XVII[th] World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

ACTIVITY ANALYSIS IN BROILER CHICKENS WITH DIFFERENT GAIT SCORES

A. AYDIN[1], O . CANGAR[1], S. EREN OZCAN[1], C. BAHR[1], D. BERCKMANS[1]

[1] D. BERCKMANS, Division M3-BIORES, Katholieke Universiteit Leuven, Kasteelpark Arenberg 30, B-3001 Heverlee, Belgium Division Measure, Model & Manage Bioresponses, Katholieke Daniel.berckmans@biw.kuleuven.be Tel: +32(0)16321726 Fax: +32(0)16321480 URL: www.m3-biores.be
[1]A. AYDIN, arda.aydin@biw.kuleuven.be.
[1]O. CANGAR, ozlem.cangar@biw.kuleuven.be.
[1]S. EREN OZCAN, sezin.erenozcan@biw.kuleuven.be.
[1]C. BAHR, claudia.bahr@biw.kuleuven.be

CSBE100361 – Presented at Section II: Farm Buildings, Equipment, Structures and Livestock Environment Conference

ABSTRACT Monitoring the activity of broilers is a potential way for determining gait score level at commercial farms. In this study, a fully-automatic monitoring technique was developed to measure the activity of broiler chickens with different gait score levels. We carried out experiments in order to assess the relationship between gait scores obtained by human experts and activity levels quantified by an automatic image monitoring system. The chickens were scored for their degree of lameness by experts according to the method of Kestin et al. (1992). For each experiment, a total of 30 birds, on day 32 were selected from a local commercial farm. Five birds were selected in each of six gait score groups (GS0 to GS5). The activity levels were obtained for all gait scores by using an automatic image monitoring system. For this purpose, video surveillance images of broilers with six different predefined gait scores were analysed. In both experiments, there was a significant relation between gait score by experts and activity monitored by image analysis. Similarly, day of experiment in relation to gait score showed significant differences in activity values ($P<0.05$). The broilers with gait score 3 (GS3) showed significantly higher activities than the other gait scores in both experiments ($P<0.05$), possibly due to their need for more feed. In experiment 1, there was no significant difference among the activities of other chickens with different gait scores. In the second experiment, GS4 and GS5 showed significantly lower activities. Overall, the results show that automatic camera monitoring system can provide an automatic tool in determination the activity in relation to gait score. This activity information can be used further to identify the effects of gait score on broiler behaviour.

Keywords: Activity, Broiler chickens, Gait score, Automatic monitoring.

INTRODUCTION The most important questions related with broiler welfare quoted in the last two decades are the growing sensitivity for metabolic and locomotion problems due to the fast growth rates and inactivity of the chickens. In commercial farm conditions, broiler chickens show low levels of activity, particularly the ones kept in high stocking densities and during the last weeks of the growing period (Blokhuis, 1990; Bizeray et al., 2002). There are many potential welfare benefits of controlling the activity of broiler chickens. Increased overall movement within the flock may improve bone development, litter condition and prevent skin lesions on the hocks, feet and breast, normally caused by prolonged sitting on poor quality litter (Bizeray et al., 2002).

Several studies have focused upon ways of increasing activity early in the growing period, although reducing activity is sometimes desirable, for example during decreasing of population. Rearing broilers in bright red light early in life increased activity and decreased leg disorders compared with broilers reared in dim blue light (Prayitno et al., 1997), whilst environmental complexity has been reported to either increase activity (Bokkers and Koene, 2003) or have no effect upon activity or gait score (Bizeray et al., 2002). High light intensity increased activity of broiler chickens and decreased leg problems and mortality without affecting production (Cherry and Barwick, 1962).

