Spatial Distribution of Laying Hens in Different Environmental Conditions by Image Processing and Correspondence Analysis

V. C. Rodrigues[1], J. A. D. Barbosa Filho[1], A. M. C. Vieira[2], F. M. C. Vieira[1], and I. J. O. Silva[1]

[1] Animal Environment Research Nucleus, University of São Paulo, Brazil

[2] Statistics Department, National University of Brasília, Brazil

Abstract. *This study used an image processing methodology for behavior verification of confined hens in thermal comfort and stress conditions in order to get information about spatial distribution over time. Two groups of five birds were analyzed during two days, in three periods, in a controlled climatic chamber. Images were collected for 10 seconds each for each period and processed to locate the geometric centers of the hens and their position inside of the rearing system. Animal tracking by video recording or image sequences can be adapted to behavior information related to space measurements, mapping of animal frequency in a determined region or the same covered distance, inactivity periods, and behavior that occurs over hours or days, a time scale that comprises the human observer efficiency. A CCD camera was placed above the climate chamber. The captured images had been stored by the program "VIDEOCAP 5,1", in BMP format and converted into JPEG with dimensions 240 x 320 and processed with MATLAB 7.0®. The procedure consists of converting RGB images for L*a*b space of colors or CIELAB. The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis. This system is able to quantify the visual differences between colors and to separate them from each other in secondary images. The pre-processed images sequences were used as information to mass center calculation in the sequence throughout the treatments. The regions were delimited: nest, free area, feeder trough, water trough and "feeder + water" trough. The results show that the regular observation of the spatial distribution of confined animals is an important indicator of their comfort or discomfort, as a preference test, and it can be an efficient tool to study hens' behavior.*

Keywords. *Image analysis, Laying hens, Welfare.*

Introduction

The researches of animal behavior have as objective to identify and quantify signals of suffering in order to eliminate the problems obeying the welfare norms (Huntingford, 1984). The behavioral changes show the requirements of ambient for the animals' survival. They search for places that contribute to the minimum thermoregulatory effort and energy expense. During this process, there are changes in the water ratio intake, search for cold places and the dispersal of birds that favors the heat loss by convection, conduction and radiation (Rutz, 1994).

Studies about the human contact with laying hens indicate that human interference in this environment can be determinative for the behavior, production and possible conditions of thermal comfort (Barnett, 1994). The system described by Xin (1998), with a camera connected to a computer, presents method of image storage, for subsequent visual analysis. This system offers an auxiliary technique to researcher due the sequence of image controlled.

In Brazil, researchers have used the acquisition of image to record the behaviors of some farm animals, such as bovines (Matarazzo, 2004; Perissinoto, 2003), swine (Pandorfi, 2002) and laying hens (Barbosa Filho, 2004; Sevegnani et al., 2001). The benefit of this system has being discussed for almost 40 years (Deshazer, 1988) and suggests many possible applications, including the continuous checking of bird activity.

Currently, a considerable number of models to find animals in an image and its dynamics characterization by automatics systems were mentioned (Tillet, 1991; Marchant, 1993; McFarlane, 1995; Benson, 2004) by some authors about the Computer Vision application to study animal behavior. These studies suggest many possible applications, including the continuous monitoring of activities through the time. The amount of information and time of analysis increased substantially, which evidenced the need of automate systems and techniques of image processing.

These procedures can generate information without the interference of the researcher. The tracking for video or image sequence is adjusted for the information on the behavior as a measure of space, animal frequency in determined region, tracking distance or periods of inactivity, even though behaviors that occur during hours, or days, which compromises the efficiency of the human observer (Spink, 2001). Assessment and control of the environment and situations about animal comfort is a problem based on ambient temperature and moisture levels.

One indicator of the environmental adjustment to the welfare animal is the analysis of behavior integrated with the environmental features. Image processing techniques offers a potential alternative to replace human observations (Shao et al., 2007). Thus, the aim of this work is to verify the behavior of laying hens under thermal comfort and stress conditions, through an image processing methodology, and to obtain information about spatial distribution based on the needs of birds throughout the time.

Material and Methods

The procedure for the spatial distribution of laying-hens based in sequence of image processing is illustrated in Figure 1.

