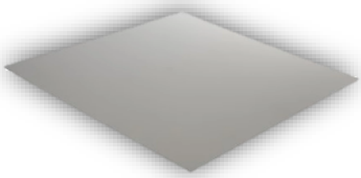
5V Relay Module

Diode IN4007

Transistor BC547

Multimeter

On / Off Switch



Galvanized Steel

Electric Alligator Clip

Electrical Tape

Stainless Steel Door Handle

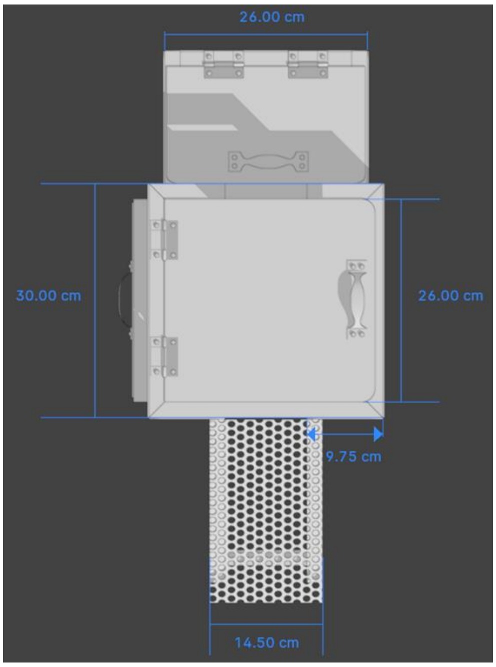
Epoxy Primer

Lacquer Thinner

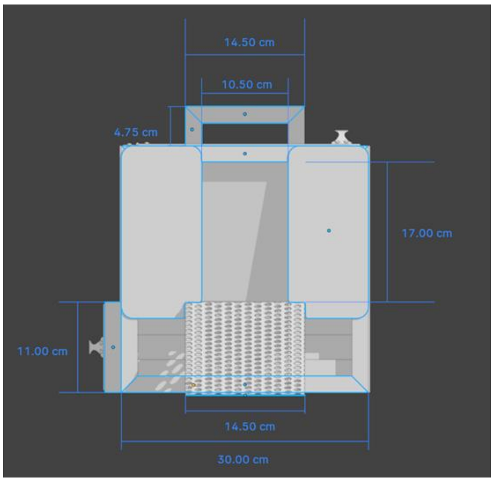
Plywood

Appendix E (Product Design)

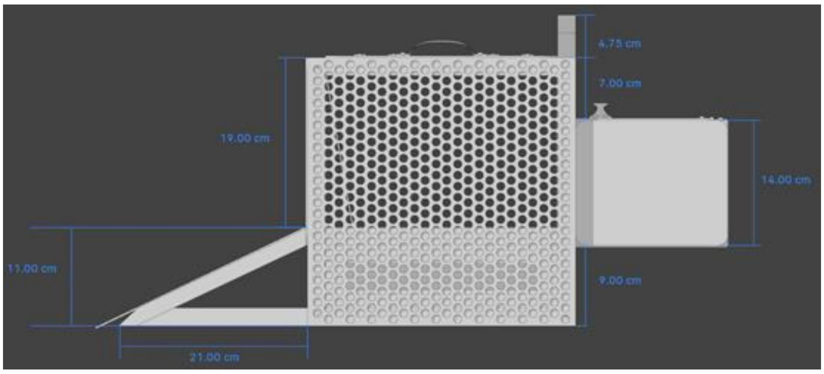
A. Top View of the AERT, designed using Blender software



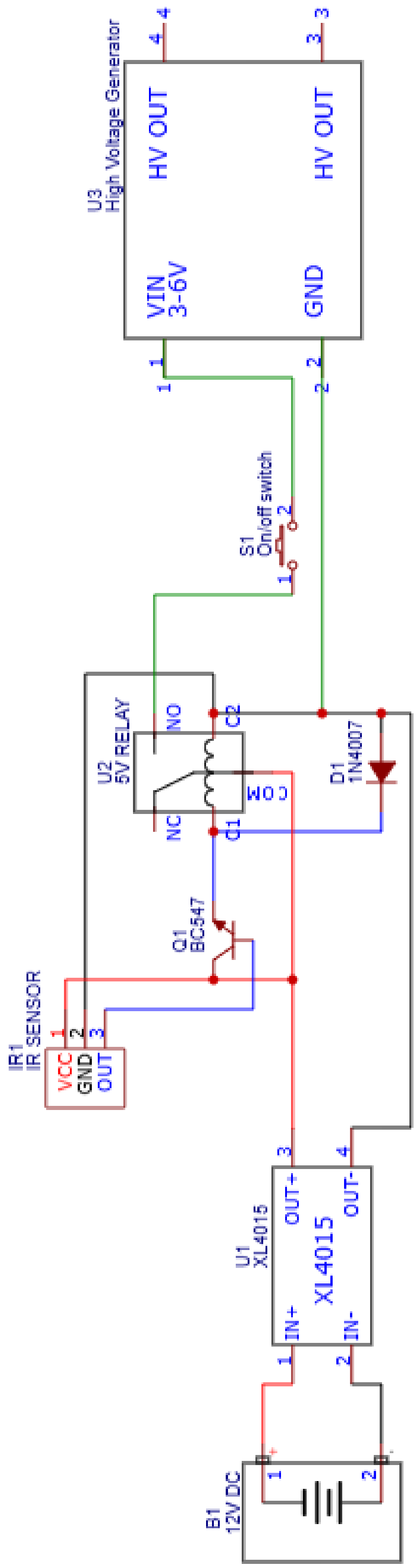
B. Front View of the AERT, designed using Blender software