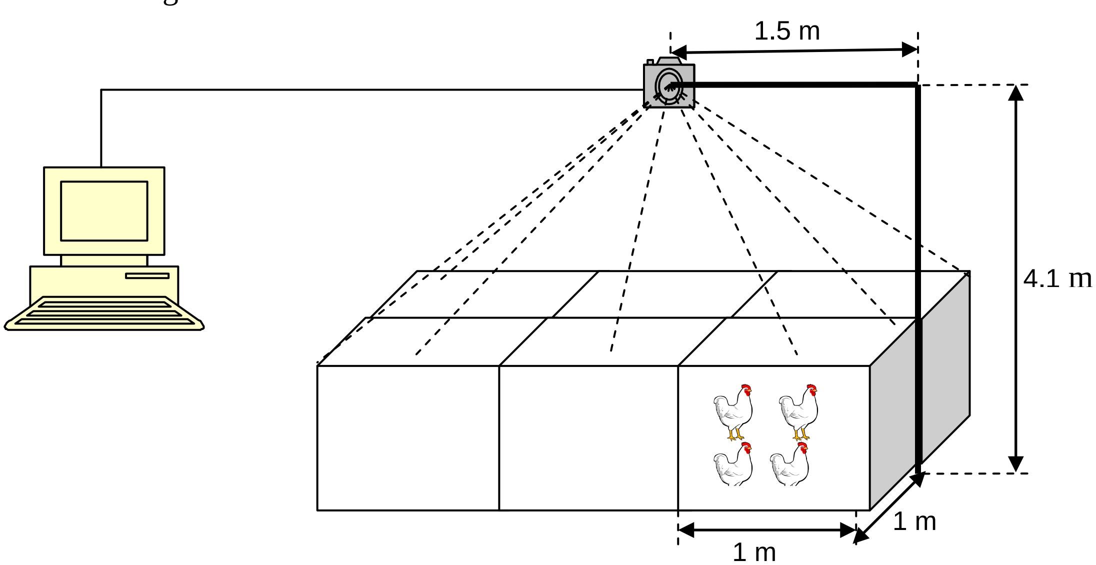
Traditional methods for determination of gait score include the manual scoring of animal behaviour in the broiler house. Recorded images can also be used for manual scoring of chicken gait score. Due to the large labour requirements; both methods have high costs. In addition to that human interpretation is subjective.

Image analysis technologies have been widely used in behaviour analysis of different animals. Thermal comfort behaviour of swine was analyzed by Shao et al. (1998) using programmable cameras. The area and the perimeter of the top view of the pigs could be extracted from the images. Individual behaviour of pigs in a pen was studied by Tillett et al. (1997). In their work, an image processing technique was used to track the animal movements. The fitting of a model to the top view image sequence provided data on position, rotation, bending and head nodding. The locomotion and posture behaviour of pregnant cows prior to calving was studied by Cangar et al. (2008). In their study, automatic real-time monitoring system was used to classify specific behaviours such as standing or lying (including incidences of motion during lying), and eating or drinking. Similar studies have also been performed to detect of lameness in dairy cattle (Song et al. 2008, Tash and Rajkondawar, 2004). Leroy et al. (2005) established a model-based computer vision system to study the behaviour of hens in furnished cages. Individual behaviours such as standing, walking and scratching could be recognised automatically and in real time.Using camera images for analysing activity is becoming an emerging technology. It is relatively cheap, non-invasive and facilitates the collection of more frequent data over longer time periods. In case of running an analysing algorithm in real time, no huge data storage is required. The existing image analysis tools were developed in pig and cow chambers in laboratory conditions. In commercial livestock houses, image analysis for behaviour classification becomes more complicated. Lighting, camera characteristics, background and test subject's traits all influence the ability of the system to recognise the subject and record its movement accurately (Hoy et al. 1996). Computer visual tracking of poultry was studied by Sergeant et al. (1998), to develop a new technique for extracting a background image which compensates for the particular idiosyncrasies inherent to the problem.The objective of this study is to investigate the activity levels of broiler chickens in relation to their gait scores using an automatic image monitoring system under laboratory conditions. Therefore, a fully automatic monitoring and image analysis system was applied to determine the average activity levels of chickens with different gait scores. The outcome of this study will allow large scale and automatic behaviour analysis of chickens with different gait scores.