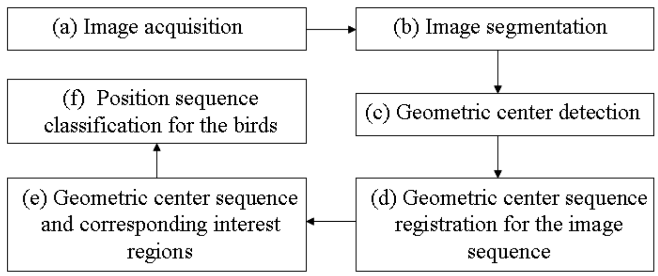

Figure 1. Schematic procedure of the laying-hens spatial distribution.

The birds were submitted to the two environmental conditions inside of the controlled climatic chamber:

1. Treatment 1: Condition of thermal comfort, T= 26°C ± 2°C and RH= 60% ± 2%,
2. Treatment 2: Condition of thermal stress, T= 35°C ± 2°C and RH= 70% ± 2%.

The laying-hens were confined in this local during period of gradual environment adaptation for a total of 21 days for each treatment. The controlled chambers structure is shown in Figure 2.

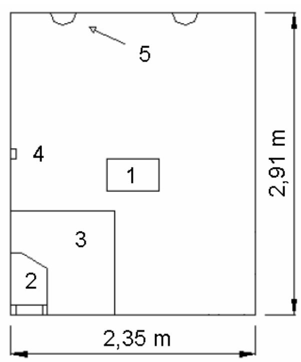

Figure 2. Lateral schematic of system structure of controlled chamber (1- Environmental control system, 2 – nest, 3 – litter, 4 – temperature and humidity sensors, 5 – CCD camera).

A CCD camera was placed above the climate chamber. The captured images had been stored by the program “VIDEOCAP 5,1”, in BMP format and converted into JPEG with dimensions 240 x 320 “pixels” and processed with software MATLAB 7.0®.

The images were related with the research developed by Barbosa Filho (2004). Images of 10 laying hens (Hy-line W36) aging 21 weeks were used. For each treatment, 5 birds were confined in the climatic chamber with litter and nest. These laying hens received non-toxic colored inks in the backs, in agreement with the methodology of Rudkin and Stewart (2003) as shown in Figure 3.

Figure 3. Laying hens confined in litter and nest with the demarcated backs.

The images are related with two days for each treatment in 3 periods of the day: morning, from 10:00 to 11:00; and afternoon from, 13:00 to 14:00 and 16:00 to 17:00. The first procedure is the image segmentation by color differences. The human visual system is able to detect three different light bands, that is, electromagnetic waves that indicate color tonalities.

These bands correspond to the tonalities of red (“Red”), green (“Green”) and blue (“Blue”) colors. The combination of these three basic colors constitutes the human vision specter and thus, the computer usually uses this color system: Red, Green and Blue colors, the RGB system, which are codified by different gray level values to the cited colors. The different combinations of this system’s colors are able to generate any type of color (Jain, 1989).

In system RGB, the value (0,0,0) represents the black color therefore all the three basic colors presents the same gray level values, in contrast of the value (255, 255, 255) representative of the white color where the three colors are presents in their maximum intensities. The segmentation of colorful images is a method to get direct information to an object of interest and it is made through the use of techniques of K-means clustering (The Math Works, 2003).

After the back plan subtraction (between image with birds and without birds) the procedure consists of converting RGB images for L*a*b space of colors or CIELAB (CIE, 1986). The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis.

This system is able to quantify the visual differences between colors and to separate them from each other in secondary images. Figure 4 shows the separation by colors of the backs of birds in different images.

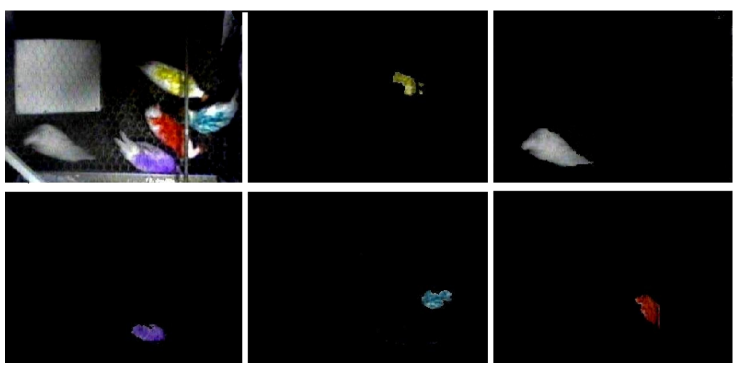

Figure 4. Separation of the birds’ backs in secondary images.

