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Design And Optimization Of Agro-Scm For Food And Energy

A REMOTE MONITORING SYSTEM OF BROILERS' BEHAVIOR IN A MULTI-AGENT BROILER CLOSED HOUSE SYSTEM

K.B. Seminar

Department of Mechanical and Bio-System Engineering,
Faculty of Agricultural Technology, IPB

R. Afnan

Department of Animal Production & Technology,
Faculty of Animal Science, IPB

M. Solahudin

Department of Mechanical and Bio-System Engineering,
Faculty of Agricultural Technology, IPB

Supriyanto

Department of Mechanical and Bio-System Engineering,
Faculty of Agricultural Technology, IPB

A.K. Wijayanto

IT for Natural Resources Management,
Faculty of Mathematic and Natural Science, IPB

M.Z. Arifin

Post Harvest Technology,
Faculty of Agricultural Technology, IPB

A. Fatikhunnada

Department of Mechanical and Bio-System Engineering,
Faculty of Agricultural Technology, IPB

ABSTRACT

One of the problems being faced by Indonesian society is inadequacy of meat supply for consumption per capita. One of the most popular and affordable meat in Indonesia, at large, is chicken meat. However, the chicken meat production and supply up to now is still inadequate to meet the meat requirements of Indonesian people. The main factor that causes inadequate of chicken meat production is on-farm managerial factor. This research aims to develop a remote monitoring system for broiler's behaviors in a closed-house system. This remote monitoring system is designed to be embedded in a supervisory control systems for broiler production in multiple closed-house systems. The remote monitoring system is developed in a internet-based environment and is equipped with many input devices including camera, video, and sensors of temperature, humidity, light intensity, and noise level. The observed behavior include the behavior of locomotion and rest, grouping, shelter seeking, eat and drink, and panting. The remote monitoring system has been partially implemented and tested.

Keywords : Remote monitoring system, broiler's house, broiler's behavior, monitoring and management of broiler' house

1. INTRODUCTION

Indonesia is a country with a number and a high population growth rate. This fact led to the demand for high-quality animal protein and high quantity as well. With the increased requirement, necessary to meet the needs of businesses by increasing the production of beef cattle as a source of

animal protein. One of the producers of animal protein is meat broiler. With no less nutritional value and the price is relatively cheaper compared to other types of meat from cattle, broiler meat may be an option.

High and fluctuating ambient temperatures in Indonesia is an obstacle in the successful cultivation and production of broilers. High ambient temperatures can reduce feeding behavior in broilers. It can be seen from the decrease in feed intake in broilers reared in high ambient temperature conditions[2] [3] [4]. The reduced consumption of feed at high ambient temperatures in an attempt to reduce the accumulation of heat in the body and is characterized by reduced body weight[5] and growth rate[4].

Broilers also included livestock-sensitive lighting. Continuous lighting will increase the time to eat, increased body weight gain and increase the formation of feathers but the cause rhythm disturbances daily (diurnal), leg and bone disorders[7] which resulted in movement difficulties broiler to get feed and water.[8]

Noise is also one of the environmental factors that influence the broiler farms. With various sources of noise, which can certainly affect the condition of broiler, which in turn will affect the durability and performance.

Based on the issues that have been raised and due to the complexity of such a broiler industry comprising multiple closed-housed systems dispersed over different geographical areas, the remote monitoring system needs to be developed to be incorporated with a supervisory control system [1].

2. SYSTEM DEVELOPMENT

2.1. Remote Monitoring Development

This research was conducted in laboratory of Bioinformatics Engineering, Department of Mechanical and Biosystem Engineering and in the field laboratory Animal Science, Department of Animal Production and Technology.

The remote monitoring system is designed on the internet platform as shown in Figure 1. Monitoring results received by the server of the supervisory control system [1] can be directed to both computer-based monitoring displays and smart-phone displays to allow stationary and mobile monitoring.

