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Is the mechanisation of catching broilers a welfare improvement?

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Abstract

In most European countries broilers are currently caught manually: broilers are caught by the leg, inverted and carried by a catcher with 3–4 birds in each hand. This method of catching broiler chickens is a welfare concern as it causes severe stress to the birds. A possible alternative to manual catching may be mechanical catching. The aim of this study was to compare the level of stress and injuries of broilers caught manually or with a harvesting machine (CIEMME Super Apollo L harvester) under commercial conditions. The results indicated that there was no significant difference in plasma corticosterone concentrations and duration of tonic immobility, which suggested that mechanically caught broilers were no more stressed than those caught manually. At the end of the catching process, mechanically caught broilers had even lower plasma corticosterone concentrations and shorter durations of tonic immobility, indicating that at this moment these broilers were less stressed than the manually caught birds. The incidence of wing haemorrhages was also reduced for broilers caught mechanically; however, there was no significant difference in the incidence of haemorrhages in the breast or legs between the two catching methods. As injuries are associated with pain and stress, this parameter is important not only for the welfare of the birds but also for product quality and the subsequent financial return. Therefore, it can be concluded that the use of the mechanical harvesting machine, CIEMME Super Apollo L, appears to be a good alternative to manual catching. Nevertheless, some aspects of mechanical catching require further improvement.

Keywords: *animal welfare, broilers, catching, injuries, machine, stress*

Introduction

Throughout the world there may be as many as 20 billion broiler chickens involved in commercial meat production at any one time, with the EU contributing 14% to this number (European Commission 2000). Commercial broiler chickens are exposed to a number of potential stressors prior to slaughter including feed deprivation, social disruption, handling, crating, transportation, shackling and stunning. The complete process is a major welfare concern; it causes severe stress to the birds, if not the most severe in their short life (Elrom 2001). Stressful situations are not only deleterious for welfare but also affect product quality and financial returns (Kettlewell & Mitchell 1994).

Possible strategies for the improvement of broiler welfare include alternatives to manual catching (Mitchell & Kettlewell 1993). Almost every aspect of broiler production has been automated or mechanised except the catching process (Lacy & Czarick 1998). In most European countries broilers are currently caught and loaded into transport modules entirely by hand. Broilers are caught by the leg, inverted and carried by a catcher, with 3–4 birds in each hand, at a rate of 1000–1300 birds per hour (Bayliss & Hinton 1990). Handling by humans may also affect bird welfare and carcass quality. Furthermore, manual bird catching is not pleasant for the catchers: it is a laborious and stressful job in an environment that becomes dusty and dirty by the process itself; therefore it is difficult to find experienced teams willing to perform this job (Kettlewell & Mitchell 1994; Metheringham & Hubrecht 1996).

For some years mechanical catching has gained importance. The evolution from manual to mechanical catching can be described as a gradual transition in which the development of transport modules was a big step forward. These transport modules were followed by fully mechanised systems using carefully designed mechanical harvesters to overcome some of the problems caused by manual catching (Kettlewell & Turner 1985; Scott 1993).

Mechanical catching has some major advantages over manual catching, in particularly the birds are no longer handled or carried inverted. Inverted handling increases the duration of tonic immobility (TI) in both layers and broilers (Duncan *et al* 1986; Jones 1992) and elevates plasma corticosterone (CORT) concentrations (Kannan & Mench 1996). Farsaie *et al* (1983), and Lacy and Czarick (1998) concluded that the mechanisation of broiler harvesting

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resulted in fewer injuries and improved welfare; however, Ekstrand (1998), and Knierim and Gocke (2003) undertook their investigations under commercial conditions and reached conflicting conclusions about the frequencies of injuries and birds that were dead on arrival (DOAs).

The aim of this study was to compare the level of stress in broilers caught manually or using the harvesting machine, the CIEMME Super Apollo L (CIEMME 2004) under commercial conditions. This machine is operational in several countries (Italy, France, Austria, Slovakia, Germany and the Netherlands) and approximately 200 machines are currently in use. Broiler-catching machines of this type are now being introduced in Belgium. However, additional information regarding this alternative to manual catching in terms of animal welfare was needed; therefore, this investigation was performed.

