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Correlations among behavior, Performance and Environment in Broiler Breeders using Multivariate Analysis

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ABSTRACT

Animal welfare issues have received much attention not only to supply farmed animal requirements, but also to ethical and cultural public concerns. Daily collected information, as well as the systematic follow-up of production stages, produces important statistical data for production assessment and control, as well as for improvement possibilities. In this scenario, this research study analyzed behavioral, production, and environmental data using Main Component Multivariable Analysis, which correlated observed behaviors, recorded using video cameras and electronic identification, with performance parameters of female broiler breeders. The aim was to start building a system to support decision-making in broiler breeder housing, based on bird behavioral parameters. Birds were housed in an environmental chamber, with three pens with different controlled environments. Bird sensitivity to environmental conditions were indicated by their behaviors, stressing the importance of behavioral observations for modern poultry management. A strong association between performance parameters and the behavior "at the nest", suggesting that this behavior may be used to predict productivity. The behaviors of "ruffling feathers", "opening wings", "preening", and "at the drinker" were negatively correlated with environmental temperature, suggesting that the increase of in the frequency of these behaviors indicate improvement of thermal welfare.

INTRODUCTION

As opposed to exports in the 1970s, quality is the main focus of animal production systems, due to the increasing international competition (Nääs, 2005). Animal welfare issues have received much attention not only to supply farmed animal requirements, but also to ethical and cultural public concerns (Prestes, 2005). According to this author, the implementation of an animal welfare program must follow the same steps of a quality program.

When environmental temperatures are high, poultry respiratory rhythm increases from approximately 29 cycles per minute (low environmental temperatures) to more than 100 cycles per minute (temperatures higher than thermoneutral zone), impairing performance. Layer egg production and quality decrease with heat stress (Faria *et al.*, 2001; Zavarize *et al.*, 2005).

Animal behavior is affected by the environment, and therefore, knowing how it affects animals allows us to identify and to quantify welfare. According to Duncan & Mench (1993), behavioral changes are the first animal response to attempt to regulate internal temperature as a function of environment, and this response can be used to predict welfare levels.

Studying dustbathing behavior in chickens, Olsson *et al.* (2002) said that this behavior is part of bird socialization. These authors observed that this behavior is simultaneously presented by several individuals in a flock. However, it is triggered by an individual, who starts dustbathing and then is mimicked by others, showing that one individual bird stimulates this behavior in the group. According to those authors, dustbathing is important for group motivation and it is an indicator of social welfare.

Several authors showed the possibility of studying animal behavior using video cameras (Estevez *et al.*, 2003; Bizeray *et al.*, 2002), and proposed periods of observation during the day. Bizeray *et al.* (2002) observed the physical activities of 1,800 broilers during 15-min periods, with a total of 1h observation per week. This time sampling was also found in other studies (Estevez *et al.*, 2003; Jong *et al.*, 2003).

Estevez *et al.* (2003) observed the behavior of layers in different group sizes. Aggressive behavior dynamics was influenced by food competition, and less aggressive interactions were observed when groups were larger, provided the same bird density was maintained. Jong *et al.* (2003) evaluated hunger behavior in broiler breeders (Hybro-G) submitted to five feed-restriction programs (90%, 70%, 50%, 35%, and 25% of *ad libitum* intake), with 10 birds per program. The authors found that lying down and idle time were the only behaviors affected by feed restriction.

Kristensen *et al.* (2000) carried out a study on the preference of layers to different ammonia concentrations. The trail was conducted for six days inside an environmental chamber divided into six compartments, with transparent roof. Video cameras were place on the roof of the chamber, and bird behavior was evaluated. Compartments contained three ammonia concentrations (0 ppm, 25 ppm, and 45 ppm), and temperature and relative humidity varied 2°C and 5%, respectively, among compartments. A 12:12h (6:00am to 6:00pm) photoperiod was simulated by the use of lamps placed over roof, which provided approximately 99 lux. During the period of darkness, a lamp of 2.75 lux was switched on to allow behavior recording. The results of this study showed that birds preferred the fresh environment, where they foraged, preened, and rested for significantly longer as compared to the environment with high ammonia concentration, which led the authors to conclude that the threshold of ammonia aversion by layers is between 0 and 25 ppm.