The pre-processing of 360 image sequences for each period was used to calculate the center of mass for each image in the sequence throughout the treatments. The regions were delimited: nest, free area, feed trough, water trough and “feed + water” trough. The regions were delimited in form to represent more than 50% of the bird body.

The images of birds were transformed to binary images. The mass centers for each bird in the sequence of binary images were calculated based on the concepts of digital images and geometry (Gonzalez and Woods, 1992).

Based on the information that digital image is formed by pixels and assume values of 0 and 1, a mass system with values 0 for pixels in black color and 1 for white can be attributed to this. In this form there is a system formed by n points (P_1, P_2,…, P_n) in the Cartesian plan, each one of these points represents an orientation such as P_n (x_n, y_n) is associated to a mass m_n that assumes two values, 0 (black pixel) and 1 (white pixel). The center of mass (x, y) of this system is defined through Equations 1 and 2:

$$x = [(m_1*x_1+m_2*x_2+\ldots+m_n*x_n)/M] \quad (1)$$

$$y = [(m_1*y_1+m_2*y_2+\ldots+m_n*y_n)/M] \quad (2)$$

Such that $M= m_1+m_2+\ldots+m_n$. The mass center, or geometric center, of the image is showed by Equation 3:

$$C = (x, y) \quad (3)$$

By this form, it was able to locate in the image the 5 birds throughout the analyzed time. The correspondence analysis of regions of interest and periods shows the contribution of each region occupied by hens in each one of the three periods analyzed.

Considering the 2 by 3 contingency table as a matrix, correspondence analysis is applied to explore graphically the similarities between regions and periods. This method consists of decomposing the matrix X as X=ULV´, where U is an orthogonal matrix formed by the eigenvectors of XX´, V is an orthogonal matrix formed by the eigenvectors of X´X and L is a diagonal matrix formed by the eigenvalues of XX.

Based on these values, a two dimensional plot can be made, where rows and columns of the contingency table are represented as a point. Linear proximity means high association between rows, columns or rows-columns (Everitt, 1992).

Results and Discussion

The frequency analysis in regions of interests, according Figures 5 and 6, show the possibility to get information about the frequencies of the birds in the studied situations. In these Figures, the birds were submitted to thermal comfort and stress situation and these figures show the aerial image of Figure 3.

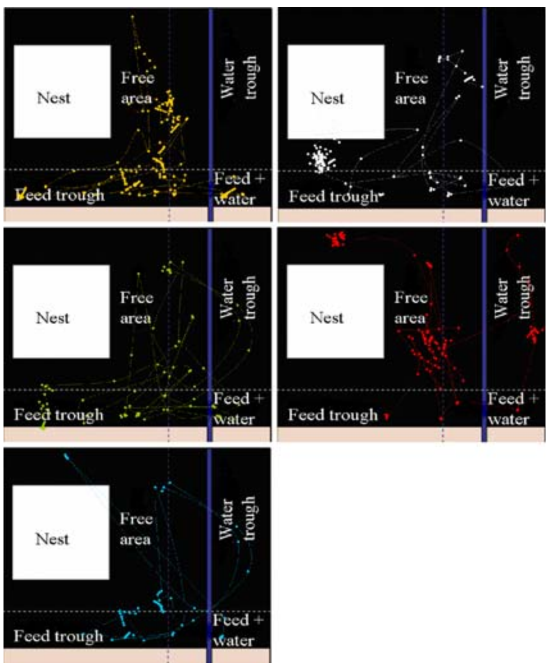

Figure 5 - Tracking of the birds in regions of interest in situations of comfort in the first period.

