Improvement of the Welfare of Broilers by Changes to a Mechanical Unloading System

D. Tinker,*[,1] P. Berry,* R. White,* N. Prescott,* S. Welch,* and J. Lankhaar†

**Silsoe Research Institute, Wrest Park, Silsoe, Bedfordshire, MK45 4HS, United Kingdom; and †Stork PMT B.V., PO Box 118, 5830 AC Boxmeer, The Netherlands*

Primary Audience: Broiler Processors, Equipment Manufacturers, Policy Makers, Researchers, Retailers, Animal Welfare Organizations, Veterinarians

SUMMARY

Assessing the impact on broiler welfare of mechanized poultry-handling equipment in commercial plants is not readily amenable to normal research techniques. This study, comparing 2 versions of a tipping-type unloader for broiler transport containers, has successfully compared qualitative and quantitative techniques. Closed circuit television was used to record images of broilers during the unloading process. For the quantitative analysis, objective data included the proportion of birds flapping their wings, climbing onto other birds during the initial unloading phase, and losing their balance during the transition between conveyor belts. A preference panel viewed the same images and provided a qualitative assessment. Both of the assessments, quantitative and qualitative, compared the welfare of the birds during unloading in the 2 versions of unloaders. The revised version (Mk II) included design changes to improve the flow of birds through the system and to reduce agitation of the birds. Both sets of assessment showed that the design changes had significantly improved the selected indicators for bird welfare.

Key words: welfare, mechanical unloading, transport system, poultry behavior, broiler

2005 J. Appl. Poult. Res. 14:330–337

DESCRIPTION OF PROBLEM

The broiler industry might consider investing in mechanical systems for live bird handling for a variety of interrelated reasons. Handling of live birds occurs at 2 stages: at the farm during harvesting when birds are caught, inverted, and loaded into transport modules; and at the processing plant when the birds are unloaded from the transport module, inverted, and placed into shackles.

Factors that might promote mechanical handling are operator welfare legislation requiring the amount of repetitive lifting and the time spent working in dusty and noisy environments to be reduced, increasing throughput of processing plants, the need to reduce downgrades and costs, and a general desire to improve bird welfare and ameliorate the concerns of the consumer.

Well-designed and developed mechanical handling systems should satisfy these factors. Mechanical handling systems enable operatives to be removed from the more strenuous and monotonous tasks; birds can be handled consistently and with increased welfare while enabling

[1]To whom correspondence should be addressed: d.tinker@ntlworld.com.

FIGURE 1. Live bird transport container; Stork GP container.

improved quality product and fewer downgrades.

Broilers express high levels of fear when in contact with humans or inverted [1, 2, 3]. A well-designed system that replaces manual handling, especially if the birds are not inverted, could remove these stressors. Mechanical harvesting systems have been assessed for bird welfare and found to be advantageous [4, 5, 6].

Whether caught manually or by machine, broilers are put into modular containers for transport to the processing plant. One of the most common transport modules in Europe consists of a frame with movable floors to ease the loading (Figure 1). The unloading of this type of transport module is by tilting the container mechanically, causing the birds to slide onto a conveyor. The unloading equipment, when combined with mechanized poultry harvesting and controlled atmosphere stunning, avoids the need to manually handle live birds.

The first objective of this study was to investigate methods of measuring bird welfare in a noninvasive but practical and repeatable manner during mechanized bird handling at a commercial plant.

In particular, one of the major mechanical unloading systems is that developed specifically for the Stork GP [7] live bird transport system. This unloading system was developed over the previous year. Therefore, the second objective of this investigation was to determine the impact on bird welfare that the revised unloader (Mk II) had compared with the earlier unloader (Mk I).

An evaluation of existing methods for assessing bird welfare was undertaken, but none was felt to be relevant or practical for this application, so new techniques were developed. The techniques would be of value in other practical applications, so additional information was recorded, and this project could be treated as an exemplar for similar investigations comparing poultry handling equipment.

