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Design of Automatic Feeder for Shrimp Farming Based on Internet of Things Technology

In shrimp farming, feeding is an important activity to achieve good shrimp growth. Manual feeding manually using hand is less effective due to unequal food distribution. Thus, an automatic feeder is required to dispense feed at predetermined time. The advantages of automatic feeder are cost-effective, low labour requirement, and can be applicable for large volumes of feed. Design of automatic feeder machine can influence the capacity and time controlling of the feeder. In this research, the automatic feeder was designed using a controlling time system based on Internet of Things (IoT) technology. During plant trial, The automatic feeding was scheduled at 7 am, 11 am, 4 pm, and 8 pm. This machine could throw shrimp food homogeneously up to 10 m far for 2,500 m^2 pond area. In shrimp farming, distribution of shrimp food in predetermined time becomes an important rule to achieve good shrimp growth.

Keywords : Automatic Feeder, Arduino Uno, Shrimp Farming

1. INTRODUCTION

Aquaculture production worlwide grows at average rate of 6.7% annually [1]. Of many aqualculture products, shrimp becomes high value commodity. In 2020, Indonesia exported app. 208,000 tonnes of shrimp worldwide and this is predicted to increase more than tripled, i.e. app 727,000 tonnes, in 2024 [2]. Of many factors, adequate and correct food supply is extremely important factor to ensure that the cultured shrimp achieve the targeted harvesting size within specific time frame. Improvement efforts therefore should be made to optimize feeding operational for shrimp maximum growth.

There are 3 types of shrimp farming, i.e. extensive shrimp farming, semi-intensive shrimp farming and intensive shrimp farming [3]. Shrimp food in extensive operation is natural food organism, e.g. phytoplankton, ophiuroids, filamentous algae, polychaetes, finfish, molluscs. Meanwhile, combination between natural and artifical food, e.g. pellets, is used in semi-intensive operation. In intensive shrimp culture operation, artificial food, e.g. in pellets form, becomes the main source of shrimp food. According to shrimp farmers, food becomes the highest operational cost in shrimp farming. This is in agreement with Poh [4] since he reported that food cost can be app. 50% of total production cost. Overfeeding does not only increase the farming cost since overfeeding can overload pond ecosystems which deteriorates water quality and huge increment of microbiota amount, some of which can be very opportunistic and pathogenic. This circumstance can increase possibility of shrimp death. Better feeding system is therefore developed in this work to minimize farming cost, to achieve targeted shrimp weight in specified farming duration and to decrease possibility of shrimp death.

According to Shipton [5], shrimp production is primarily based on hand feeding and the use of feeding trays was used to monitor food consumption. In hand-feeding, farmers can monitor feeding behaviour and manually adjust the feed ratio. Most traditional shrimp farming in Indonesia still apply this manual method. The successful of this method strongly depends on expertise of farmers. The first design of automatic feeder was found by David C. Smeltzer in 1985. This automatic feeder can be used to maintain a regular feeding schedule. The automatic feeder should be able to disperse shrimp food at a predetermined dosage and schedule. The automatic feeding machine controls the amount of food which is fed in the shrimp pond at different intervals of time. The automatic feeding machine should uniformly spread the feed across the water body to reduce excessively high food concentration at particular pond position while other positions have excessively

low food concentration. Unconsumed shrimp food in area where food concentration is excessively high causes explosive growth of pathogenic bacteria. When shrimp feeds these pathogenic bacteria, shrimp can be ill and may lead to shrimp death. The automatic feeder is ebenficial for shrimp farming since it is cost-effective, reduces labour requirements and allows large volumes of shrimp food to be fed efficiently and homogeneously [5].

Many works have been dedicated to improve the automatic feeding system. Automatic feeder machines are commercially available since in the beginning of 1990s but the commercial machines are expensive and thus economically unachievable for most farmers in many developing countries. This circumstance encourages many researches from developing countries to develop local low cost automatic feeder system. To decrease the cost of this system, Uddin *et al.* [6] applied low cost microcontrol system. Their feeder system can already send short message service (SMS) to the farmer when food amount in storage hopper already reaches the low limit. The farmer can then visit the pond to refill the storage hopper. A timer is applied in their system to automatically control the feeding frequency. Sabari *et al.* [7] applied Arduino UNO in their automatic feeder system which has lower cost than other commercial microcontroller systems. The communication between feeding machine and the farmer is via general packet radio service (GPRS) data based on 2G mobile phone technology. Dada *et al.* [8] applied microcontroller system to regulate automatic fish feeder machine (**Figure 1**). Their feeder system can already accommodate different food types. However, food can only be dropped near the feeder system. Thus excessively high food concentration occurs near the automatic feeder which may lead to unwanted circumstance as previously discussed.