The rate of haemorrhages and DOAs, duration of TI, plasma glucose and plasma CORT concentrations were measured. A wide variety of parameters were used to make it possible to draw scientific conclusions regarding the validity of mechanical harvesting as an alternative to manual catching, from an animal welfare point of view.

Materials and methods

Data were obtained from flocks of six-week old broilers of three different breeds: Cobb, Hybro and Ross 308; the flocks were of mixed sexes. The two catching methods — manual and mechanical — were examined at commercial farms in Belgium and the Netherlands. Ten broiler houses were selected for this study and contained flocks of between 12 thousand and 21 thousand birds, ranging in weight from 2.2 kg to 2.5 kg. When possible, one specific catching method was examined once per week in facilities complying with our selection criteria: shed design, flock size, body weight, age and breed were comparable for all broilers houses used in this experiment. Although these criteria were taken into account, in practical studies the different groups cannot be expected to be completely identical with regard to all background data. Even if catching occurred repeatedly at only one farm, the treatment conditions may still not be totally equal. Therefore, 'farm' was included as a random effect in the statistical analysis to take into account dependency between birds in the same flock.

It can not be excluded that broilers of different lines may not have the same susceptibility to disease and stress; however, the lines used in this experiment were Cobb, Hybro and Ross 308, which are all fast-growing broilers. Therefore, it can be argued that using different lines had no influence or a negligible influence on the effect of the catching method.

An original aim of the study was to compare both harvesting methods in the same season (March–May); however, because of an outbreak of Avian Influenza the project was interrupted for several months. Consequently, the observations were spread over two seasons: during the spring and summer 2003. This research was approved by the Ethical Commission of the Katholieke Universiteit of Leuven.

The catching machine used in this study is made by CIEMME of Cazzago San Martino, Italy (CIEMME 2004); the model used was the Super Apollo L. It has a 6 m wide mechanical gathering platform, which catches the birds, and a conveyer belt covered with rubber fingers that take the birds to a loading unit at the rear of the machine. The 6 m conveyer belt is divided into 1.5 m sections so the machine is adapted to the irregular surface of broiler house floors. A counting system using the weight of the broilers is available on the machine: when a preset weight is reached the conveyer belt stops automatically. Two people operate the machine while a third person walks in front of the machine to herd the birds and pick up carcasses. The catching rate is 12–32 tons live-weight per hour depending on the speed of the conveyer belt, which is influenced by, for example, the condition of the ground.

Stress parameters

At each farm, blood samples were taken and the TI was investigated three times: 45 min before the start of catching, 15 min after catching started and when the chicken house was almost empty. On each occasion, blood was collected from 12 broilers taken out of containers immediately after catching, and 12 different broilers were tested for TI. In addition, blood was taken from another 12 broilers that were left in a container for 10 min in the chicken house before being removed. Blood was taken from 48 broilers and a further 36 broilers were tested for TI from each flock; therefore, a total of 240 blood samples were collected and 180 broilers were tested for TI per catching method.

Blood sampling

Blood samples were collected from the wing vein using a gauge needle and dispensed into heparinized tubes. The tubes were kept on ice until the plasma was separated by centrifugation for 10 min at 1500 rpm. Plasma samples were stored at –20°C until assayed. Plasma CORT concentration was measured by radio-immunoassay kit (IDS Inc: Boldon, UK) with a sensitivity of 0.39 ng ml^{-1}, cross-reacted with aldosterone (0.20%), cortisol (0.40%) and deoxyCORT (3.30%). Plasma samples were heated at 80°C for 10 min to inactivate corticosterone–binding proteins.

Plasma glucose concentrations were determined spectrophotometrically with the Monarch Chemistry System (Monarch Chemistry System: Instrumentation Laboratories, Zaventem, Belgium) using the IL Test™ Glucose.