MATERIALS AND METHODS

The Stork GP [7] live bird supply system is based around a container (Figure 1) used to transport the birds to the processing plant where, after a period of holding, the containers are loaded into the fully automatic container handling system, which transfers and unloads the container. The containers are then washed before

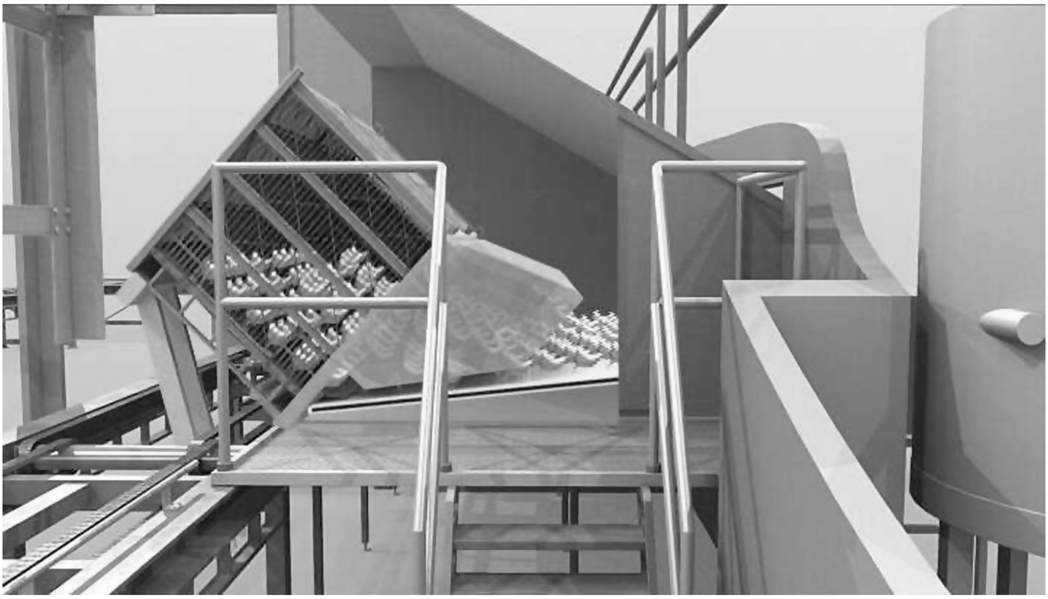

FIGURE 2. Cutaway view of automatic container handling system with container emptying.

being returned to a farm for refilling. Broiler containers were used for this investigation. These had 4 tiers, holding birds at a rate of 170 cm^2/kg liveweight. These containers have a total area of 108,800 cm^2, corresponding to 640 kg liveweight for the complete container.

The operating principle of the unloader (Figure 2) is that full containers are transferred to the unloading station by a conveyor. The container's 4 flap doors automatically drop down, and chutes are located against the openings as the container is tilted. The birds slide down the chutes to an inclined resilient conveyor belt (belt 1), which is wider than the container. The birds are carried along on belt 1 to a cross-conveyor (belt 2) that carries the birds to a stunning system and shackle hang-on station. The container is automatically checked to see that it is empty. If it is not empty, then the operation is repeated, and an attendant is signaled.

The design is commercial, and full details of the changes from Mk I to Mk II are not available. General changes from the Mk I to the Mk II were that the area of belt 1 was increased; the chutes were lengthened to reduce the angle and widened to increase the area per bird available as they slid from the container; the downstream, vertical corner by the junction of belts 1 and 2 was rounded, rather than a sharp transition, to give a smoother exit for the birds; the surface texture of belt 2 was changed to give the birds more grip when standing; and both of the belts on the Mk II ran slightly faster than those of the Mk I, again effectively increasing the area for each bird transported.

To install and operate such large and expensive machines either simultaneously or sequentially at the same plant was not possible, so 2 broiler processing plants, one with an Mk I and one with an Mk II unloader system were used. To avoid too many differences between the incoming flocks, the trials at the 2 plants were timed to be close to one another to avoid great differences in weather conditions (there was a delay of 5 wk); used birds of the same strain and of similar age (Ross at age 44 or 40 d); used manual catching; used Stork GP containers and had a similar transport route (mix of country roads and rural main roads taking 40 min); and had a similar throughput (8,400 and 8,100 birds/h).