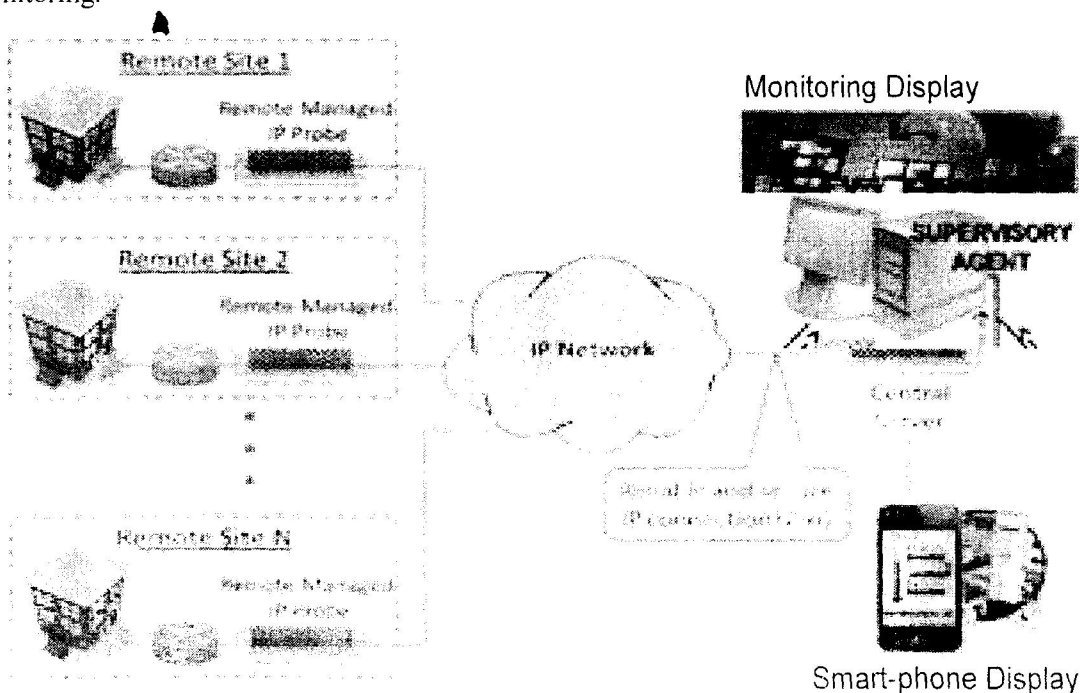


Figure 1 : Architecture of the Remote Monitoring System.

Each remote site (client) is equipped with sensing device module as shown in Figure 2.

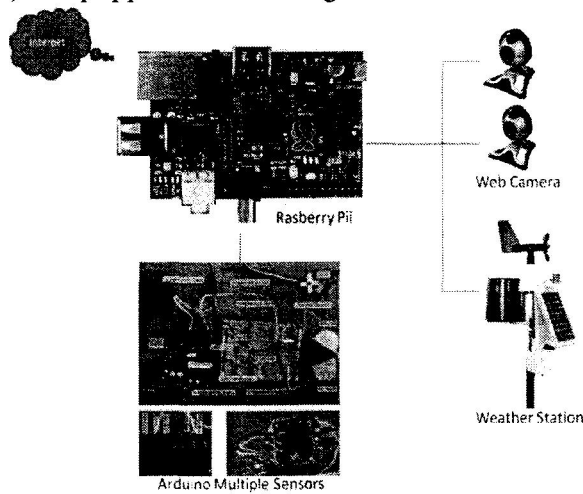


Figure 2 : Remote system devices at remote sites.

3. MONITORING SET UP

3.1. Cage and tools preparation

Preparation needed for the cage to be used appropriately and in accordance to the broiler. Preparation includes cleaning, manufacture of insulation, and installation of lighting and camera layout settings. Insulation is necessary to limit the range of motion of broiler. Partition size created is $1.12 \times 1.12\text{m}^2$. Broilers were placed as many as 12 broilers for each partition. This is in accordance with the recommendation that the maximum density for an area of about $1\text{-}2\text{m}^2$ bulk head can be charged around 10-12 broilers.