Tonic immobility tests

Broilers were taken out of the containers, placed on a wooden board and restrained on their back for a period of 15 s by putting one hand on the sternum and the other hand on the neck of the bird (Jones 1986). The duration of latency was recorded until the bird righted itself. The number of inductions required to induce TI (for a minimum of 10 s) was also counted. A score of 0 s for the duration of TI was given if TI of the bird was not induced after five attempts. If TI lasted longer than 10 min, a maximum score of 600 s was given for TI duration.

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Table 1 Tonic immobility responses (mean ± SEM) of six-week old broilers during the catching process (n = number of birds; ns = not significant).

Duration of TI(s)	Manual catching n = 60	Mechanical catching n = 60	*P* value
Before catching	131.70[b] ± 15.74	168.70[b] ± 23.14	ns
At the beginning of the catching process	281.15[a] ± 26.29	254.18[a] ± 23.96	ns
At the end of the catching process	344.23[a] ± 25.29	279.72[a] ± 27.19	0.0342

Values with different superscripts are significantly different during the catching process (comparing before, at the beginning and at the end) within a column ($P < 0.05$).

The observers sat nearby and their presence, as shown in a previous study by Jones (1990), had no influence. Each observer tested two birds simultaneously; background noise in the farm was consistently high with either catching method.

Injuries and birds dead on arrival

Injuries caused by the catching and loading of the broilers were determined at the slaughterhouse, according to the legislative standards of The Dutch Product Board for Poultry and Eggs (Productschappen Vee, Vlees en Eieren 2001). For every 2000 broilers, 100 chickens were tested at random on each lorry. Haemorrhages in the wings, legs and breast were counted and percentages calculated for each broiler house. The number of DOAs was also calculated at the slaughterhouse. The results were analysed from the 10 studied farms; in addition, the catching and loading injuries (eg DOAs) from a further 130 farms, selected at random, were also analysed.

Statistical analysis

The assumption of normality of the outcomes was assessed by applying normal probability plots. The distribution of the plasma CORT concentrations was skewed; therefore, a logarithmic transformation was applied so that the data would be normally distributed.

The data of the plasma glucose and plasma CORT concentrations were analysed by two-way ANOVA using the mixed procedure of the SAS® system (version 8.1 1999; Statistical Analysis Systems Institute Inc, Cary, NC, USA) with flock, catching method and time of sampling as classification variables. 'Farm' was included as a random effect to take into account dependency between birds in the same flock. Differences among treatments were considered significant if $P < 0.05$.

Data on the induction and duration of TI, the frequency of injuries and number of DOAs were analysed using the Kruskal-Wallis one-way analysis of variance to compare the responses across treatment groups. The Mann-Whitney *U* test was used to make comparisons between treatment groups. Non-parametric tests were used because these data were not normally distributed.

Results

Background data

There was no effect of season for any of the investigated variables: TI, blood parameters, frequency of injuries and DOAs were not influenced by the different catching periods (ie spring versus summer).

There was no significant difference between the manually and mechanically caught flocks with regard to the age of the broilers (43.60 ± 1.03 days versus 43.20 ± 0.20 days), body weight (2373.80 ± 119.13 g versus 2394.00 ± 58.45 g) and average flock size (19 424.00 ± 2671.36 versus 17 796.10 ± 4782.42). The flocks used in this experiment were Cobb (two flocks), Hybro (one flock) and Ross 308 (two flocks) for both catching methods.

Tonic immobility tests

For both harvesting methods, the mean number of inductions required to induce TI in the broilers decreased during the catching process. During catching, manually caught broilers showed no significant differences in the number of inductions compared with mechanically caught broilers. However, there was a significant difference between manually and mechanically caught broilers before catching started (data not shown).