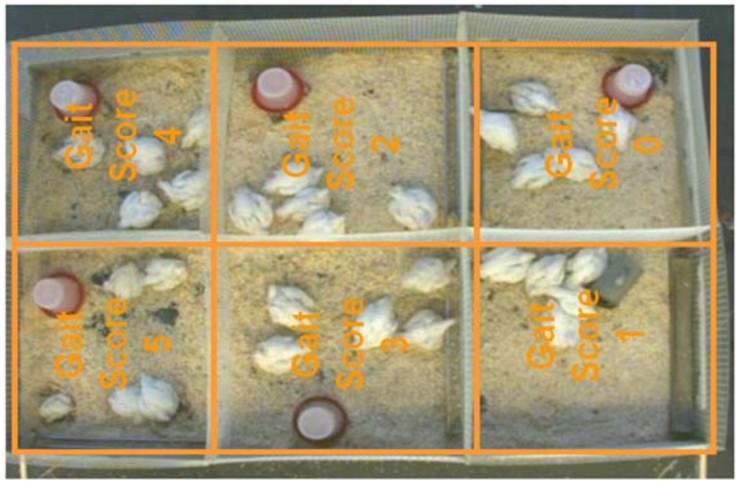
MATERIALS AND METHODS

Birds, experimental design and video recordings The experiments were conducted with Ross 308 broilers which were vaccinated using a spray administration technique against Newcastle disease (NDV, Poulvac) and infectious bronchitis (IB Primer, Poulvac). On day 23, they were vaccinated additionally in the stables using a drink water vaccination technique against Gumboro (Bursine 2, Poulvac) and Newcastle disease (Hipraviar NDV, Clone). For the first 9 days, a prestarter diet with 23% protein and 2890 kcal AMEn/kg (apparent metabolisable energy) was given. From day 10 until day13, starter diet with 22 % protein and 2794 kcal AMEn/kg, and from day 14 to day 32, grower diet with 20 % protein and 2899 kcal AMEn/kg, were provided.

A total of 60 birds, mixed sex, 32 days old were selected from local commercial farm (Provincial Center for Applied Poultry Research, Geel, Belgium) using the gait scoring method of Kestin et al., (1992). According to Kestin et al., (1992), lameness of the chickens were ranked in the increasing order from the gait score zero (GS0) to gait score five (GS5) where GS0 being the healtiest. The birds then were transported to the laboratory. The laboratory test installation had six stainless steel compartments (100 cm x 100 cm, width x length). In each compartment the same number of mixed sex birds having the same gait score level was housed with a stocking density of 5 birds /m^2. Birds were kept on floor pens on wood shavings. Feed and water were freely available to all birds. Birds were allowed a minimum of two days to recover from the stress of transport and acclimatize to their new environment. Lights were kept on during the video recordings as shown in Table 1.



(a)



(b)

Figure 1. Laboratory set up with a computer, camera, cages with five chickens in each compartment (a), and one example from recorded top view images (b).

A digital video camera, Guppy F036C equipped with a C30811KP 8,5mm lens (Pentax) was mounted 4.1 m above the floor with its lens pointing downwards and directly above the center of the six pens to get a top view of all pens in the camera image (see figure 1b). The camera was connected to a PC with a built-in frame grabber (E119932-U, AWM 20276, VW-1) using an IEEE 1394 fire wire cable. Images were captured with a resolution of 1024 x 768 pixels at a sample rate of 3.5 frames per second. Video recordings were made during 5 days.

Image calibration Prior to the experiments, the image was calibrated so that the areas of pixels in the image could be converted to units of cm^2 on the pen floor. With the known dimensions of the pen (1m x 1m) and by measuring these distances in the camera pixels in units of pixels, a linear factor relating image coordinates to positions within the broiler pen could be estimated as f = 0.33 cm per pixel. Therefore, the distance between two points, one pixel apart is 0.33 cm on the pen floor and the area of a region the size of one pixel is $f^2 = 0.11\ cm^2$ on the pen floor.