The main data recording fell into 3 categories: carcass damage, quantitative behavioral and logistical data of the birds, and qualitative behavioral data as assessed by a human preference panel.

The birds were monitored by video within the unloading systems. The quantitative infor-

FIGURE 3. View through open hatch of pipe camera and vacuum clamp.

mation was obtained by counting behavioral responses, such as wing flaps, and noting logistical information, such as numbers of birds climbing on others as an indication of overcrowding.

Concern has been expressed over the welfare of live birds in mechanical handling systems. It was believed that the improvements to bird handling facilitated by the design changes could be demonstrated and that a preference panel could notice the difference in the handling of the birds in the 2 versions. The panel was expected to be a quicker method of comparing the 2 systems than the rigorous quantitative assessment and could prove advantageous for further equipment development assessments. A statistician advised on the operation of the panel, including the number of panelists needed to ensure that the qualitative assessments would be statistically valid.

The quantitative and qualitative data were captured, using the same video equipment, but subsequent analyses were separate.

Carcass Damage

Inspection of the carcasses during bleed-out and after chilling was for broken wings, scratches, and bruises. However, to determine whether scratches and other injuries occurred before or during unloading was not possible. The birds came from different farms and were caught by different crews, so the data could not be satisfactorily statistically analyzed and are not included here.

Quantitative Data Capture

The data capture used sealed nightview black and white closed circuit television pipe cameras [8] with built-in infrared light emitting diodes to illuminate the scene in the enclosed unloader. These cameras were connected to a multiplexer [9] that allowed up to 4 views to be recorded simultaneously by a standard VHS video recorder. The multiplexer allowed full-screen monitoring of individual cameras on playback to a suitable monitor.

The cameras were fitted with vacuum clamps to hold them onto flat surfaces inside the unloader (Figure 3). After some positioning trials, satisfactory views of the following target areas were obtained: (unloading) belt 1 from the end of the unloading chutes to near the end of belt 1, (transition) belt 2 at the start of the junction between belts 1 and 2, and (corner) belt 2 at the end of the junction between belts 1 and 2. Figure 4 gives a schematic plan of the camera positions and fields of view.

Data recording of the belt 1 video started 25 s after the beginning of the tip. Individual birds could not be seen clearly prior to this point because of wing flapping. Data were then recorded over 4 consecutive 20-s periods for each of 5 containers and for a given window, marked on the monitor, and representing a constant area of belt 1, which was occupied by 20 birds at the start of data recording. This area represented about 60% of the belt width and included 1 edge.

The frequency data for each 20-s period were recorded for the numbers of birds' wing flapping (as an indicator of agitation or loss of balance or both) and climbing on top of other birds (as an indicator of overcrowding).

Prior to the next container being tipped, the number of birds remaining on the window area of belt 1 was recorded. The number of these birds covered by newly arrived birds from the next container load was recorded.

At the transition between belt 1 and the start of belt 2, the behaviors of 20 birds (chosen at random) were analyzed. Data recording commenced 25 s following the container tip and included the following: posture on belt 1: standing, crouching, sitting; direction on belt 1: forwards (facing direction of travel), backwards, left, or right; behavior on transition from belt 1 to belt 2: wing flaps, single-leg paddling (described below), loss of balance, or running in opposite direction to belt 2; posture on belt 2: standing, crouching, or sitting; and direction on belt 2: forwards, backwards, left, or right.

Single-leg paddling occurs when the bird is sideways on belt 1, and as the leading leg goes onto belt 2, the bird paddles that leading leg to avoid losing balance, while the trailing leg is still on belt 1.

Some of these data do not directly imply any welfare consequence, but it was recorded to see if it could be used to improve future designs. Single-leg paddling and running in the opposite direction on belt 2 were not significantly different for the 2 systems and are not included in the analysis.

The frequency data was the total number of times that the behavior was observed for each of 20 birds from 5 containers.