The results of the duration of TI are presented in Table 1. Mean durations of TI were only significantly different between both harvesting methods at the end of the catching process ($P = 0.0342$). Broilers that were caught manually showed longer durations of TI than the mechanically caught broilers at this time: 344.23 s and 279.72 s, respectively. Although the mean duration of TI significantly increased during both catching methods, manually caught broilers had durations of TI that were 2.6 times longer at the end of the catching process compared with the duration before catching had started (from 131.70 s to 344.23 s); the duration of TI of mechanically caught broilers only increased by 1.6 times during catching (from 168.70 s to 279.72 s). The results of the duration of TI indicated that birds which needed fewer inductions to induce TI also tended to have longer durations of TI. Broilers that required only one induction to induce TI had a TI duration of 281.72 ± 15.56 s, whereas after five inductions the TI duration was only 58.04 ± 27.50 s. Both measures (ie susceptibility to TI and duration of TI) were well correlated ($P < 0.0001$), with the exception of four inductions.

Blood analysis

The effect of the catching method and time of measurement on plasma glucose concentrations are presented in Figure 1. Only a time effect was present: once the catching process started the values of glucose increased significantly ($P = 0.0023$). The

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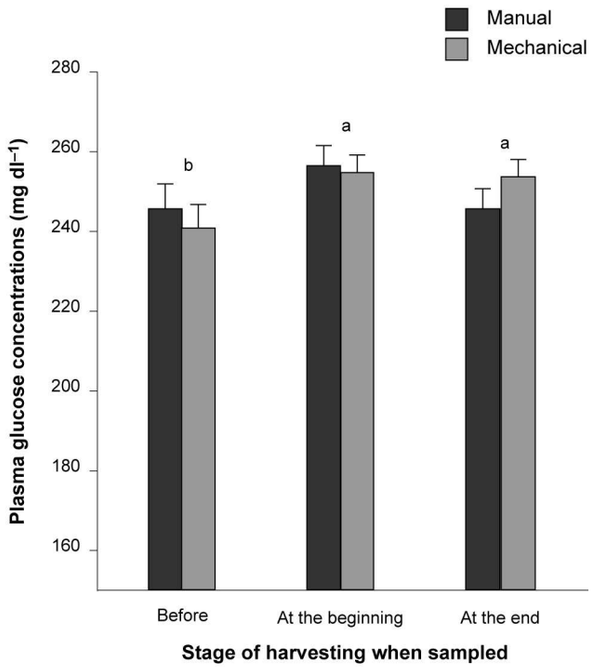
Figure 1



Plasma glucose concentrations (mean ± SEM) of both catching methods, manual (n = 60) and mechanical (n = 60), for different stages of the catching process (values with different superscripts are significantly different during the catching process at $P < 0.005$).

mean values of the plasma glucose concentrations were 243.49 ± 2.51 mg dl^{-1} before catching started and increased to 256.61 ± 2.75 mg dl^{-1} at the beginning of the catching process. During catching no further significant increase in the glucose concentration was observed for either method.

The mean values of plasma CORT concentrations at the different times of measurement are presented in Figure 2. The statistical analysis revealed that there was only a significant effect for time of measurement ($P < 0.0001$). Plasma CORT concentrations (mean values of both harvesting methods together) increased during the catching process except at the end of catching. Before catching started, mean CORT concentration was 10.64 ± 0.72 ng ml^{-1}. This increased significantly to 17.82 ± 0.88 ng ml^{-1} after 15 min of catching, but at the end of the catching process there was a significant decline to 15.41 ± 1.05 ng ml^{-1}. Blood taken from birds after 10 min in the containers showed plasma CORT concentrations were significantly raised above the values obtained before or during catching to 26.09 ± 1.13 ng ml^{-1}.

The effect of catching method on the plasma CORT concentrations was not significant at any measuring occasion in this experiment. However, some differences between manual and mechanical catching method existed at the end of the catching process. Plasma CORT concentrations of manually caught broilers increased during the experimental period, from 9.52 ± 0.91 ng ml^{-1} before catching to 15.91 ± 1.15 ng ml^{-1} at the beginning of the catching process and reached 16.07 ± 1.51 ng ml^{-1} at the end of the catching process. However, chickens caught mechanically showed a significant decrease of plasma CORT concentrations at the end of the catching process compared with the beginning of the catching process (14.72 ± 1.47 ng ml^{-1} versus 19.72 ± 1.31 ng ml^{-1}).