Activity measurements Activity of different gait score chickens was measured using the "Eyenamic software"(Leroy et al., 2006). The software automatically grabbed 3.5 frame per second monochrome images I(x, y, t) from the camera, with I being the intensity of the pixel at coordinates (x, y) in that image. The difference of the intensity values with the previous image I$(x, y, t-1)$, was calculated. From this difference image, the binary 'activity image' $I_a(x, y, t)$ was calculated, containing the pixels for which the intensity change exceeded a threshold:

$$\mathbf{I}_a(x,y,t) = \begin{cases} 1 & \text{if } \mathbf{I}(x,y,t) - \mathbf{I}(x,y,t-1) > \tau_1 \\ 0 & \text{otherwise} \end{cases} \quad \text{(a)}$$

From the activity image $\mathbf{I}_a(x, y, t)$ the activity index $a_i(t)$ for zone Z_i was calculated as the fraction of moving pixels with respect to the total number of chicken area pixels **(1).**

Activity image ($\mathbf{I}_a$) area was normalised by the total area of the chickens (1) in each compartment to compare the results independent of the size of the chickens.

$$a_i(t) = \frac{\sum_{(x,y)\in Z_i} \mathbf{I}_a(x,y,t)}{\sum_{(x,y)\in Z_i} 1} \qquad \text{(b)}$$

To eliminate the errors coming due to different size of birds, the total amount of movement observed was normalised for the average size of the birds in each box. The threshold τ_1 accounted for small intensity changes due to noise, e.g. electrical noise in the coax cabling and image acquisition circuits, small lighting variations, etc. The value of the threshold was set to 10% of the maximal intensity value, estimated by looking at the intensity variation of an 'empty' region, outside of the broiler pen in the first 210 images, equivalent to one minute of recording. The pixel area summed in the nominator and denominator of equation (b) has an accuracy of one pixel which, using the camera calibration factor was equivalent to an area of 0.11 cm^2.

Statistical analysis A Kruskal-Wallis Test was used to analyze the effects of gait score on birds' activity. Kruskal-Wallis Test was chosen due to the fact that recording times and numbers of frames were not equal among experiment days. Since the recording times were not equal between the different days of experiment, all records were divided into five minutes of intervals which provided enough sample size for the statistical analysis. The calculations were performed using the Statistics Toolbox of Matlab (The Math Works, Massachusetts, USA).

RESULTS AND DISCUSSION

Activity and gait score A fully-automatic image monitoring tool was applied to calculate the activity index of in total 30 chickens divided into six groups with a different gait score.

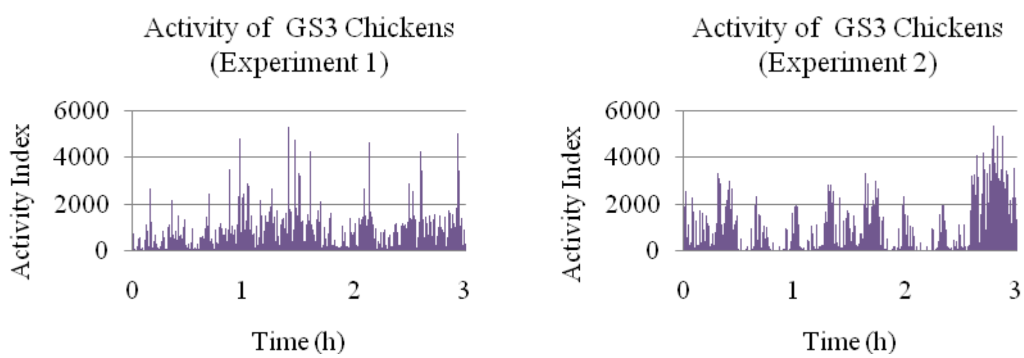
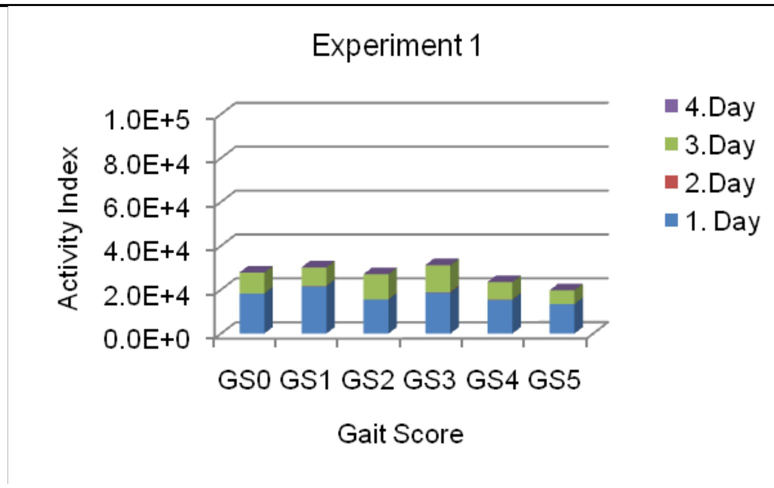