Figure 1. Automatic feeding system developed by Dada *et al.* [8]

2. MATERIALS AND METHODS

The machine design is explained in **Figure 2**. The total height of the machine is 770 mm and the food maximum capacity is 10 kg. In the shrimp pond with size of 2,500 m^2, food demand is 7 kg per day. This machine is aimed for shrimp feeding uses artificial feed as pellet (**Figure 3**). Auto feeder design can be divided into hardware and software design. Hardware design consists of the electronics and mechanical sections. The auto feeder uses many components for the electronics system such as a microcontroller (Arduino UNO), RTC module, Bluetooth module, LCD, electric motor and potentiometer 10K. The block diagram of the electronic system is shown in **Figure 4**.

Arduino UNO is the microcontroller which controls the operation of auto feeder. Electric motor is used to rotate the feed thrower. Arduino UNO and electric motor are then connected by relay. RTC module is used to schedule the feeding time. It shows real time clock (hour, minutes, and second). The system uses 16x2 LCD to display the time of scheduled feeding. Arduino UNO and android mobile can be connected using Bluetooth module. Arduino UNO sends notification to android mobile for the feeding schedule and auto feeder conditions (ON and OFF). The circuit diagram can be seed in **Figure 5**. Software design for Android application uses MIT app inventor to create the user interface. **Figure 6a** shows the mobile application for shrimp auto feeder.
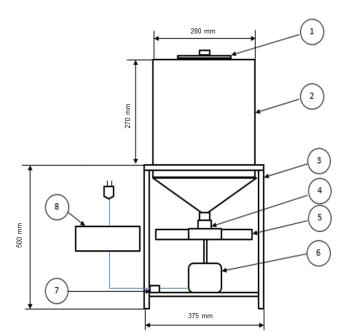
1. Cover the feed container
2. Galvalume skeleton
3. Pipe T ¾ dim
4. Pipe ¾ dim
5. Electric motor ¼ HP
6. Capacitor
7. Arduino module

Figure 2. The design of automatic feeder for shrimp pond

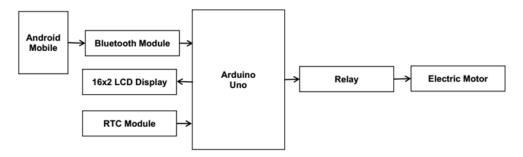**Figure 3.** Commercial pellet shrimp feed

Figure 4. Block diagram of automatic feeder system

User control of Shrimp Auto Feeder is using Android application. The user can select mobile device which will be paired by clicking on Bluetooth button. The user can also connect and disconnect Bluetooth from application. The application can show notification about feeding schedule and condition of auto feeder. The notification is sent by Arduino UNO which consists of programming language. Special program developed in this work sets feeding time of RTC module. In addition, farmer can control auto feeder manually from ON and OFF button. Minimum version of Android devices can be used is JellyBean. The main flow of software application is shown in **Figure 6b**.
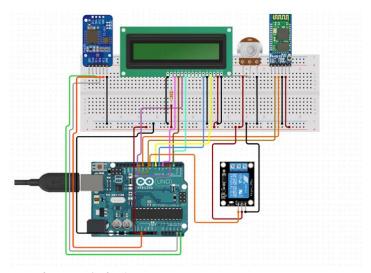
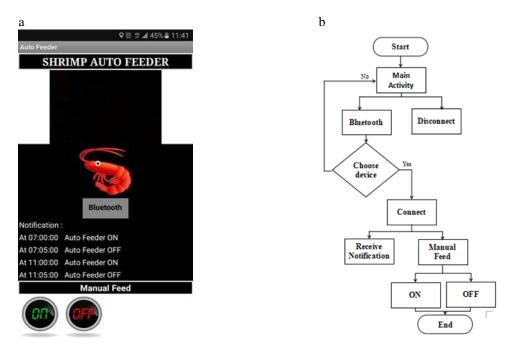**Figure 5.** Circuit diagram of automatic feeder system