3.2. Image capturing

Image capturing done by using Canon Powershot A2200 14 megapixels digital camera when the broilers were 15 days old. This age of broilers was chosen to avoid high mortality. Broilers have had ability to survive in extreme temperature. Image capturing done by three parameters includes temperature (T), light intensity (L), and noise (N).

The temperature parameter consist of 2 values, they are comfort (T1) in range of 20°C to 25°C and high temperature (T2) in range of 26°C to 40°C . Light intensity parameter consist of three values, they are low (L1) for under 5 lux of light intensity, comfort (L2) for 5 lux of light intensity, and high (L3) for more than 5 lux intensity. Noise parameter consist of two values, they are comfort (N1), in range of 30 to 60 dB, and noisy (N2), in range of 61 to 90 dB.

Images captured are four photos and two videos for each combination. Each video has 20 seconds of duration. Three times image capturing done for each combination. So, there would be 144 photos and 72 videos.

3.3. Analysis of behavior

The behavior observed in this study is a behavior that can be analyzed visually through images that have been obtained. Observed behavior include:

1. Locomotion and rest

Calculated by comparing the number of broilers that did locomotion behavior of the number of broilers that are not moving.

2. Gathering

Calculated by counting the number of broilers that were separated from the group.

3. Avoiding danger

Observed by looking at the trend of broilers to avoid the forms of the dangers that exist around the cage.

4. Feeding and drinking

Feeding behavior was calculated by recording the number of broilers near the feed tray and peck feed. Drinking behavior is calculated by recording the number of broilers that are near the water and suck water.

5. Panting

Calculated by recording the number of broilers had seen skelter (panting) were analyzed through video. The number of broilers that do panting calculated for each video, and then averaged for each treatment combination.

Behavior of locomotion and resting, gathering, avoid danger, locomotion, eating and drinking, observed through image analysis. In locomotion behavior analysis, there are three images that are used for analysis. The first image is used as a reference for comparison with the second image. Similarly, the second image is the reference imago to be compared with the third. Panting behavior can be observed by means of video analysis. The number of broilers that do count and percentage the panting behavior. Percentage of panting will show how many broilers do panting behavior in the cage.

4. RESULT AND DISCUSSION

4.1. Locomotion and Rest Behavior Observation

The behavior of locomotion observed by calculating the percentage of migrating chicken in 3-5 minutes for each interval. Based on observations of the picture, an increase in temperature tends to decrease the activity of locomotion, as shown by the graph in Figure 3.

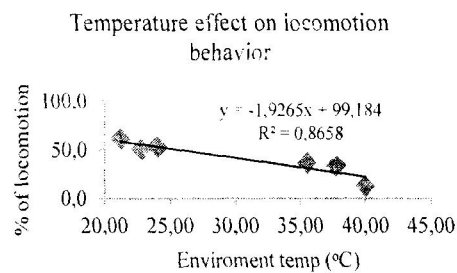


Figure3: Charts of temperature effect to locomotion

This fact suggests that broilers trying to regulate their body temperature by thermo regulation mechanism. At low temperature conditions, broiler trying to improve the body heat by doing a lot of movement, such as locomoting.

Based on observations of the high intensity influence, it appears that the effect of different light intensity affects the behavior of broiler locomotion. Effect of light intensity on the behavior of locomotion demonstrated by Figure 4.

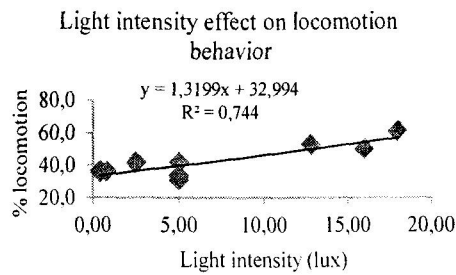


Figure4: Charts of light intensity effect to locomotion

The graphs showed a positive relationship between the intensity of light given to the locomotion behaviors that occur. Light stimulates the secretion patterns of several hormones that control behavior and regulate daily rhythms[10]. According Rendenetal [11], a lower light intensity will decrease the activity of locomotion and standing.