Figure 2. One example of continuous activity index measurement of GS3 group chickens during 3-h our experiment.

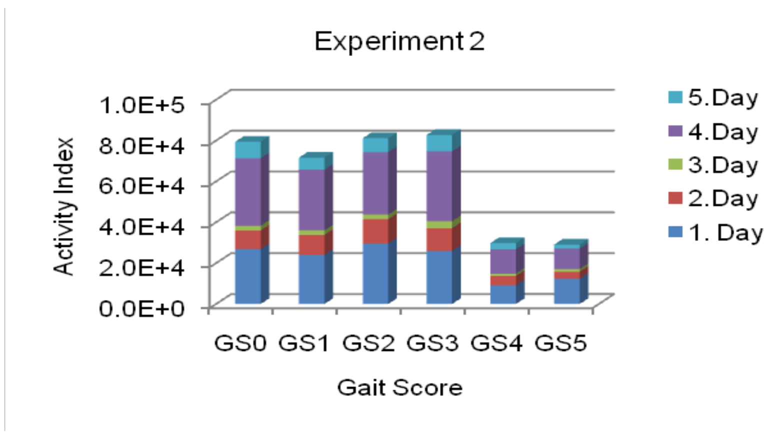
As can be seen in figure 2, there is a fast dynamic change in activity over time. No specific pattern has been observed. Therefore, cumulative activity values over time have been taken for further analysis.

Table 1. Daily numbers of frames and recording times of the experiments.

Year	Experimental	Recording	Number	Year	Experimental	Recording	Number
2008	1	00:35:01	113523	2009	1	21:33:10	289796
	2	00:02:57	961		2	04:45:08	62998
	3	02:19:09	83496		3	00:56:52	14400
	4	02:46:40	961		4	20:29:54	276298
	Total	05:43:47	198941		5	02:25:37	32400
					Total	50:10:41	675892



(a)



(b)

Figure 3. Activity index of the different gait score chickens during experiment 1 (a) and experiment 2 (b).

Figure 3 shows daily cumulative activity levels at the end of each experiment. Since the recording times were not equal between the days, cumulative activity of different gait score chickens reached to different values at the end of the experiments. By dividing the frames into five minutes intervals, it was possible to compare sub-cumulative activities in both experiments with different recording times (Table 1)

As can be seen in Table 2, the results of the Kruskal-Wallis Test revealed that there is a significant relation between the gait score and activity in both experiments ($P<0.05$). Besides, the day of experiment did have an influence on the activity at 5% significance level (see table 2, $P = 0$).

Table 2. Results of Analysis of Variance for the effects of gait score and experimental day on activity.