Daily collected information, as well as the systematic follow-up of production stages, produces important statistical data for production assessment and control, as well as for improvement possibilities (Kebeler & Schiefer, 1996). According Zambalde *et al.* (1996), technological developments in computer science and agricultural instruments, used with software applications, provide farmers with powerful tools to better manage and control their businesses. Frost *et al.* (1997) stressed that animal production systems need to adapt themselves to new technologies of production monitoring integrated to information management systems in order to ensure optimal production, growth, and health of farmed animals, as consumers increasingly seek for products with quality guarantee and lower prices.

The present study evaluated behavioral, performance, and environmental data using Main Component Multivariate Analysis. Behaviors, observed by means of video cameras and electronic identification, were correlated with performance parameters of broilers breeders housed in an environmental chamber and with environmental data. The aim was to start building a system to support decision-making in broiler breeder housing, based on bird behavioral parameters.

MATERIALS AND METHODS

The present experiment was carried out between July, 2005 and August, 2005, during nine days, in an environmental chamber in the experimental farm of FEAGRI-UNICAMP, Campinas, SP, located at latitude 22° 53' S and longitude 47° 03'W.

Birds

Groups of ten female and two male Ross 308 (32 weeks), Cobb-500 (26 weeks) and Hybro-PG (29 weeks) broiler breeders, were placed in pens (2.5m x 1.2m) located inside an environmental chamber, summing up 20 females and 6 males, as shown in Figure 1a. Bird densities were 315cm²/bird and 5 females/male. These densities were based on densities commonly used in commercial farms, both in terms of birds/m² (200cm²/bird) and female to male ratio (8 females/ male).

Environmental conditions

Birds were exposed to three different controlled temperatures: 26.3°C, 29.5°C, and 33.0°C. In order to minimize its effects on the treatments, relative humidity was fixed in 75% ± 5% for all three temperatures. This is considered by Tinoco (2001) to be within the

