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TRI-AXIAL ACCELEROMETERS OFFER A POTENTIAL ALTERNATIVE METHOD TO MONITOR BEHAVIOUR OF PIGS DURING STUNNING

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I. INTRODUCTION

Monitoring the welfare of pigs at the abattoir is possible through the application of tools such as the Welfare Quality® protocol that assess welfare in the unloading area, in the lairage, as pigs move from lairage to stunning, after killing and assess stunning effectiveness [1]. However, measuring welfare during controlled atmosphere stunning under commercial conditions is challenging [2]. Group stunning makes the assessment of behaviour difficult and the ability to interpret behaviours becomes difficult as image quality of low-light video recording quality deteriorates (camera lens fouled with waste build-up). Alternative approaches have been considered, for instance, Bonnichsen et al. [2] took the approach of training an AI model to objectively and repeatably measure the activity during stunning.
Tri-axial accelerometers are electromechanical devices that measure accelerating forces in three-dimensions (x-, y- and z- axes) [3] and have been used to detect changes in animal behaviour resulting from health and welfare issues across different livestock species [4]. Accelerometers generate data that can be processed by algorithms in real-time that interpret these movements as specific patterns of behaviour [3]. The objective of this work was to determine if behaviours observed in pigs during the carbon dioxide (CO_2) stunning process were reflected in changes in activity detected by tri-axial accelerometers, which would allow for monitoring of behaviour without the need for video recording. We hypothesized that the timing of changes in activity detected by accelerometers will strongly correlate with the timing of observed behaviours.

II. MATERIALS AND METHODS

Tri-axial accelerometers (Movella Tracker MM31100, Henderson, NV, USA) were fitted to the right ear of pigs, using a modified tag applicator, within the lairage of a commercial pig abattoir. Pigs were randomly selected from within lairage pens that were reflective of pigs being presented to slaughter whilst allowing researchers suitable time to track these pigs through the raceway and slaughter process. The abattoir used a manual lairage operation and a raceway equipped with automatic gates, and a seven gondola backloader CO_2 stunner (Frontmatec ML7, Frontmatec Group, Kolding, DK) processing approximately 700 pigs per hour.
The response of pigs within the CO_2 stunner was recorded using a single fixed camera focused on the first-stop position, offering a field of view encompassing the entire width of the gondola. During the gondola's descent pigs entered the field of view prior to them detecting CO_2 and allowed viewing for six seconds after descent from the first-stop before the next gondola obscured more than 50% of the prior gondola. The five behavioural measures recorded from video footage were: latency from gondola movement to CO_2 exposure (detection of CO_2 was determined from behaviour change; pigs sniffing, opening their mouths, increased movement), latency to loss of posture, latency to the cessation of convulsions. External cameras allowed monitoring of entry into and exit from the stunner.
Accelerometer data, time-stamped units of the acceleration of gravity [4], along three axes recorded 25 times per second (25 Hz), was successfully downloaded for 10 pigs. The variance of each axis within one second epochs was calculated and plotted against time (Figure 1) to visualize low (small variance values) to high (large variance values) changes of movement as the pig transitioned through the stunner. The timing of recorded behavioural measures were overlaid over the accelerometer variance data; the recorded exit time and corresponding spike in variance associated with pigs exiting the stunner were used to align the measures, and entry time was set as zero seconds.
The time when each of the five behavioural measures occurred and the time when low to high changes of movement occurred was compared using simple regression analysis (Minitab® Statistical Software, Minitab, LLC, State College, PA, USA) with behavioural measures as the predictor variable and the time when low to high changes of movement as the response variable.

III. RESULTS AND DISCUSSION

There was a highly statistically significant relationship between event timing as determined by behavioural observation and low to high changes of movement as detected by accelerometer (R^2 = 1.00, $F(1,47)$ = 83871.2, P < 0.001). Observed behaviour showed an initial period of limited movement in response to the novelty of the gondola and its descent, corresponding to very low variance/change of movement (Figure 1) until the first detection of CO_2 by the pigs (~ 12 seconds in this system). Pigs' reaction to the presence of CO_2 was characterized by sniffing, gaping of the mouth and increased agitation, before transitioning into loss of posture (~8 seconds after exposure to CO_2 in this system), which further transitioned into a loss of generalized motor control and convulsions characterized by high variance values across all three-axes. Once convulsions ceased (~26 seconds after exposure to CO_2 in this system) pigs remained motionless with corresponding very low variance in acceleration, until the fully unconscious pigs exited from the gondola onto the shackling station, with high variance associated with this tumbling movement.

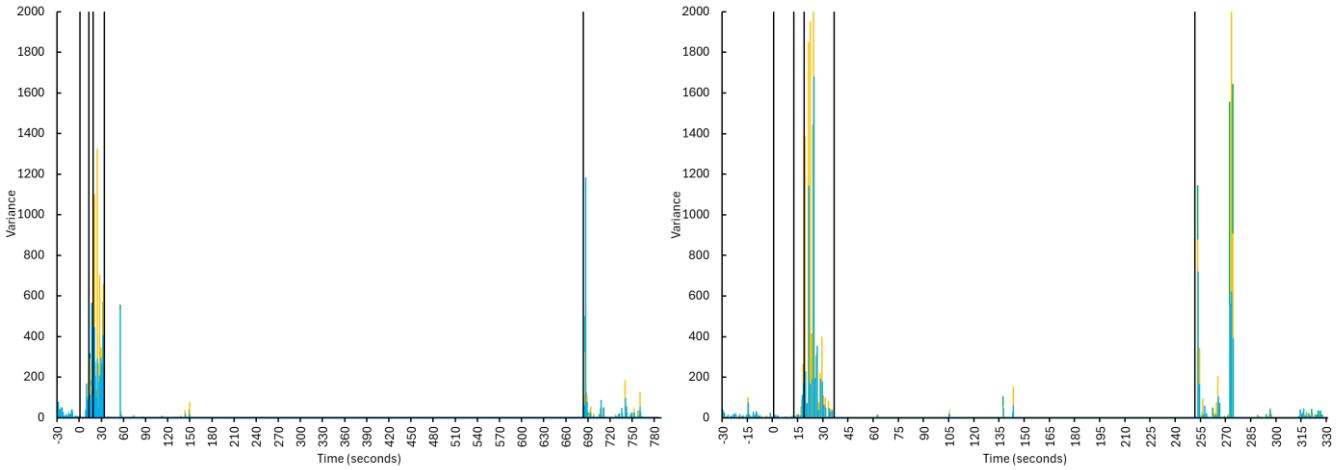


Figure 1. Plots of variance per second for two pigs fitted with tri-axial accelerometers (Ax ■, Ay ■, Az ■) as they moved through a minimal-handling high-concentration carbon dioxide stunning system. Behavioural events observed from video recordings are plotted as solid black lines; from the left on each plot, entry to gondola (0 seconds), first gas exposure, loss of posture, cessation of convulsions, exit from gondola.

IV. CONCLUSION

Accelerometer data, variance within one second epochs, explained the behaviour of pigs within a CO_2 stunner and strongly correlated with the timing of observed behaviours, supporting our hypothesis. However, transitions that occur when pigs go from a state of low to high movement, or vice versa, are more pronounced and consistent between pigs than when the degree or type of movement changes – i.e. the transition from loss of posture to convulsions. These findings provide an alternative method to assess pigs' response to CO_2 stunning. Further work is required to improve data acquisition, automate the processing of data and determine if these behaviours are transferred to movement of the gondola, which would increase the number of pigs able to be monitored.

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