Injuries and birds dead on arrival

Percentages of DOAs (Table 2) differed significantly between the two catching methods ($P < 0.0001$): 0.20 ± 0.03% after manual catching compared with 0.31 ± 0.04% after mechanical catching.

The percentage of haemorrhages in the wings was significantly lower ($P < 0.0001$) when birds were caught mechanically (4.24 ± 0.30%) compared with manually caught birds (7.71 ± 0.30%). Haemorrhages in the legs were also lower after mechanical catching, but were not significant. There was no difference in the percentages of haemorrhages in the breast between the two catching methods (Table 2).

Discussion

Measuring the stress level of animals is difficult and therefore a combination of physiological, physical and behavioural parameters was chosen in this study. Because injuries are associated with pain and stress, this parameter is important not only for the welfare of the birds but also for product quality and the subsequent financial return. Plasma CORT concentrations and the duration of TI are two parameters that are often used to evaluate differences in the stress of broilers harvested mechanically or manually. TI duration is a very sensitive measure of the fear and stress level of broilers (Campo & Carnicer 1994) and plasma CORT concentration is a direct measure of the secretion of the stress hormone. Elevation indicates an increase in the activity of hypothalamus-pituitary-adrenal-axis and indicates that the animal is experiencing stress (Zulkifli & Siegel 1995). Plasma glucose concentrations are also elevated by experiencing stress as a consequence of glycogenolysis and gluconeogenesis (Elrom 2000a).

In the present study both measures of short-term stress suggested that either catching process caused severe stress to the broilers; however, the mechanically caught broilers were no more fearful or stressed than the manually caught broilers.

In this study, there was a significant increase in plasma CORT concentrations after harvesting of the broilers started; this agreed with previous research which showed that manual and machine catching is very stressful for broilers (Scott 1993). In agreement with the plasma CORT concentrations, the number of inductions required to induce TI declined and the duration of TI increased during the catching process confirming that the broilers became more stressed. However, because the numbers of inductions were significantly different between the two groups before the catching process started, no firm conclusions could be drawn on the basis of this parameter. This significant difference between the two groups might relate to a sampling effect (Jones 1986) or differences between the sexes (Jones & Faure 1982). If the two groups were actually different, before either catching method was initiated, this would be

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Table 2 Percentages of birds (mean ± SEM) with different types of haemorrhages and percentage of birds dead on arrival for both catching methods (n = number of flocks; ns = not significant).

	Manual catching n = 65	Mechanical catching n = 65	*P* value
Haemorrhages			
Breast	0.26 ± 0.05%	0.26 ± 0.04%	ns
Legs	0.20 ± 0.04%	0.18 ± 0.02%	ns
Wings	7.71 ± 0.45%	4.24 ± 0.30%	< 0.0001
Dead on arrival	0.20 ± 0.03%	0.31 ± 0.04%	< 0.0001

reflected in other behavioural and physiological parameters, which was not the case. In addition, analysis of the background data of broiler age, flock size, body weight and breed revealed no significant differences between the two groups.

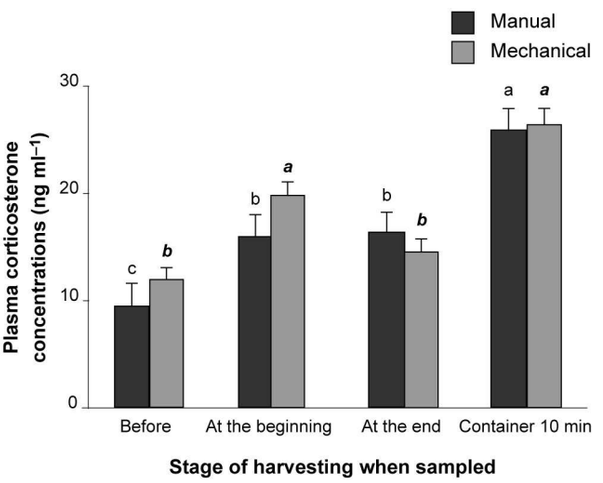
Therefore, the results of the duration of TI were used to draw the main conclusions about the fearfulness of broilers during either catching method. Furthermore, the duration of TI appeared to be a more sensitive measure of stress than the susceptibility to TI (Jones 1986; Cashman *et al* 1989); both measures (susceptibility to TI and duration of TI) were negatively correlated ($P < 0.0001$).