However, based on observation, there is no significant effect between intensity of noise on the behavior of locomotion. The relationship between noise intensity locomotion behavior depicted in Figure 5.

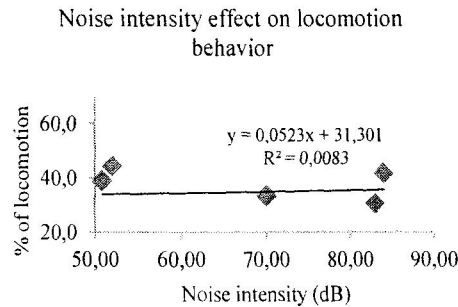


Figure5 : Charts of noise effect to locomotion

Based on the graph in Figure 4, it appears that there is no significant effect between noise intensity locomotion behavior happens. This is shown by the trend line and the equation of the line obtained. The figure represents the gradient of the slope of the line is very small, indicating that the intensity of the noise was not significant. The graphics on the condition of high temperature (T2) showed decreased locomotion trend on increasing the intensity of the noise. This is influenced by the high temperature conditions that force broilers to reduce activity, including locomotion.

Chloupek, *et.al.* (2008)[12] have performed experiments of the influence of different intensity of noise (80d Band 100dB) to stress that occurs in broilers. Chloupek found that broiler experiencing stress on both the intensity of the noise is given. While in this study, the average intensity of a given noise does not reach 80 dB. Thus, it can be concluded that the low intensity of the effect of noise on the behavior of locomotion in this study due to a given level of intensity noise is below the tolerance limit of broilers.

Activity of rest can be analyzed by calculating the percentage of locomotion with low activity. Highest of rest activities undertaken by broilers in cages with heat stress. This happens because broilers in high temperature treatment seek to minimize heat production in the body in an effort to keep the body temperature to remain at a comfortable temperature. One of the efforts is by reducing the activity.

Locomotion and rest activity is closely related to other activities, gather and shelter seeking to avoid danger. The high activity of locomotion will lead broilers tend to separate from one another, so that the lower the percentage gathered. Hazard avoidance behavior is instinct that every animal, including broilers. The existence of hazard avoidance behavior will improve locomotion activity and tend to minimize the chance of broiler to rest.

4.2. Gathering and Rest Behavior Observation

Behavior of gathering theoretically is one of the works done by broilers to prevent heat loss from the body to compensate for the low temperature environment. Activity of gathering calculated by counting the number of broiler crowd parted with the other. Thus, the higher number of split broilers indicates that the gathered closer. Conversely, if the number of broilers that separated is high, indicating that little of broiler gathered. The relationship between the temperatures on the gathering activities is shown in Figure 6.

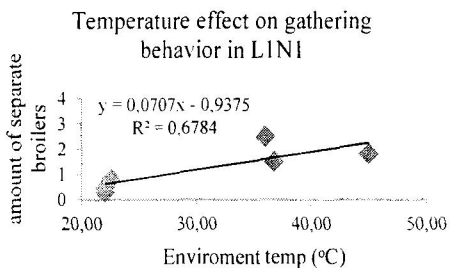


Figure 6 : Charts of temperature effect to gathering behavior.

Gathering activity closely related to the thermo regulation in broilers. Gathering of broilers with one another is an attempt to maintain the stability of body temperature due to the influence of temperature, especially at low temperature conditions. Broilers will tend to converge at the low ambient temperature conditions (cold stress), and instead will tend to disperse at high ambient temperature conditions (heat stress). Behavior of broilers which gathered at low ambient temperature conditions aimed to keep the body temperature in optimal conditions. By gathering, the broiler's body temperature will be maintained because of the heat exchange between individuals broiler.