TABLE 1. Numbers of birds, from maximum of 20, still in the observation window and landed upon, at the next tipping[1]

	Still in window	Landed upon
Mk I	18.9 (1.42)[2]	15.4 (1.36)
Mk II	9.2 (0.99)	8.1 (0.99)

[1]Mk I = earlier version of tipping-type unloader; Mk II = revised version of tipping-type unloader.
[2]Standard errors are given in parentheses. The data shown are significantly different at $P < 0.05$. The data shown were summarized and analyzed for interactions and are not derived from multiple range tests. Data that did not show significant differences are not presented.

Qualitative Data Capture and Analysis

To obtain the qualitative behavioral data the sections of video recording used for the quantitative data were used. The videos were transferred to digital format MPEG files by using Observer software [10] and a Broadway video-to-audio video interleaved (AVI)-to-moving picture experts group (MPEG) hardware card [11] with a personal computer. The MPEG clips corresponded directly to those used for the quantitative data, but the views at the corner (at the end of the junction between belts 1 and 2) were also included.

Twelve staff technicians from Silsoe Research Institute, equally divided between male

TABLE 2. Mean incidence (%) of orientation for the 2 systems—belt 1[1]

	Forward[2]	Backward	Right	Left
Mk I	25.4 (3.6)[3]	15.3 (2.7)	33.6 (4.0)	25.7 (3.6)
Mk II	15.0 (2.6)	30.3 (3.6)	29.7 (3.6)	25.0 (3.3)

[1]Mk I = earlier version of tipping-type unloader; Mk II = revised version of tipping-type unloader.
[2]Orientation follows the direction of travel of belt 1.
[3]Standard errors are given in parentheses. The data shown are significantly different at $P < 0.01$. The data shown were summarized and analyzed for interactions and are not derived from multiple range tests. Data that did not show significant differences are not presented.

TABLE 3. Mean incidence (%) of posture for the 2 systems—belt 2[1]

	Stand	Crouch	Sit
Mk I	15.4 (1.6)[2]	67.4 (2.5)	17.2 (1.6)
Mk II	40.3 (2.5)	45.0 (2.7)	14.6 (1.6)

[1]Mk I = earlier version of tipping-type unloader; Mk II = revised version of tipping-type unloader.
[2]Standard errors are given in parentheses. The data show a significant interaction between system and posture at $P <$ 0.01. The data shown were summarized and analyzed for interactions and is not derived from multiple range tests. Data that did not show significant differences are not presented.

TABLE 4. Preference panel results: proportion of birds considered to have been handled better in each system[1]

Item	Mk I	Mk II	SED[2]
Tip (camera 1)	0.02	0.98	
Transition (camera 2)	0.06	0.94	0.057
Corner (camera 3)	0.21	0.79	

[1]Mk I = earlier version of tipping-type unloader; Mk II = revised version of tipping-type unloader.
[2]Standard error of the difference. The data shown are significantly different at $P < 0.001$. The data shown were summarized and analyzed for interactions and are not derived from multiple range tests. Data that did not show significant differences are not presented.

and female and without experience of poultry handling systems, were chosen for the assessment panel. The panelists were divided into 6 pairs, not allowed to confer, and presented with corresponding pairs of MPEG clips from the 3 camera positions in the 2 systems. The order of presentation for the camera position was in sets of 3 as a Latin square. The clips were chosen at random and shown on a computer monitor that allowed 2 clips to be opened and run simultaneously on a repeating loop. Each pair of panelists saw 36 clips (18 sets of 2). Each panelist was required to select a preferable clip from each pair. The panelists were briefed about the unloading operation and where the camera positions were but were not given a set of criteria on which to base their selections.

Quantitative Data Analysis

Generalized linear models were used to assess the effects of the 3 main factors, namely unloader version, bird posture, and bird direction of travel on the measured occurrences, including wing flaps, climbing on top, loss of balance, single-leg paddling, and running against the direction of travel. All the analyses were conducted using GENSTAT [12].

RESULTS AND DISCUSSION

Unloading Phase

The numbers of birds in the observation window were counted for each of four, 20-s periods. The numbers of birds in the observation window were not significantly different for the 2 systems, being 20.0 for the Mk I and 19.4 for the Mk II.