The results indicated that there were no significant differences in TI duration or plasma CORT concentrations between the two harvesting methods except at the end of the catching process, which suggested that mechanically caught birds were no more fearful or stressed than broilers that were caught manually. Previous studies have indicated that mechanical catching should be preferred over manual catching (Duncan *et al* 1986; Knierim & Gocke 2003). Kannan and Mench (1996) suggest that holding the broilers upright could reduce handling stress. These findings correspond with the conclusions of Jones (1992) who noticed that rough handling prolonged the duration of TI. Furthermore, Duncan *et al* (1986) suggested that catching broilers by a carefully designed machine rather than by hand could reduce stress. This was supported by lower heart rates and shorter durations of TI in birds that were caught mechanically compared with birds that were caught manually. In particular, Duncan *et al* (1986) stated that the differences in duration of TI suggested that the birds caught by the machine were no more fearful than those birds handled as gently as possible.

Different reasons could explain some differences between the studies. Almost all of the previous studies were performed on a small scale and were therefore less realistic of the conditions that chickens experience on a commercial scale. Furthermore, blood samples were taken at different time intervals — in some studies blood was collected up to two hours after broilers were caught — whereas, in this study, blood sampling occurred immediately after catching.

Mechanically caught broilers appeared to be less stressed at the end of the catching process; they had significantly lower durations of TI compared with the manually caught broilers ($P < 0.05$), as well as lower plasma CORT concentrations. It is possible that broilers were initially stressed by the noise

Figure 2



Plasma corticosterone concentrations (mean ± SEM) of both catching methods, manual (n = 60) and mechanical (n = 60), for different stages of the catching process (values with different superscripts are significantly different during the catching process at $P < 0.005$: a, b, c for manual catching and ***a, b*** for mechanical catching).

rather than by the catching process itself and that by the end of the catching process they were more accustomed to the presence and noise of the catching machine. Broilers kept in the containers for 10 min after catching had high plasma CORT concentrations: a mean value of 26.09 ± 1.13 ng ml^{-1} (for both catching methods combined) was reached, indicating that the broilers experienced additional stress during confinement in the containers.

The plasma glucose concentrations increased when harvesting started. Elrom (2000a) showed that the concentration of plasma glucose increases because of the release of catecholamines and glucocorticosteroids as a consequence of stress. There was no further significant increase in plasma glucose concentrations during the catching process, which corresponds with the plasma CORT concentrations.

Several studies state that injuries appear less frequently after mechanical catching compared with manual catching (Farsaie *et al* 1983; Lacy & Czarick 1994; Elrom 2000b). The results of this study corroborate the concern over

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haemorrhages in the wings and legs. The proportion of haemorrhages in the wings decreased the most, with smaller reductions in haemorrhages in the legs; the catching method had no influence on the percentage of haemorrhages in the breast. These findings support those of Knierim and Gocke (2003) who found fewer injuries after mechanical catching. Comparing the results of this study and those of Knierim and Gocke (2003) reveals that the percentages of breast bruises were similar but wing bruises were a lot higher in this study (4.24 ± 0.30%) compared with that of Knierim and Gocke (2003) (0.93 ± 0.27%). Conversely leg bruises were lower in this study (0.18 ± 0.02%) compared with that of Knierim and Gocke (2003) (0.62 ± 0.15%). Ekstrand (1998), however, found more bruises in mechanically caught broilers. A possible reason for this is the different method of manual catching used in Sweden: birds are held upright and carried by a catcher with fewer birds in each hand. Furthermore, Gregory and Wilkins (1990) stated that a lot of damage, which resulted in broken bones, occurred during processing rather than during handling and transport. Broken bones were not quantified in this study; this parameter was omitted because broilers were examined when hanging on the shackles directly after evisceration.