Graph in Figure 7 shows the relationship between the intensity of light given to the gathering activities conducted by broilers. Increasing of the intensity of light given, will reduce the density of broilers group. It is shown by the increasing number of the split. This is related to the activities of locomotion. The higher the intensity of light would make it easier to see the other broilers, which in turn makes the broilers to move easier.

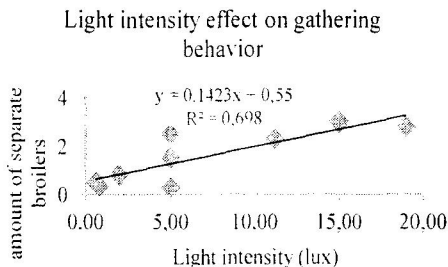


Figure7: Charts of light intensity effect to gathering behavior.

Different trends shown by the graph of light intensity effects on behavior converge at high temperature condition (T2) and high noise (N2). This influenced the activity of broiler to reduce heat

production at high temperature conditions. One way to reduce the heat production of broiler to do is by reducing the density of each other.

The observation on the effect of noise on the activity of gathering is not significant, as shown in Figure 8. Based on observations using video, noise affects only a moment when the noise first appeared. Forms of behavior that indicated the emergence of broilers when noise appeared was a surprised for a moment, and was not continuously occur.

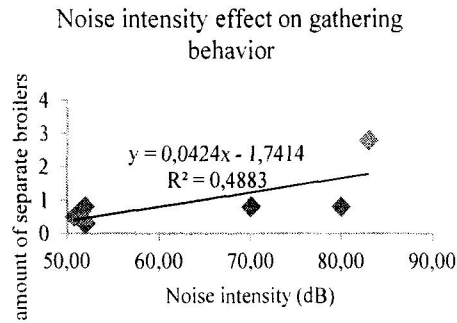


Figure8 : Charts of noise effect to gathering behavior

4.3. Feeding and Drinking Behavior Observation

Feeding and drinking behavior observed by counting the number of broilers near the tray of feed or drinking water, and doing feeding and drinking activities. An observation of feeding behavior is presented in Figure 9.

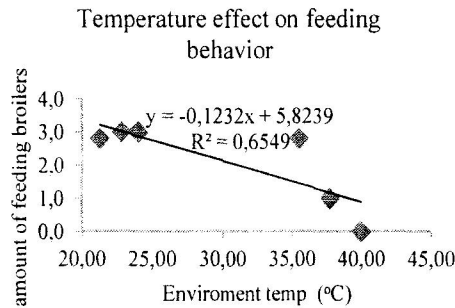


Figure1 : Charts of temperature effect to feeding behavior

One attempt to do to maintain the stability of broilers body temperature is by regulating the activity of feeding. High temperature conditions will force the broiler to lower the body's metabolic activity by lowering the feed intake. This is evident from observations that indicate that the number of broilers that consumed the feed will decrease at high ambient temperature conditions (heat stress).

Water consumption will increase at high ambient temperature conditions, as shown in Figure 10.

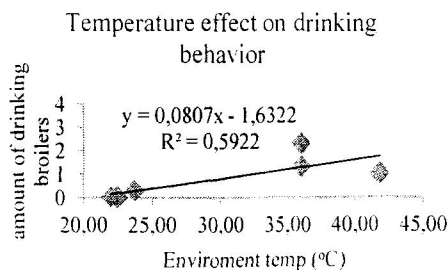


Figure2 : Charts of temperature effect to drinking behavior

The high temperature will cause reduced body activity, decreased feed intake and increased water intake to lower body temperature. This is related to the changes in physiological and biochemical in the body. Water is one of the important components in life thermo regulatory closely related mechanisms and the ability to survive at high environmental temperatures.