a

b

Figure 6. Application of shrimp auto feeder: a) User interface, b) Flowchart

3. RESULTS AND DISCUSSIONS

Figure 7 shows the prototype of automatic feeder machine. Top cover is used to protect shrimp food, electric motor, control system and communication module from rain, corrosion, dust and reaction with pond atmosphere. The top cover uses aluminium while the machine frame uses stainless steel. Both materials are selected to prevent oxidation of cover and frame since shrimp pond in Sidoarjo is located near sea. However, the frame should be placed above another base which can be made from concrete or steel. This is to provide high stability particularly when the automatic feeder is in operation condition. During operation, centrifugal force is used to throw the food. This centrifugal force increases the load of electric motor. Therefore, the feeder uses light PVC pipe to prevent high gravitational load on electric motor. In addition, PVC pipe was used since it has relatively low price, can be easily purchased in building material sores, can be easily replaced and has high resistance to corrosion. The PVC pipe however should be regularly replaced since it is deteriorated by the ultraviolet and heat load from the sun.

Figure 7. Prototype of automatic shrimp feeder

Trial Result and Future Research Activity

During the trial, the automatic feeder can throw pellets up to 10 meters away. Since the pellets are distributed by centrifugal force, shrimp food is then expected to be homogeneously distributed among all pond area. During the trial, dosage rate after sunset was reduced. This reduced dosage was successfully controlled by the farmer using internet connection in their mobile phones. After sunset, lack of photosynthesis process inside pond water may lead to decrease of dissolved oxygen in water. In contrary, this circumstance increase CO_2 concentration in water. Shrimp requires oxygen when it consumes food but the oxygen availability in water decreases after sunset. During trial period, more unconsumed food was observed after sunset. This unconsumed food results in many problems in shrimp farming, e.g. waste accumulation, increase of ammonia and nitrate concentration, decrease of oxygen level, significant increase of algae, outbreaks of parasites, lower pH level and cloudy water. These factors can cause shrimp death.

In this prototype, food capacity in the hopper is only 10 kg. Therefore, pellets should be regularly added every day since the daily food demand is 7 kg. Thus, further research should be worked out to increase food capacity in hopper. Any stronger base should be used in case the pond base is soft soil or the water depth is more than specified in this prototype (50 cm). Details specification of automatic shrimp feeder is shown in the **Table 1.** Particular specification of this automatic feeder machine, e.g. feeding schedule, can also be reset according to the type of cultured shrimp since each shrimp type has different feeding behaviour. For example, Poh [4] reported that Pacific white shrimp feeds more as water temperature increases.

Table 1. Specification of automatic shrimp feeder.

Specification	Result
The distance of catapult feeder	10 m
Maximum feed capacity	10 kg
The distance between machine and water level	50 cm
Feeding schedule	7 am, 11 am, 4 pm, and 8 pm

Meanwhile, Martinez Cordova *et al.* [8] reported that feeding quality, e.g. feeding weight, also depends on water temperature and dissolved oxygen. Carbajal-Hernandez *et al.* [11] and Bórquez-Lopez *et al.* [12] developed fuzzy logic for automatic feeder system to increase the efficiency of feeding system. As water pond temperature decreases, the feeding dosage decreases (**Figure 6**). Vice versa, feeding dosage increases with

increasing dissolved oxygen in pond water. Based on this data, future research project is required to include both factors in the automatic feeding machine.
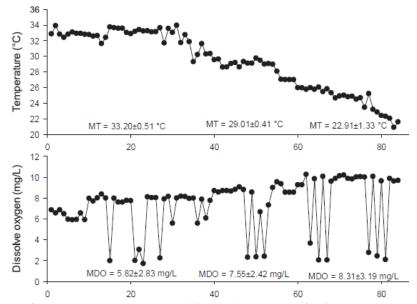

Figure 7. Influence of water pond temperature and dissolved oxygen on feeding dosage [12]

4. CONCLUSIONS

Of many factors, feeding of shrimp in artificial aquaculture becomes important. Meanwhile, commercial automatic feeder system is expensive for most farmers in developing countries. Automatic feeder system is then locally developed in many developing countries to overcome these challenges. To reduce farmer working load, the automatic feeder system should automatically dispense food at determined schedule. During the plant trial, the feeder system was successfully set to automatically dispense shrimp food at 7 am, 11 am, 4 pm and 8 pm. The automatic feeder system developed in this work was proven to dispense pelletized shrimp food up to 10 m away. After sunset, the amount of dispensed food should be reduced and this could be remotely regulated by the farmer using internet connection in mobile phone. Further researches however should be worked out, e.g. by correlating the feeding rate and amount with water temperature and oxygen level of pond water.

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