The proportion of DOAs at the slaughterhouse was greater for mechanically caught broilers than for those caught manually. The results of the DOAs are similar to previous studies indicating a mortality of 0.1–0.6% (Ekstrand 1998). This large variation can be attributed to a number of reasons; not only environmental factors, such as the transport, slaughtering process, and climate, but also age and health status of the broilers. In addition, methods of catching and loading can be involved. In this experiment there was no significant effect of season on the percentage of DOAs. Furthermore, there were no significant differences between the manually and mechanically caught flocks with regard to the age of the broilers, body weight and average flock size. The transport, stunning and slaughtering conditions were similar for birds caught mechanically and manually; therefore, deaths resulting from these factors should be similar for both catching methods. During the experiment there were no problems regarding the use of the machine. There were no difficulties in achieving an appropriate speed of the conveyor belt or constant occupation rates in the transport modules. Furthermore, broilers remained calm during catching and gathering occurred very normally.

The health status of the flock was not examined in this study and could be a possible reason for the higher percentage of DOAs after mechanical catching. However, a more acceptable argument could be that the machine picked up sick, injured or dead animals, as suggested by Ekstrand (1998), and Knierim and Gocke (2003). The machine is not able to distinguish between these birds and healthy birds, whereas during manual catching these birds are not picked up. This hypothesis was supported by the discovery of dead birds in the transport modules when collecting broilers from these modules for blood sampling after catching. The 'shape' of these birds and their body temperature indicated that they had been dead for at least two hours and had not died during mechanical catching. Furthermore, the small number of dead birds that were left in the poultry house after mechanical harvesting (approximately one third of that number after manual catching) suggested that many of these birds had been picked up. Therefore, the higher mortality rate after mechanical catching is probably not caused by the machine *per se*.

Animal welfare implications

This study indicates that mechanically caught broilers are no more stressed than manually caught broilers. At the end of the harvesting process, mechanically caught broilers had lower plasma CORT concentrations and a shorter duration of TI, indicating that at this time these broilers were less stressed than those that had been caught manually. The use of the catching machine also significantly reduced haemorrhaging in the wings; however, haemorrhages in the breast and legs were not significantly different between catching methods. As injuries are associated with pain, and therefore stress, these factors indicate improved welfare for the mechanically caught birds and a subsequent improved financial return resulting from fewer downgraded birds.

It is concluded that the use of this mechanical harvester, the CIEMME Super Apollo L, appears to be a good alternative to the manual catching of birds. From a human point of view, the conditions for the catchers are also improved, with bending and lifting greatly reduced.

Nevertheless there are two important shortcomings of the machine: the rather high percentage of wing haemorrhages (even though far fewer than with manual catching), and the possibility of picking up of dead birds. To overcome these problems, further technical developments are required. First, the amount of wing flapping could be reduced by decreasing the height the birds fall from the conveyer belt into the transport modules; more wing-flapping during falling makes the birds more susceptible to wing damage (Scott 1993). Second, the height of the mechanical gathering platform could be adjusted so that birds can still easily get on but dead birds are not picked up. Furthermore, the person walking in front of the machine must take greater responsibility for picking up carcasses; therefore, it is essential to emphasise the importance of training the personnel. The welfare of birds may be improved by the use of a good mechanical catching method but this needs well-trained staff to be applied effectively.