4.4. Panting Behavior Observation

The temperature in the cage that is too high will cause stress in broilers. One form of adaptation by broiler in anticipation of stress due to high temperatures is to release heat from the body by way of panting. Mechanism of panting in broilers occurs when the body's heat loss to the environment through radiation, conduction, and convection (sensible heat) is inadequate. Broiler will change the pattern becomes in sensible heat loss through the process of evaporation of water from their respiratory tract (evaporation).

In this study, the observation of panting is through the video recordings. Initial hypothesis was panting behavior only occurs in broilers fed a high temperature treatment. However, based on observations, the behavior panting not only occurs in broiler fed a high temperature treatment. Panting behavior occurs in almost all broilers fed a high temperature at each treatment combination of light intensity and noise intensity. Panting behavior has been seen since the early observations at the three-week-old broilers. Behavior of panting does not appear to have happened in broilers treated comfortable temperature. Panting behavior observed to occur in broilers through out a combination of high temperature treatment. This suggests that temperature is the dominant factor of panting. The effect of temperature on the panting behavior further illustrated in Figure 11.

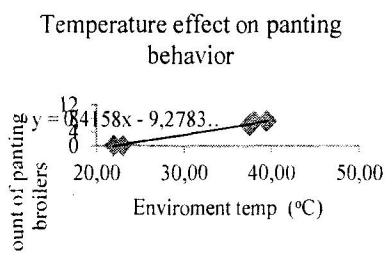


Figure3 : Charts of temperature effect to panting behavior

4.5. Image Vs Video Comparison for Behavior Observation

In essence, behavioral analysis performed in this study using the image media more than video. Based on the research that has been done, there are some advantages and disadvantages of the use of images and/or video to the analysis of animal behaviors specially broilers.

a. Locomotion and rest behavior

Locomotion behavior is due to the movement of the dynamic behavior performed by broilers. In this study, the locomotion behavior analysis is done using image media assisted by video. Locomotion and rest behavior will be more easily observed using image media. By using images, behavior analysis by creating a percentage of displacement that occurs will be easier, because the image does not move so it can be easy to calculate the change in position between the images of the broilers with the next image. However, the use of images for locomotion behavior analysis also has disadvantages. The disadvantage is that a picture freezes the incidents just as the image captured by the camera. Each picture is taken at each given time duration, in this case the duration taken every three to five minutes. So it can give rise to the likelihood of occurrence of migration of broilers in the duration. If the captured image appears to be no further change in position, then it is not necessarily true worth. Since there is a possibility that its position is changed in the duration of time, and coincidentally returned to its original position as when the previous image was

taken. This can be over come by using the video recording of the same event. Thus, the truth can be as curtained due toa change in the position of locomotion made by broilers in the duration of time.

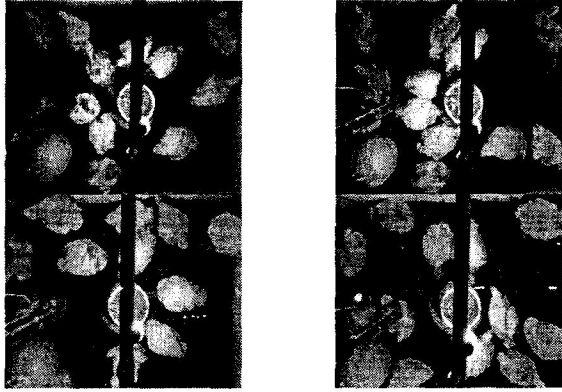


Figure4 : Locomotion and rest observation by using image

b. Gathering behavior

Behavior of gathering commonly occurs in broilers that are at a low ambient temperature conditions. Behavior of gathering is done as efforts to maintain body temperature in order to stay in a comfortable condition. Behavioral observations of gathering can be done using the images. By using images, the behavior can be observed effectively as because gathering is a static behavior, thus recording a moment in time will be relatively not much different from the record next time. In Figure 19, seen clearly the activity of broilers gathered done at low temperature conditions.

c. Shelter seeking behavior

The threat of danger makes broilers behave to avoid danger. Forms of hazard avoidance behavior: seen in this study are the behavior of avoiding the threat of heat. This behavior is clearly shown in the image. From all the media images are captured and analyzed, showing the pattern of distribution of broiler that look to avoid the heat source. The videos are not fully used in this observation.