The frequency of wing flapping (an indication of agitation) and climbing onto others (overcrowding) were analyzed as proportions of numbers of birds in the observation window. For the 2 systems, the wing flapping was significantly reduced from a proportion of 0.44 for the Mk I to only 0.29 for the Mk II system ($P < 0.05$), but there was no significant difference for the numbers of birds climbing onto others. These 2 facts indicate that the birds were less agitated by the reduced chute angle but initially were not spread further apart in the Mk II system.

The number of birds still in the observation window of belt 1 at the time of tipping of the next container was counted, and the number of those fallen upon was recorded (Table 1).

A clear difference between the 2 systems was noted. The larger area of the Mk II belt 1 and its slightly higher belt speed ensured that fewer birds were left in the tipping zone; therefore, fewer birds were landed on by birds from the next tipping.

Transition Phase

The transition phase is the point in which the birds transfer from belt 1 to belt 2. There are 2 points of interest, and cameras 2 and 3 (Figure 4) observed both. The posture, orientation, and behavior of birds were observed and recorded immediately before, during, and after the transition.

The orientation of birds approaching the transition showed a statistically significant interaction with the system (Table 2). There was a considerable increase in numbers of birds traveling backwards on the Mk II belt 1, which is likely to be attributed to a gentler tipping action, giving birds more time to face uphill, their natural reaction, once they start to slide.

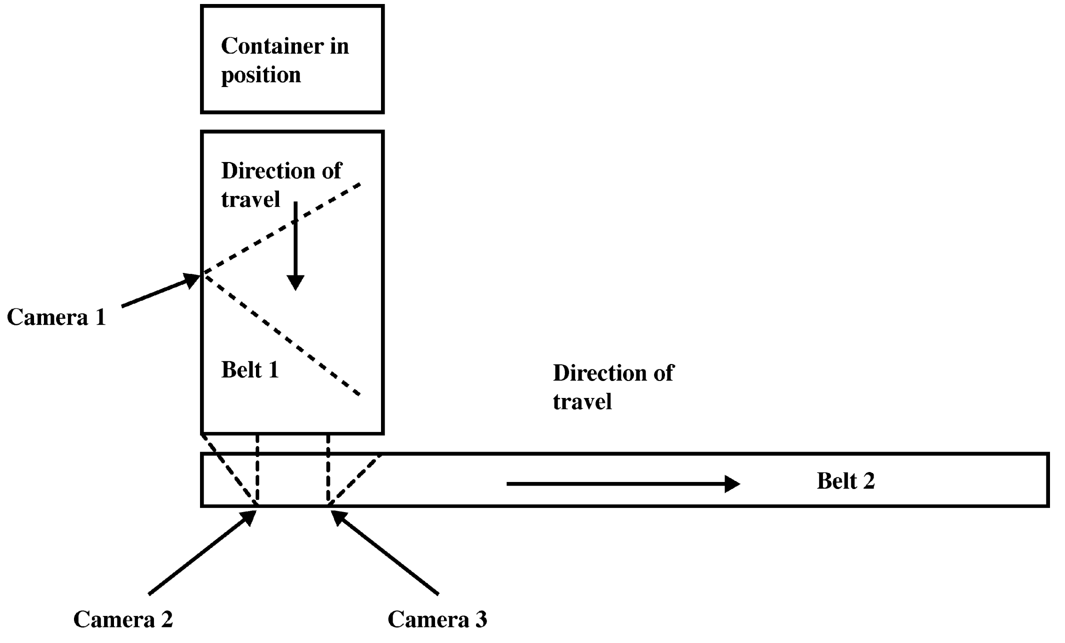

FIGURE 4. Schematic plan view of the camera positions in relation to major components.

Statistically significant interactions occurred between the system and mean numbers of wing flap per bird at transition. The incidence of wing flaps by birds in the Mk II system was 1.70 compared with 1.95 ($P < 0.001$) for those in the Mk I system, indicating a smoother transfer between the belts for the Mk II.

Loss of balance was also affected by the system. The mean number of occasions that a bird lost balance was only 0.56 in the Mk II compared with 1.38 for the Mk I ($P < 0.05$). The amount of loss of balance is remarkably low considering that there is a change in level, speed, and direction between the 2 belts.