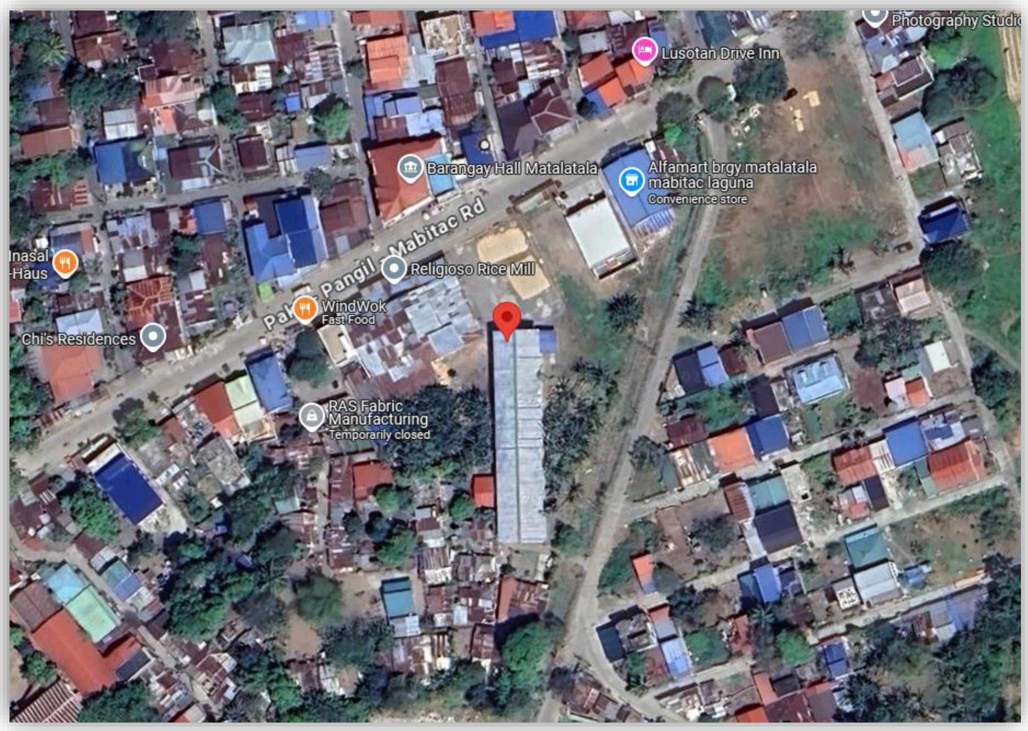
C. Side View of the AERT, designed using Blender software



D. Electrical Schematic Diagram of the AERT's Circuitry, designed using EasyEDA Std

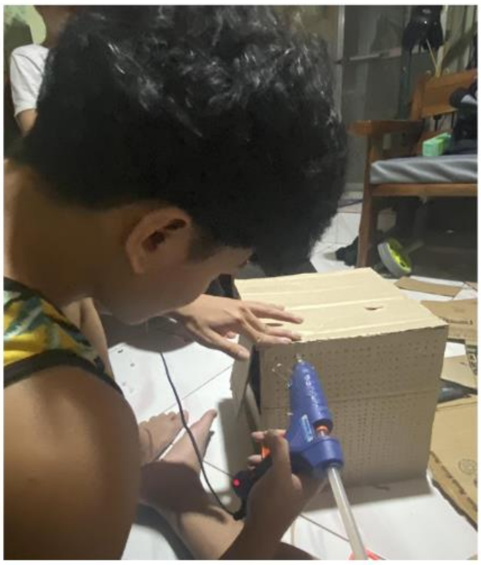


Appendix F (Map of Research Setting)



Appendix G (Photographs)

A. Documentation showing the assembly process of the AERT prototype.

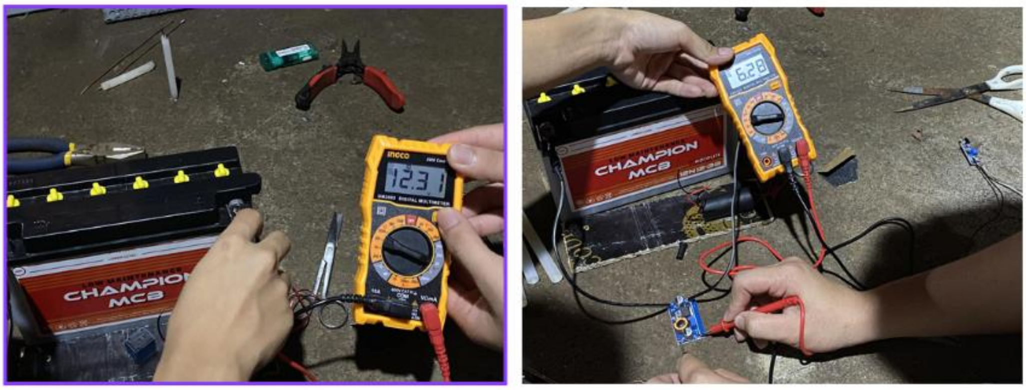


B. Documentation showing the construction of the AERT structure.

C. Documentation of the process of applying the mixture of lacquer thinner and epoxy primer on the exterior of the trap.

D. Documentation showing the electronic circuitry inside the battery compartment.

E. Documentation of the researcher's measuring the battery's voltage.



F. Documentation of the behavior of the rats:

Without AERT:

With AERT:

Appendix H (Curriculum Vitae)

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- Aesthetic
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