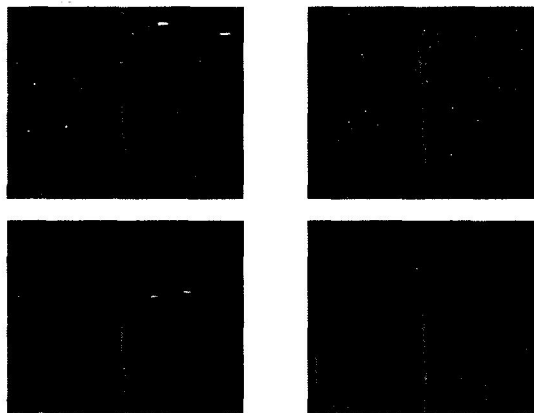
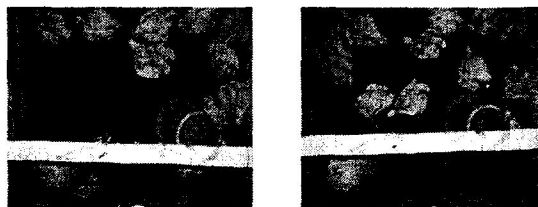


Figure5 : Gathering behavior clearly observed by using image



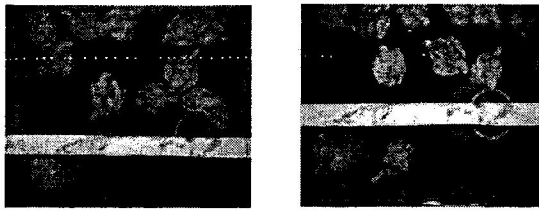


Figure6 : Shelter seeking behavior analysis by using image

In Figure 20, it appears the uniform movement patterns as a result of the behavior of avoiding danger. Figure 20 was taken on broilers fed high temperature treatment. By using images, hazard avoidance behavior can already be observed. Thus using only a complementary video media that can be used to ensure the observed behavior.

d. Feeding and drinking behavior

Feeding and drinking behavior is a behavior that usually occur in response to changes in temperature, both extreme heat and extreme cold. Observation of eating and drinking behavior can be observed only by using images. In the analysis of images, broilers deemed to feed or drink if the activity is near feed or drink trays. Similar to the behavior of locomotion and resting, feeding and drinking behavior recorded on the image is a momentary event recording (freeze).



Figure 7 : Feeding and drinking behavior observed by using image

Analysis of the behavior of feeding and drinking is done by counting the number of broilers that feed and drink marked with the broilers head was right near the feed or drink tray. Errors that can occur in the analysis of images to feeding and drinking behavior are broilers not actually feed neither drink. So that video is needed to ensure the feeding or drinking activities done by broilers.

e. Panting behavior

Panting is behavior of broilers at high temperature conditions. Panting marked with skelter broilers trying to remove body heat to maintain body temperature at normal conditions. Panting behavior will be difficult to seeon the media image, as shown in Figure 22 (a). Thus, the form of video recordings will be in dispensable in behavioral of panting observations. In this study, behavioral observations of panting use more of videos than images. By using video, panting behavior evident, marked with mouth open and skelter, and the movement of the ribs.



Figure8 : Panting observation by using image (a), and video (b)

The effectiveness and ease of panting behavior analysis through video depending on the position or angle of the video. Video screen shot shown in Figure 22 (b) is a video taken with the camera, just above the object of observation. On the right camera position over the object, the panting behavior seen hardly. Panting behavior would be relatively easier looks at the video with the camera close to the object (close-up).