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References

Bayliss PA and Hinton MH 1990 Transportation of broilers with special reference to mortality rates. *Applied Animal Behaviour Science 28*: 93-118

Campo JL and Carnicer C 1994 Effects of several 'stressors' on tonic immobility reaction of chickens. *Archiv für Geflugelkunde 58*: 75-78

Cashman PJ, Nicol CJ and Jones RB 1989 Effects of transportation on the tonic immobility fear reactions of broilers. *British Poultry Science 30*: 211-221

CIEMME 2004 http://www.ciemmecalabria.com/english/super-apollo.htm (accessed 9 February 2006)

Duncan IJH, Slee GS, Kettlewell P, Berry P and Carlisle AJ 1986 Comparison of the stressfulness of harvesting broiler chickens by machine and by hand. *British Poultry Science 27*: 109-114

Ekstrand C 1998 An observational cohort study of the effects of catching method on carcase rejection rates in broilers. *Animal Welfare 7*: 87-96

Elrom K 2000a Handling and transportation of broilers: welfare, stress, fear and meat quality. Part II: stress. *Israel Journal of Veterinary Medicine 55(2)*

Elrom K 2000b Handling and transportation of broilers: welfare, stress, fear and meat quality. Part IV: handling of broilers. *Israel Journal of Veterinary Medicine 55(4)*

Elrom K 2001 Handling and transportation of broilers: welfare, stress, fear and meat quality. Part VI: the consequences of handling and transportation of chickens. *Israel Journal of Veterinary Medicine 56(2)*

European Commission 2000 *The Welfare of Chickens Kept for Meat Production (Broilers)*. Europese Commissie: Brussels, Belgium. http://europa.eu.int/comm/food/fs/sc/scah/out39_en.pdf (accessed 9 February 2006)

Farsaie A, Carr LE and Wabeck CJ 1983 Mechanical harvest of broilers. *Transactions of the ASAE 26*: 1650-1653

Gregory N and Wilkins L 1990 Broken bones in chickens: effect of stunning and processing in broilers. *British Poultry Science 31*: 53-58

Jones RB 1986 The tonic immobility reaction of the domestic fowl: a review. *World's Poultry Science Journal 42*: 82-96

Jones RB 1990 Is the experimenter an influential variable in studies of tonic immobility in the domestic fowl? *Biology of Behaviour 15:* 93-103

Jones RB 1992 The nature of handling immediately prior to test affects tonic immobility fear reactions in laying hens and broilers. *Applied Animal Behaviour Science 34*: 247-254

Jones RB and Faure JM 1982 Tonic immobility in the domestic fowl as a function of social rank. *Biology of Behaviour 7*: 27-32

Kannan G and Mench JA 1996 Influence of different handling methods and crating periods on plasma CORT concentrations in broilers. *British Poultry Science 37*: 21-31

Kettlewell PJ and Mitchell MA 1994 Catching, handling and loading of poultry for road transportation. *World's Poultry Science Journal 50*: 54-56

Kettlewell PJ and Turner MJB 1985 A review of broiler chicken catching and transport systems. *Journal of Agricultural Engineering Research 31*: 93-114

Knierim U and Gocke A 2003 Effect of catching broilers by hand or machine on rates of injuries and dead-on arrivals. *Animal Welfare 12*: 63-73

Lacy MP and Czarick M 1994 Field testing of a mechanized broiler harvesting system. *Poultry Science 73, Suppl 1*: 41 (abstract)

Lacy MP and Czarick M 1998 Mechanical harvesting of broilers. *Poultry Science 77*: 1794-1797

Metheringham J and Hubrecht R 1996 Poultry in transit — a cause for concern. *British Veterinary Journal 152*: 247-249

Mitchell MA and Kettlewell PJ 1993 Catching and transport of broiler chickens. In: Savory CJ and Hughes BO (eds) *Fourth European Symposium on Poultry Welfare* pp 219-229. Universities Federation for Animal Welfare: Wheathampstead, UK

Productschappen Vee, Vlees en Eieren 2001 Brochure. Beoordelingssysteem kwaliteit vleeskuikens, Rijswijk, The Netherlands [Title translation: Product qualities animals, meat and eggs 2001 Pamphlet. Evaluation system quality broilers]

Scott GB 1993 Poultry handling: a review of mechanical devices and their effect on bird welfare. *World's Poultry Science Journal 49*: 44-57

Zulkifli I and Siegel PB 1995 Is there a positive side to stress? *World's Poultry Science Journal 51*: 63-76

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