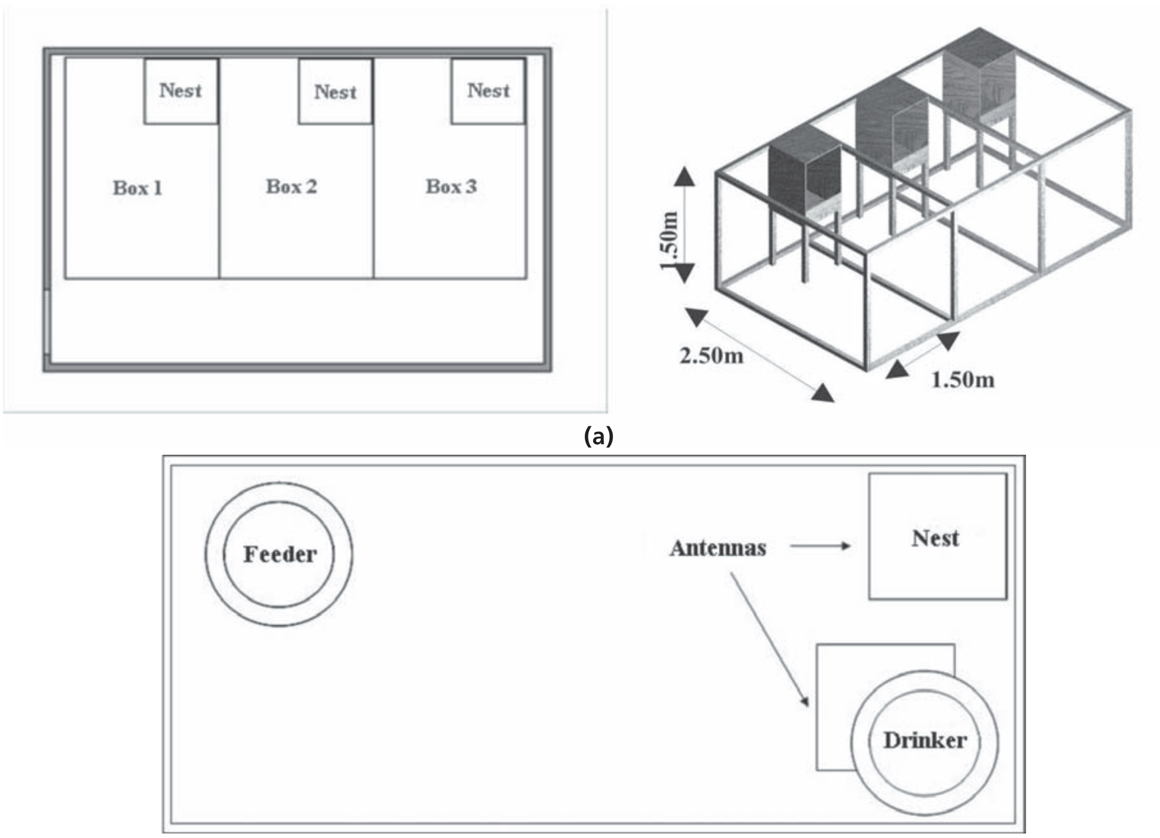

Figure 1 - Diagram of the location of pens in the environmental chamber (a) and of equipment in the pens (b).

comfort zone. Temperature variation inside the environmental chamber was ± 1°C, as measured by a Hobo® temperature/relative humidity probe placed inside each pen. Bird behavior and performance data in each environment were collected for three days. The same individuals in the pen were observed. Ammonia concentration was monitored, and recorded once daily at random times, using a suction pump and Dragüer® graduated tubes.

Feed

Birds from each genetic line were fed the same feed formulation provided at the farm of origin, containing approximately 2,860 kcal/kg metabolizable energy and 17% crude protein. Therefore, feed was not considered as an experimental treatment.

Experimental Procedure

Breeders of a same genetic line were housed together in the same pen (Figura 1a). All breeders were electronically identified by a Trovan® transponder inserted in the leg, as recommended by Pereira (2003). The period of habituation of birds to the environmental chamber consisted of submitting birds to comfort environmental conditions of 24°C and 75% for three days. After this period, environmental chamber temperature was increased to 26.3°C, when behavior and performance started to be monitored.

All birds were submitted to a single photoperiod of 14h of light and 10h of darkness.

Feeding regime was the same as practiced during lay (controlled daily intake) in commercial farms, i.e., feed was offered once daily at 167 g/bird for Ross and Hybro-PG birds, and 140 g/bird Cobb-500 birds.

Data recording

All behaviors described in Table 1 were observed by electronic identification antennas – one placed in the nest, and the other at the drinker in each pen, as shown in Figure 1b, which monitored the use of these equipment, and by video cameras (one per pen) placed over the roof of the environmental chamber, which monitored other behaviors.

Each day was divided in two periods: morning (6 am to 12 pm) and afternoon (12 pm to 6 pm). This division was defined after the observation that the presence of feed influenced breeder behavior. Feed was supplied always at the same time in the morning,

Table 1 - Ethogram of the recorded behaviors.

Behavior	Description
Opening wings	When the bird flaps both wings
Stretching	The bird stretches one wing and one leg of the same body hemisphere.
Threatening	One bird stands before another, stretches its neck, ruffles its feathers, spreads both wings, and looks at the other bird downwards.
Ruffling feathers	Action of ruffling and shaking all body feathers
At the drinker	Bird stands at the drinker, indepedent of the act of drinking.
Drinking	Action of standing in front of the drinker and drinking.
Pecking	The bird aggressively pecks any part of the body of another bird.
Foraging	Movement of scratching the litter barckwards with its feetm and searching for food in the litter.
Running	Movement of a bird between two distant points at a higher speed than usually observed.
Lying down	The bird sits or lies down on the litter.
Dustbathing	Bath performed by the bird using the litter as substrate to loose heat by conduction.
Preening	The bird arranges its feathers with the beak, inducing the uropigeal gland.
Mounting	Male or female bird climbs on the back of another bird. This can be interpreted as an aggressive behavior (female-female) or as a reproductive behavior (male-female).
At the nest	Situation when the bird is in the nest.
Chasing	One birds runs after another bird, aiming at pecking or other form of aggression.
Prostration	The bird lies on the litter, with open beak, half-opened wings, and pants, aiming at increasing the surface area for heat exchange with the environment.