On belt 2 there were statistically significant interactions between the system and posture (Table 3), whereas the interaction between system and posture was not significant for belt 1. Significantly more birds were standing on belt 2 in the Mk II system and far fewer crouching (Table 3). The likelihood is that the changes to the belting material, reduced ingress of light, and a more consistent belt speed allowed the birds to feel more stable and so be more comfortable standing in the Mk II system.

Qualitative Data Analysis

The panel demonstrated a very strong preference for the Mk II system in the tipping and transitional phases (Table 4). The corner (camera 3), for which there was a lower preference of 79%, was more difficult to see since the relatively low camera position meant that birds already on belt 2 partially obscured the view of many of the birds still on belt 1 and approaching the junction. As the camera was in the same position for both systems, it can be assumed that the reduction in clear views of the birds was similar.

Because equipment type is confounded with factors, such as farm of bird origin, conditions during transport and lairage, and the age of the birds, this should be considered in interpreting the results of this study.

CONCLUSIONS AND APPLICATIONS

1. The use of infrared closed circuit television cameras and video recording allowed quantitative analysis to show differences between welfare-related parameters of the 2 versions of the mechanical handling system for Stork GP transport containers.

2. The analysis of the quantitative data for the 2 systems showed that the Mk II system was improved compared with the Mk I. The data sets for the Mk II were either significantly better than, or not significantly different to, the corresponding data sets for the Mk I system. On no occasion was the Mk II significantly worse than the Mk I.
3. Analysis of the panel results showed a strong preference for the Mk II system with 2 of the 3 target areas being favored by 94 to 98%, and the third target area favored by 79%. This latter area was more difficult to view consistently so was more difficult to assess.
4. The quantitative and qualitative analyses indicate that many of the suppositions of the engineers designing the system modifications are valid. Notable are changes to the transition to improve the stability of the birds, and changes to the belt 1 area and speed, so that increased area per bird and longer chutes apparently reduced the agitation of the birds on belt 1.
5. Combining the quantitative and qualitative data provides a useful benchmark for current mechanized bird handling systems and will allow future modifications to be assessed.

REFERENCES AND NOTES

1. Duncan, I. J. H. 1989. The assessment of welfare during the handling and transport of broilers. Pages 93–107 in Proc. 3rd European Symposium on Poultry Welfare. J. M. Faure and A. D. Mills, ed. WPSA, Beckbergen, The Netherlands.

2. Duncan, I. J. H. 1990. Reactions of poultry to human beings. Pages 121–131 in Social Stress. R. Zayan, and R. Dantzer, ed. Martinus Nijhoff, Leiden, The Netherlands.

3. Hansen, I., B. O. Braastad, J. Storbraten, and M. Tofastrud. 1993. Differences in fearfulness indicated by tonic immobility between laying hens in aviaries and in cages. Anim. Welf. 2:105–112.

4. Duncan, I. J. H., G. S. Slee, P. J. Kettlewell, P. S. Berry, and A. J. Carlisle. 1986. Comparison of the stressfulness of harvesting broiler chickens by machine and by hand. Br. Poult. Sci. 27:109–114.

5. Ekstrand, C. 1998. An observational cohort study of the effects of catching method on carcase rejection rates in broilers. Anim. Welf. 7:87–96.

6. Knierim, U., and A. Gocke. 2003. Effect of catching broilers by hand or machine on rates of injuries and dead-on-arrivals. Anim. Welf. 12:63–73.

7. Stork PMT, 5830 AC, Boxmeer, The Netherlands.

8. Henry's Electronics Ltd., London.

9. Model CMP043, Henry's Electronics Ltd., London.

10. Noldus Information Technology, Wageningen, The Netherlands.

11. Broadway, Marlboro, MA.

12. GENSTAT, 6th ed., NAG Ltd., Jordan Hill Road, Oxford, UK.

Acknowledgments

This work was supported by Stork PMT. We are grateful to the processing plants for their hospitality and access to the unloading systems. The authors would like to thank S. Hartnell who gave considerable advice and time in assisting this project.