Experiment 1

Source	Sum of Squares	Degrees of freedom	Mean Squared	F value	P(>F)
Gait Score	2,59E+10	5	5,18E+09	7,18	0
E. Day	9,10E+10	3	3,03E+10	42,11	0
Error	4,06E+12	5628	7,21E+08		
Total	4,43E+12	5651			

(a)

Experiment 2

Source	Sum of Squares	Degrees of freedom	Mean Squared	F value	P(>F)
Gait Score	2,82E+13	5	5,63E+12	66,79	0
E. Day	2,63E+13	4	6,56E+12	77,82	0
Error	3,18E+14	3774	8,43E+10		
Total	4,05E+14	3803			

(b)

As shown in Table 3, activity of GS3 (mean ± standard deviation) was found significantly higher than the other gait scores in the first experiment (4.82 ± 3.40^b), as opposed to our expectations. One of the possible reasons would be that GS3 chickens are bigger and heavier than the other groups; they peck and fight for feed more than the other groups. There was no significant difference among the activities of other gait scores in the first experiment (Table 3).

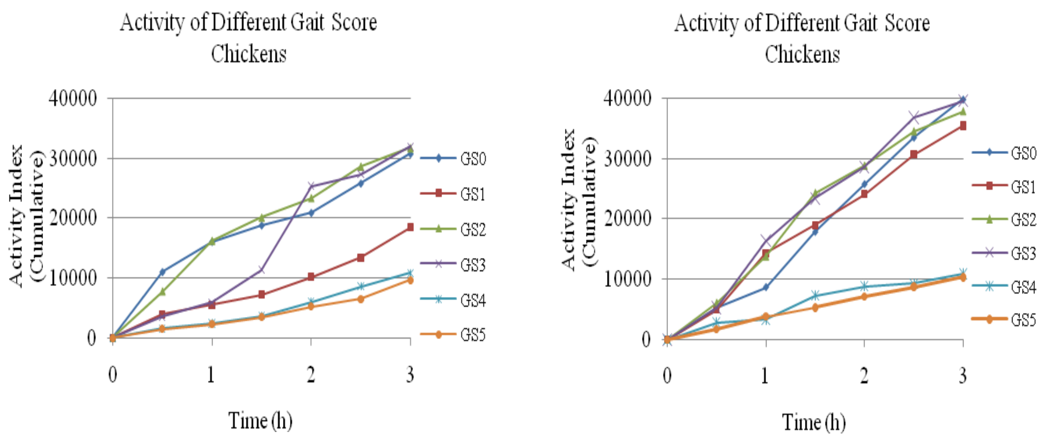
Table 3. The estimated mean activity index for broiler chickens at different gait scores with standard deviation, weight and body area of chickens.

	Activity Index		Weight (kg)		Body Area (cm2)	
	Exp. 1 ($x10^4$)	Exp. 2 ($x10^5$)	Exp. 1	Exp. 2	Exp. 1	Exp. 2
GS0	1.94 ± 1.45^{1a}	4.51 ± 3.83^{1a}	1.16 ± 0.28^{1ab}	1.32 ± 0.32^{a}	208.06 ± 42.29^{1ab}	235.66 ± 47.88^{1ac}
GS1	2.28 ± 2.39^{a}	4.27 ± 4.07^{a}	1.35 ± 0.15^{a}	1.49 ± 0.17^{ab}	231.79 ± 23.37^{ab}	209.81 ± 21.18^{ac}
GS2	2.62 ± 2.17^{a}	5.02 ± 4.57^{a}	1.31 ± 0.09^{a}	1.67 ± 0.12^{ab}	280.63 ± 16.24^{b}	220.43 ± 12.78^{ab}
GS3	4.82 ± 3.40^{b}	6.08 ± 4.66^{b}	1.45 ± 0.05^{a}	1.76 ± 0.13^{b}	307.42 ± 19.19^{b}	227.42 ± 6.81^{b}
GS4	2.19 ± 2.07^{a}	1.58 ± 1.37^{c}	1.28 ± 0.30^{a}	1.27 ± 0.30^{a}	185.24 ± 40.21^{ab}	187.16 ± 40.62^{c}
GS5	0.98 ± 0.90^{a}	1.89 ± 1.68^{c}	0.90 ± 0.10^{b}	1.37 ± 0.16^{ab}	245.38 ± 23.20^{a}	160.70 ± 15.20^{a}