Figure9 : Panting behavior observed by using closed-up video

4.7. Research Implementation in Broiler Farming

Poultry farming in Indonesia continues to experience growth. Especially in terms of technology implementation. While most implementations of the technology have been made by the company in large scale farms. The technology has been implemented in farms generally are environmental control technology, especially the ambient temperature. Control mechanism used is to keep the ambient temperature at the recommended temperature conditions. Though there is a possibility of a change in the characteristics of broilers as a form of adaptation to environmental conditions. In addition, not all environmental conditions can be detected by the temperature control equipment. Another factor that may occur, which could hamper monitoring of conditions of broilers is a factor of environmental control equipment failure (e.g., evaporative cooling pad, heater, etc.). It certainly cannot be detected by the sensor control that has been there. So the method of temperature control can be said to be not very effective.

Alimuddin, et.al (2010)[13] has made temperature control system technology development in the closed house based on adaptive neuro-fuzzy inference system (ANFIS). The research aim to design an ANFIS control system for controlling the temperature in a closed cage (closed house) for broilers. In addition to temperature, the study also developed a control system that includes the RH of environment, lighting, and ammonia levels. Furthermore, Alimuddin, et al (2011)[1] has developed a supervisory control system for temperature and humidity in the closed cage broiler house.

The use of cameras as media in monitoring environmental conditions in the broilers coop is a new thing. Bloemen, et al (1997) [14] has presented a method to quantify the behavioral response of animals to their micro-environment by using a camera system and a digitiser board. One of three application of the study measured the behavioral responses of broiler chickens to their thermal environment. The study concluded that the developed image analysis technique can be employed to quantify the behavioural responses of the tested animals to their micro environment, in an easy and accurate way.

By the study of the behavior of broilers using camera as was done in this study, the potential implementation of camera technology at the farm would be enormous. This is also supported by the camera technology continues to grow rapidly. The implementation can be done is to use the camera as a medium surveillance as an early warning system. Media that can be used is in the form of pictures and videos. However, to avoid large memory resource usage, it can be arranged as not to do store the results in a memory. Supervision can be done directly by the user / brainware, in this case is a supervisor, armed with knowledge of the behavioral characteristics of broiler visually. In further

development, can be made with an automatic control method of image analysis directly performed by a system by combining the results of previous studies. So as to minimize the use of human resources.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The remote monitoring system has been developed and has been implemented to monitor broiler's behaviors. Temperature is the most significant parameter affecting the behavior of locomotion and rest, gather, shelter seeking, feed and drink, and panting in broilers in this study. The intensity of light directly affects the behavior of locomotion and rest, as well as feeding and drinking. Noise by up to 80dB intensity level did not influence on the behavior of broilers in this study.

The use of pictures and video as a behavioral study analysis of broilers are more effective when used together. Analysis using pictures used to observe the behavior of spatially (e.g. gathering). The analysis can be done using video to behavioral observations focused on the dynamic movement. An advantage of pictures is the use of memory resources are relatively lower compared to video media. The advantage of video media is able to record and explain in detail the events that occurred on the object of observation.

Implementation of camera technology on broilers industry would be very nice to be developed, given the use of camera technology is still new in the poultry farming, and the weakness of the temperature control mechanism using a sensor that has been there. Implementation of camera technology can be combined with the results of previous studies that the control system supervisory the chicken coop. An implementation that can be further developed is an image based early warning system on broilers farms.

5.2. Recommendations

To achieve the increased production of broilers, breeders need to improve the quality of maintenance management. Include keeping the environmental conditions of the cage, and keep it in accordance with the characteristics of broilers in the optimum temperature 23°C, 5 lux of light intensity, and free from the influence of noise. The study examined only five of behavior consisting of locomotion behaviors and rest, shelter seeking, gathering, feeding and drinking, and panting. Future studies may examine other behaviors that will support the development of a visual study of the behavior of broilers. Further studies can be done by implementing behavior-based broilers image into an actual application form that can be used in broilers farm business in a closed house.

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