Monitoring and Controlling the Infestation of *Sitophilus Oryzae*

DOI: TBA
Received: 18 April 2025
Accepted: 19 April 2025
Published online: Day July 2025
Open access

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Sitophilus oryzae can destroy 10–40 % of stored grain worldwide and routinely infests rice—the Philippines' staple energy source. Chemical fumigants such as phosphine and methyl bromide or costly gamma-ray treatment curb the pest but risk grain quality and are impractical for small operators. Because weevils die at 40–50 °C and all life stages are eliminated at ≈49 °C within an hour, we designed a low-cost, heat-based monitoring and control system. A U-shaped tubular heating element, regulated by a thermostat to mimic sunlight intensity, warms the grain; a webcam supplies real-time visual tracking; and an SMS module notifies users the moment *S. oryzae* is detected. The prototype is adaptable to rice, wheat, and other grains, enabling farmers, millers, and store owners to protect large stocks without chemicals. By uniting continuous surveillance with targeted thermal disinfestation, the system offers an eco-friendly, scalable solution that can markedly reduce post-harvest losses and strengthen food security.

Infestation of Sitophilus oryzae is considered to be an environmental damage affecting the main source of energy in the Philippines which is the rice grain products. Monitoring and controlling the infestation is the most sustainable method to avoid environmental and agricultural loss of grain products. Researchers integrate a technology that focuses on monitoring and controlling the infestation of Sitophilus oryzae. U-type tubular heating element is attached to the prototype along with a thermostat control switch to provide a specific amount of heat that is comparable to the heat index of the sunlight as heat is the most favorable way of avoiding and controlling the infestation. There is a webcam installed by the researchers to have a real-time point of view of how the Sitophilus oryzae are moving themselves during the process. Researchers provide an SMS notification once a Sitophilus oryzae is detected in the prototype. The system is purposefully conceptualized so that it can be used in different types of rice, grain, and other wheat products. Researchers provide this system to maintain the good condition of rice and wheat products, especially for those who have large stocks of them, like farmers and store owners.

Rice, wheat, grain, and feeds are one of the primary

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essential supplies in a commercial business here in the Philippines. However, grain damage due to pest infestation is a problem especially for those who have a large amount of stocks of rice grains. Study by Castilla et al (2021) stated that pests surveillance systems are necessary for staple foods in order to secure food security in the face of continuous rising of population. In this action, implementation of pest management can contribute to a lower yield loss.

Pest control is a traditional way of controlling the infestation. Sitophilus oryzae is the greatest threat to the rice and other wheat grain products time after time. A report in 2018 stated that 330, 300 sacks of imported mills were infested by a specific species Sitophilus oryzae and due its infestation, an estimated 10-40% of the annual worldwide mass production of grains was reported as the overall damage of these grains. To control the infestation, insecticides and fumigation with the registered chemicals such as phosphine and methyl bromide are used as pest control to this species, Sitophilus oryzae.

Nowadays, store owners are currently dealing with loss of total income as well as decrease in good stocks and grains. Heat control is favorable against grain insects and pests such as the S. Oryzae that can develop internally inside the grains. 40-50°C are considered lethal to these stored-grain insects. The extreme heat of 120° F can kill all life stages of weevils for one hour. Other studies and research conducted using gamma-ray radiation were applied to define the morality of the S. Oryzae. An eco-friendly control method, but it can cost a lot of money for small store owners. Some fumigation and insecticides to control and contain these pests, but overdoses of chemicals and incorrect use of these may harm the total quality of the grains and feed stocks. The studies explore postharvest disinfestation treatment protocols for pest control in stored products, focusing on various insect species. The thermal death kinetics of adult rice weevils reveal a 0-order kinetic reaction model with an activation energy of 505 kJ/mol. One promising approach is heat treatment, which involves progressively increasing the temperatures to 120°F-140°F for a whole day. Moreover, the use of heat treatment, fumigation, and spraying as alternative pest control techniques is highlighted.

Results and Conclusions

The goal of the study was to create a monitoring device that could monitor and detect the Sitophilus Oryzae in real-time viewing by using deep learning in technology. The system was developed using an Arduino UNO, Node MCU, web camera, heating element and other components to enable the real-time viewing analytics and notify the user. The web camera was implemented in Arduino UNO to analyze and detect the S. Oryzae. Also, the heating element is implemented in Arduino with a set of timer for quick and deep heating when it operates. The system was designed using a modular architecture for easy maintainability and economic feasibility. Integration, acceptance and unit test was conducted on recognition and detection of Sitophilus Oryzae which can analyze and notify the user by sending a SMS successfully. 30 survey respondents evaluated the system's functionality, reliability, durability, extensibility and economic feasibility. Based on the respondent evaluation using the Likert scale computation. The functionality of the project system gave a 4.51 rate, giving the scale of Outstanding level. The people who participated in this study found that the proposed project system functions correctly, achieves all the expected results, it's easy to use and fulfills the user's needs. The second criterion is reliability which gave a 4.39 rate, giving the scale of Above Satisfactory level. They observed that the proposed project system can be

used at any time and location with a little no to its functionality. Moreover, the project system operates with minimal to no errors during its operations. The third criterion is durability which also gave a 4.34 rate, giving the scale of Above Satisfactory level. They noted that the proposed project system needs very little maintenance after it has been used. The fourth criterion is extensibility has a 4.79 rate, giving the scale of Outstanding level. They identified that there's a part of the project system that can be enhanced or developed for the next future researcher. The last criterion is economic feasibility which gave a 4.84 rate, giving the scale of Outstanding level. They observed that the proposed project system provides prolonged utility and can be viewed as a worthwhile investment. Furthermore, the overall cost of the system is justified by its performance. Overall, the proposed project system has been evaluated to be in Outstanding level as the respondents rate it to an average of 4.57.

The integration of the web camera is for dark object detection. A real-time point of view of the camera can be viewed through a webpage and the integration of thermal heating elements instead of using the solar heat index to create heat temperature. Additionally, the creation of a website is included in the system for real-time viewing. This innovative approach leverages a modular hardware and software architecture, establishing a robust framework for preventing a loss of quality when it comes to foods and to ensure the safeness. The project has not only showcased compelling proof of concept but has also underscored its ability to promptly notify the user upon monitoring and detecting the S. Oryzae. The impressive accuracy demonstrated in identifying dark objects while doing the heating phase at the same time on rice weevil (Sitophilus Oryzae) further validates the practicality of deep learning models like webcam and thermal heating device within the realm of web applications. The effectiveness of heat as a pest control on this specific pest called Sitophilus oryzae is very favorable and reliable. Generating a heat into a prototype that is comparable to the heat index of sunlight is convenient in indoor use to avoid infestation. The overwhelmingly positive response received regarding the proposed project system's functionality and user-friendliness underscores its effectiveness in preventing the infestation of the products for safety.

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