[1] Mean ± Standard Deviation

[a - b - c] means, within a column , with no superscript in common differ significantly (P<0.05)

In the second experiment, the highest activity was again found in GS3 (6.08 ± 4.66^b) as in the first experiment ($P<0.05$). Similar to first experiment, GS3 chickens were again bigger and heavier. Therefore, it is assumed that they frequently visited the feeder. On the other hand, GS4 (1.58 ± 1.37^c) and GS5 (1.89 ± 1.68^c) were found to have the lowest activities in the second experiment different from the results of the first experiment. As can be seen in Table 3, there was no significant difference in the level of activity among GS0, GS1 and GS2 in both experiments.



(a) **(b)**

Figure 4. One example of the cumulative activity index of different gait score chickens during experiment 1 (a) and experiment 2 (b), over three hours.

Cumulative activity differences between the gait scores over three hour measurement can be seen in Figure 4. Especially, significant activity difference between the GS4-GS5 and other gait scores could be easily seen in the second experiment in Figure 4b.

DISCUSSION AND CONCLUSION Studies suggest that broilers are motivated to walk long distances for feed and that their motivation can be manipulated, also within body weight groups. Accelerated growth rates and heavier body weights were stated to have an influence on the locomotion (Kestin et al., 2001). A heavy body weight requires more from the yet not fully grown skeleton system and that leads to abnormal 'gait scores' (Corr et al., 2003). Lameness significantly changes the time budgets of many behaviours and dramatically alters feeding strategy (Weeks et al., 2000). The nature of the apparent relationship between lameness and reduced activity levels remains unclear in literature (Hester, 1994). In this study, the relation between the gait score and activity was investigated in 60 commercial broiler chickens reared in laboratory conditions for two experiments. It was found that a significant relation between the gait scores and activity exists ($p<0.05$). In contrast to our expectations, the relation between activity and gait score was not linear. The GS3 birds reached the highest activity level instead of GS0 (Figure 1). Bokkers et al. (2007) showed that the high body weight of broilers can be considered as a physical constraint to be active and probably to behave normally. However, as shown in Table 3, we found that the most active GS3 chickens had the highest body area (307.42 ± 19.19^{b} cm^2) during the experiments. This could be explained by the feeding strategy and weight of the birds. As can be seen in Table 3, the body weights of chickens are significantly different ($P<0.05$) and the GS3 chickens had the highest body weight (1.76 ± 0.13^{b} kg). They need more feeding than the other birds, and they could be more active than the others because they eat more although in this study, the feed intake of chickens has not been quantified.

In this research it's stated that there is a significant relation between the gait scores and activity ($p<0.05$), and more experiments are needed to see the repeatability of the results. This automatic monitoring of activity will allow researcher to study behaviour analysis of different gait score groups. Therefore, in future, implementation of suggested system in field conditions should be tested. These experiments should be repeated to observe whether the findings of experiment 2 is consistent, that is, there is a significant low activity of high gait score chickens (GS4&GS5). In that case, this automatic activity monitoring tool can be used on indicator of high gait scores (GS4&GS5) in the field conditions.

REFERENCES

Bizeray, D., Estevez, I., Leterrier, C., Faure, J.M., 2002. Effects of increasing environmental complexity on the physical activity of broiler chickens. Appl. Anim. Behav. Sci. 79, 27–41.

Blokhuis, H.J., Van Der Haar, J.W., 1990. The effect of the stocking density on the behaviour of broilers. ZADI (Germany, Federal Republic of) v. 54(2) p. 74-77.

Bokkers, E.A.M., Koene, P., 2003. Behaviour of fast- and slow-growing broilers to 12 weeks of age and the physical consequences. Appl. Anim. Behav. Sci. 81, 59–72.