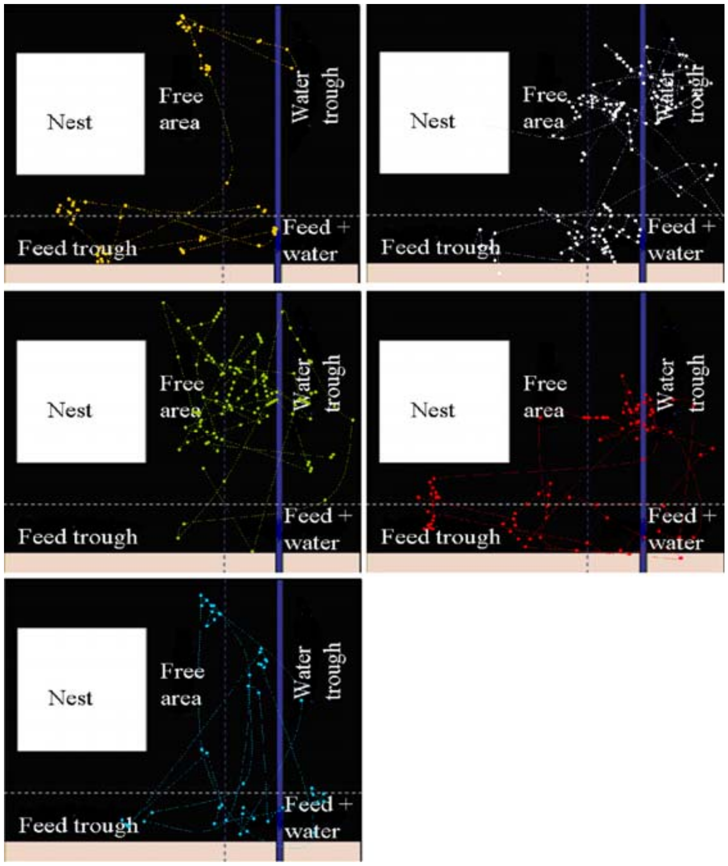

Figure 6 – Tracking of the birds in region of interest in situations of stress in the first period.

These graphics (Figure 7) show the similarities between regions and periods to thermal comfort and stress situation. The blue dots are the areas and the red dots are the periods.

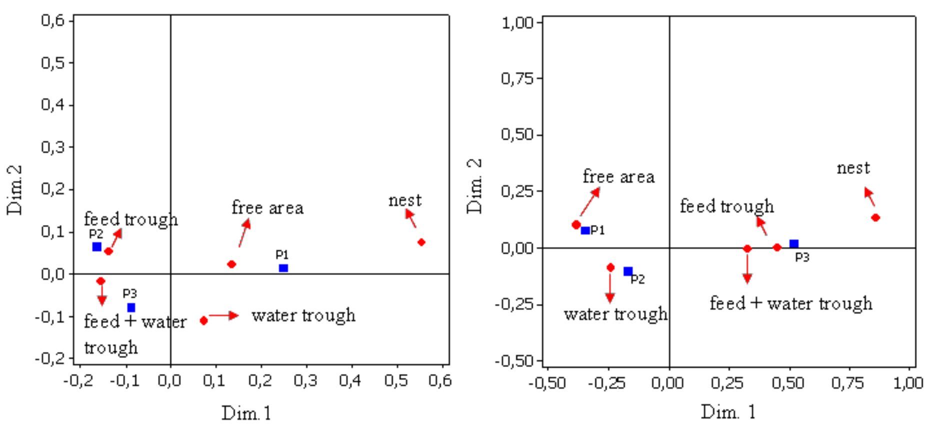

Figure 7 - Similarities between regions and periods of thermal comfort (left graphic) and stress situation (right graphic) through correspondence analysis plot.

The dimensions 1 and 2 could be a comfort index or other variables relatives to data if was possible. For the condition of comfort: (a) the area most occupied in the first period is the free area, where the laying hens were not eating or ingesting water. This is explained by pre posture and the behaviors of posture that are characterized by need of proximity to the nest. Nesting behavior is more common in the morning, whilst a higher frequency of birds in the nest or near was also observed, reflecting the usual pattern of oviposition (Carmichael et al., 1998).

In the second period, the hens showed a higher frequency in the feed trough area, and in the afternoon period, between 16:00 and 17:00, in the feed + water trough. In the situation of thermal stress (b), the free area is related to period 1 too, due behaviors of pre posture and posture like a condition of comfort. About period 2, the higher frequency refers to the water trough region and period 3 is related to the feed trough, which could be explained by the pecking on the ration, or even by the fact that the ration could be found in the floor and the hens explore these objects with out the intention to eat.