and remained in the feeder until around 12 pm, and this was considered to determine the period times. Thirty minutes of recorded video per day, divided in 15 min in the morning and 15 min in the afternoon, were selected for behavioral observation. This is an adaptation of the method applied by Bizeray *et al.* (2002) and Estevez *et al.* (2003).

Frequency of occurrence and duration of each observed behavior were recorded. The association of behavioral frequencies and duration with production performance was analyzed in model with different main components. Subsequently, in order to identify correlations between mean occurrence frequency and mean duration of the observed behaviors, a third main component model was built, including all measured parameters.

Production performance and data recording

Production performance parameters, such as number of eggs produced (corrected by the production schedule of the flocks in the original farms), egg weight, percentage of hatched eggs, hatchling weight, and eggshell weight, were recorded and correlated with behavioral data. Eggs produced in each environment were daily collected, cleaned, stored for a maximum period of three days, and incubated in a 270-egg capacity incubator. As eggs were incubated with the smaller end up, it was necessary to transfer the eggs to a hatcher (120-egg capacity) to turn them to the correct position for hatching. After hatching, chicks and their eggshells were individually weighed in a precision scale.

All data were recorded and managed using a software, and later analyzed by Main Component Multivariate Analysis.

Main Component Multivariate Analysis graphically shows the association among variables. The graph components (main components) are products of all observed and non-observed variables that contributed to explain each of the measured variables. Each variable is expressed by a vector which is originated in some point inside the graph, and grows in magnitude to the outside. Variables expressed by small vectors are not well explained by the main components of the model, and therefore should not be important for analyses. Vectors establishing 90° angles are not significantly correlated or associated. On the other hand, vectors growing in the same direction and sense are positively correlated, i.e., the increase of the value of one variable implies in the increase of the value of the other variable; if the opposite happens, there is negative association.

This statistical analysis tool allows the observation of bias and associations among variables. The effect of behavior changes as a function of the environment is not fully known, as many authors (Estevez *et al.*, 2003; Olsson *et al.*, 2002) studied behavior only from ethology perspective. In poultry production, there are few articles, such as those of Curto (2002) and Pereira (2003), who studied the correlation of poultry behavior with environment and production performance seeking better economic results.

The power of explaining main component is related to the analyzed variables and their correlations. Aiming at providing a deeper analysis, the present study shows three multivariate graphs: 1) mean frequency of occurrence of behaviors, performance and environment;

2) mean duration of behaviors, performance and environment; and 3) mean frequency and duration of behaviors, performance and environment.

RESULTS AND DISCUSSION

The methodology used for recording behavioral data allowed observing the birds with no human interference. Zambalde *et al.* (1996), Kebeler & Schiefer (1996), and Frost *et al.* (1997) stimulate the use of information technology and electronic sensor to monitor animal productions systems in order to improve process efficiency and control. The recording data by electronic identification technology, using radiofrequency as communication between a transponder inserted in an animal and receptor antenna, was efficient to record use behaviors in the present experiment, which is consistent with the observations of Curto (2002).

Video camera recordings allowed classifying behaviors according to frequency of occurrence and duration, demonstrating important differences. Some aggressive behaviors reported in literature (Estevez *et al.*, 2003; Pettit-Riley *et al.* 2002), such as mounting, pecking, and chasing, were not observed. Although Estevez *et al.* (2003) report that aggressive behaviors are influenced by group size, the absence of these behaviors in the present experiment is probably due to the duration of observation of the recordings (15 continuous minutes), which has been widely used in research studies (Bizeray *et al.*, 2002; Estevez *et al.*, 2003; Jong *et al.*, 2003).

The results are expressed as the mean of behaviors and perfomance parameters of the three genetic lines.

Figure 2 shows the association among performance parameters and mean occurrence of behaviors, with no differentiation of genetic line. The position of the vectors highlights three groups with expressive associations. The first group corresponds to the mean frequencies of the behaviors "ruffling feathers", "opening wings", "foraging", "preening", and "drinking". These behaviors present high positive correlation with each other, and strong negative correlation with environmental temperature, suggesting that the frequency of these behaviors is related to an improvement in thermal welfare. The second group includes the behaviors "lying", "dustbathing", and "going to the nest". The third group consists of the performance parameters "eggshell weight", "hatchling weight", "number of hatched eggs", "average egg weight", and the behavior "nest use", suggesting dependence among these variables. Temperature was positively correlated with the behaviors "dustbathing" and "at the drinker".

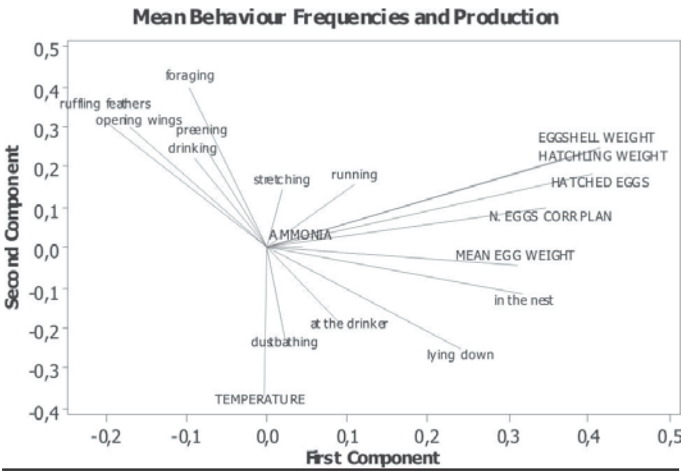

Figure 2 - Main Component graph comparing mean frequency of occurrence of observed behaviors with production and environment.

Except for the behavior "nest use", which was associated with performance parameters, no association was observed between mean frequency of occurrence of behaviors and production performance. Temperature was positively correlated with the behaviors "dustbathing" and "at the drinker", and negatively correlated with the behaviors "running" and "stretching".

In Figure 3, which shows the association of behavior duration with performance parameters, again three different groups are observed. The first group includes the behaviors "dustbathing", "foraging", and "preening", which are positively correlated with each other, and present negative correlation with the third group, which consists of performance parameters. The second group consists of the behaviors "drinking", "lying down", and "at the drinker", which are positively correlated with each other and with temperature. The mean duration of "in the nest" was strongly associated with performance parameters, suggesting that this behavior has a positive effect on production performance.

On the other hand, "foraging" and "preening" suggest production performance losses. However, when the values of the main components are considered, it is observed that behaviors are better explained by the second component, whereas performance parameters are explained by the first

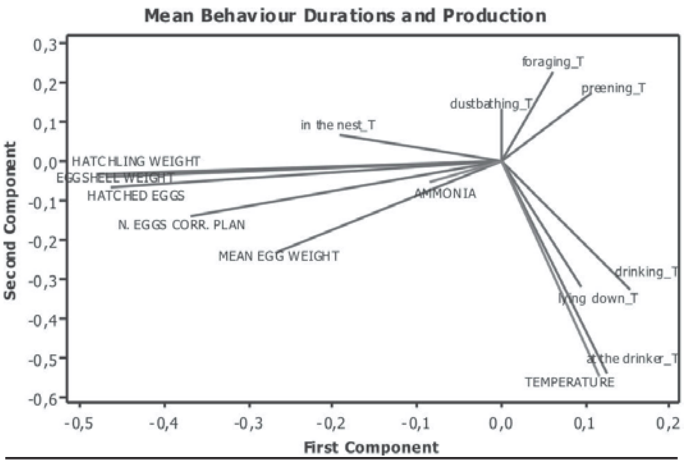

Figure 3 - Main Component graph comparing mean duration of observed behaviors with production and environment.

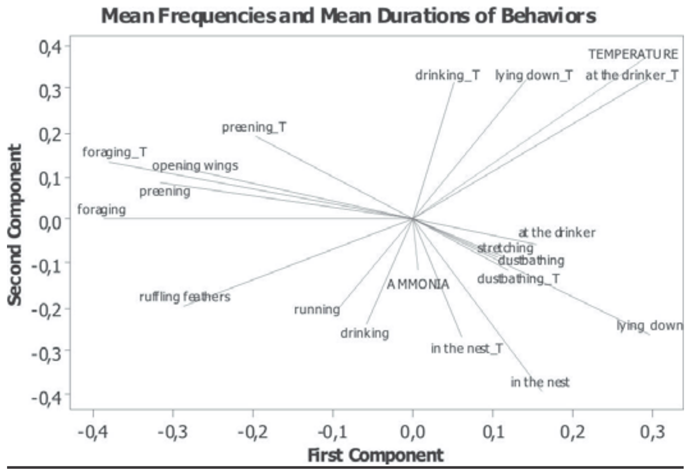

Figure 4 - Main Component graph comparing mean frequency of occurrence with mean duration of observed behaviors.

component. Moreover, the lower magnitudes of the vectors associated to duration of the behaviors "foraging" and "preening", as compared to the magnitude of the performance vectors, are not explained by neither of the main components, and therefore, associations with these parameters cannot be inferred.

Both in Figures 2 and 3, a positive association between ammonia concentration and production parameters was observed, suggesting that increasing ammonia concentration may positively affect production. However, the magnitude of this vector does not allow the clear identification of the association strength with the performance parameters. There was no correlation between performance parameters and temperature in these Figures, but the positive association between performance parameters and duration of "at the nest" and "lying down" suggest that these behaviors could be used to evaluate broiler breeder welfare, as, according to Faria *et al.* (2001) and Zavarize *et al.* (2005), egg production and quality decrease with heat stress.

Figure 4 shows the associations among all observed behavioral parameters. Mean durations are indicated in the graph with an index _T, whereas mean frequencies of occurrence are not followed by any index.

The frequency of occurrence of the behaviors "foraging", "preening", "dustbathing", and "at the nest" presented strong positive association with the duration of the corresponding "foraging_T", "preening_T", "dustbathing_T" and "at the nest_T" behaviors, respectively. The behaviors "drinking" and "drinking_T" showed significant negative correlation. This observation, added to the positive association of "drinking_T" with temperature, indicates that when temperature increases, the birds remained at drinker longer. This consistent with the findings of Curto (2002) and Pereira (2003), who observed longer permanence at the drinker when environmental temperatures were high. Figure 4 also shows that behavior "at the drinker_T" is also positively associated with temperature, suggesting a real dependence of this behavior on this environmental parameter. The frequency of occurrence of "lying down" was not associated with the duration of this behavior (lying down_T). The strong association of the frequency of occurrence of "opening wings" and "preening" with mean duration of "foraging" (foraging_T), which are negatively correlated with temperature, suggests that these three behaviors are related to broiler breeder welfare.

CONCLUSIONS

The analyses allow us to conclude that broiler breeder behavior was strongly affected by the environment, even under low amplitudes of temperature and ammonia concentration. This indicates that the bird's behavior expresses its sensitivity to the environment. The observation of bird behavior for adequate management is essential in modern poultry production.

A strong association was observed between performance parameters and the behavior "at the nest", suggesting that this behavior could be used to predict productivity levels. The frequencies of "ruffling feathers", "opening wings", "foraging", "preening", and "drinking" were negatively correlated with temperature, suggesting that as thermal welfare is improved when the frequency of these behaviors increase.

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