Bokkers, E.A.M., Zimmerman, P.H., Bas Rodenburg, T., Koene, P. 2007. Walking behaviour of heavy and light broilers in an operant runway test with varying durations of feed deprivation and feed access. Ethology Group, Department of Animal Sciences, Wageningen University, P.O. Box 338, 6700 AH Wageningen, the Netherlands Applied Animal Behaviour Science 108, 129–142.

Cangar, O., Leroy, T., Guarino, M., Vranken, E., Fallon, R., Lenehan, J., Meed, J., Berckmans, D. 2008. Automatic real-time monitoring of locomotion and posture behaviour of pregnant cows prior to calving using online image analysis. Computers and Electronics in Agriculture 64, 53–60.

Corr, S. A., Gentle, M. J., Mccorquodale, C. C., Bennett, D. 2003. The Effect of Morphology on Walking Ability in the Modern Broiler: a Gait Analysis Study. Anim. Welfare. 12(2):159-171.

Hester, P.Y., 1994. The role of environment and management on leg abnormalities in meat-type fowl. Poult. Sci. 73, 904–915.

Hoy, J.B., Koehler, P.G., Patterson, R.S., 1996. A microcomputer-based system for real-time analysis of animal movement. J. Neurosci. Methods 64, 157–161.

Kestin, S.C., Knowles, T.G., Tinch, A.E., Gregory, N.G., 1992. Prevalence of leg weakness in broiler chickens and its relationship with genotype. Vet. Rec. 131, 190–194.

Kestin, S. C.; S. Gordon, G. Su and P. Sorensen. 2001. Relationships in Broiler Chickens between Lameness, Liveweight, Growth Rate and Age. Vet. Rec. 148(7):195-197.

Leroy, T., Vranken, E., Van Brecht, A., Struelens, E., Janssen, A., Tuyttens, F., De Baere, K., Zoons, J., Sonck, B., Berckmans, D., 2005. A quantitative computer vision method for on-line classification of poultry behavior in furnished cages. Trans. ASAE 49 (3), 795–802.

Leroy T., Vranken E., Van Brecht A., Struelens E., Sonck B., Berckmans D. 2006a. A computer vision method for on-line behavioral quantification of individually caged poultry. Transactions of the ASABE 49 (3): 795-802.

Prayitno, D.S., Phillips, C.J.C., Stokes, D.K., 1997b. The effects of color and intensity of light on behavior and leg disorders in broiler chickens. Poult. Sci. 76, 1674–1681.

Sergeant, D., Boyle, R., and Forbes, M., 1998. Computer visual tracking of poultry. Computers and Electronics in Agriculture 21, pp. 1–18.

Shao, J., Xin, H., Harmon, J.D., 1998. Comparison of image feature extraction for classification of swine thermal comfort behavior. Computers and Electronics in Agriculture. 19 (3), 223–232.

Song, X., Leroy, T., Vranken, E., Maertens, W., Sonck B., Berckmans, D., 2008. Automatic detection of lameness in dairy cattle—vision-based trackway analysis in cow's locomotion, Computers and Electronics in Agriculture 64 (1) (2008), pp. 39–44.

Tasch, U., and Rajkondawar, P.G., 2004. The development of a SoftSeparator (TM) for a lameness diagnostic system, Computers and Electronics in Agriculture 44 (3) (2004), pp. 239–245.

Tillett, R.D., Onyango, C.M., Marchant, J.A., 1997. Using model-based image processing to track animal movements: livestock monitoring. Computers and Electronics in Agriculture. 17 (2), 249–261.

Weeks, C.A., Danbury, T.D., Davies, H.C., Hunt, P., Kestin, S.C. 2000. The behaviour of broiler chickens and its modification by lameness. Department of Clinical Veterinary Science, University of Bristol, Langford, Bristol BS40 5DU, UK Applied Animal Behaviour Science 67, 111–125