Those behaviors, in conditions of thermal stress, are alike the real situation, which occurs in the field which means that in those periods the hens are searching for the water trough and the nest region is reduced. For the comfort situation, there is a higher correlation between period 1 and the free area. During the day, in this particular time, the hens are searching for the nest. The period 2 shows more correlation with the feed trough in which the hens were in this region having food. The period 3 showed a high level of correlation with the feed + water trough.

Thus, the hens had access of food and water. In the stress situation, the period 1 and the free area showed the highest correlation, just like the comfort situation. It shows that the stress did not had influence the nest search behavior. Period 2 and the water trough showed a higher correlation than the others periods, and period 3 and feed trough also showed a higher correlation level.

According to Lesson and Summers (1991), critical temperatures above 27 °C, the demand for energy is increased so that the birds body can start the mechanisms of thermoregulation. Duncan (1974) reported that exist an animal behavior trend to feeding when the animals remain confined due to the little space to natural behaviors. Thus, the behavioral trends of the birds are consistent with the patterns recorded in the literature and therefore which can be explained by sequential images analysis.

Compared with the authors reported above, this technique is a mixture of opportunities presented by various researchers about animal behavior in images sequence. The present study shows some problems as to the time spent for such application of the technique, for example, the images that have undergone separation of colors or sequences separated for each image, which has generated a large database of images to be processed.

A second step to optimize the technique and that becomes valid is automate the process of calculation, the geometric centre for each animal with the back in the same color saving processing time. Initially, the first problem was get the codes of each color and separate the colors of the whole sequence of images because the humidity of the chamber climate affecting the luminosity of the place due to the condensation under the lamp and this affect the luminosity inside of the chamber, changing the true colors of birds backs. For each period was obtained a code of numbers for each color.

Conclusion

These methods are showed as an efficient tool to characterize the animal distribution when submitted a different situations. Regular observation of the spatial distribution of confined animals is an important indicator of their comfort or discomfort. The use of standard imaging equipment, coupled with the specific image analysis described in this paper has shown be trustworthy, free of subjectivity in monitoring of laying hens, straightforward and reliable.

It is about one of efficient ways to analyze images quickly to understand the dynamics of confined animals throughout time. Through of the frequencies in determined regions the birds show its needs, in agreement with its condition of comfort or stress.

References

Barbosa Filho, J. A. D. 2004. Welfare evaluation by image analysis of laying hens in different housing systems and environment conditions. Piracicaba-SP, Dissertation (Master-degree) – Superior School of Agriculture Luiz de Queiroz, University of São Paulo.

Barnett, J.L.; Hemsworth, P.H.; Hennessy, D.P.; Mccallum, T.H.; Newman, E.A. 1994. The effects of modifying the amount of human contact on behavioural, physiological and production responses of laying hens. *Appl. Animal Behaviour Sci.* Australian. 41: 87-100.

Benson, E.R. (2004). Poultry behavior analysis system using machine vision. *Appl. Poultry Eng. News*, Delaware. 2: 2-3.

Carmichael, N.L., Jones, R.B., Mills, A.D. 1998. Social preferences in Japanese quail chicks from lines selected for low or high social reinstatement motivation: effects of number and line identity of the stimulus birds. *Appl. Anim. Behav.Sci.* 58: 353–363.

Commission Internationale De I'eclairage (CIE). 1986. *Colorimetry*. 2nd ed. Bureau Central de la CIE, Paris: (Publ. CIE 15.2-1986 ISBN 3 900 734 003), p. 86.

Deshazer, J. A. 1988. Imaging systems to improve stockmaship in pig production. ARFC Inst. Eng. Res. Div. Note DN 1459, p. 24.

Duncan, I. J. H., Wood-Gush,D. G.M. 1974. An analisys of displacement preening in the domestic fowl. *Animal Behaviour*, Amsterdam, v. 20, p. 68-71.

Everitt, B. S. 1992. *The Analysis of Contingency Tables.* London: Chapman & Hall.

Gonzalez, R. C, Woods, R. E. 1992. Digital Image Processing. Edgard Blucher.

Huntingford, F. A. 1984. In: *The Study of Animal Behaviour*. London: Chapman & Hall, p.350-356.

Jain, A. K. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall.