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FREQUENCY WEIGHTINGS FOR THE AVERSION OF BROILER BIRDS TO HORIZONTAL AND VERTICAL VIBRATION

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1. INTRODUCTION

Broiler birds live on litter-covered floors and do not experience imposed bodily motions until, at a weight of about 2 kg, they are transported to the processing factory. They are placed in groups of about 25 into moulded plastic containers held in metal frameworks on the lorry. Vibration in the containers of poultry transporters shows a fundamental vehicle frequency in the vertical axis in the range 1 to 4 Hz [1,2]. Lateral and longitudinal resonances occur at 1 to 3 and 13 to 18 Hz [1,2].For a laden vehicle, root sum of squares acceleration magnitudes derived from the three translational axes are between 1.0 and 2.5 m/s^2 [1,2]. When these values are frequency weighted according to human response of discomfort they lie between 0.3 and 1.5 m/s^2, indicating fairly uncomfortable conditions for the seated human [3]. There are no corresponding frequency weightings for broiler birds and it is not, therefore, possible to assess the extent to which their welfare is compromised by these vibrational conditions. With birds, short-term stress or injury arises during the bird's journey of about 4 h [4]. This current paper outlines some possible frequency weightings appropriate to the aversion of broiler birds during transport.

The aversion of birds to vibration can be assessed using passive avoidance, operant conditioning [5,6,7]. Birds are trained to peck at a computer controlled operant panel for a food reward. At first each response is rewarded, but as the bird learns the technique the number of responses is increased for each reward. When fully trained an aversive vibration treatment is superimposed. Birds do not have to take any action to stop the treatment as it ends automatically after a fixed length of time.

2. METHODOLOGY

Broilers aged 28 days were housed in individual cages (0.5 x 0.5 x 0.5 m) and allowed to habituate in a training room. Temperature, noise and light levels were controlled. Alternate cages contained a plastic key disc, representing the operant panel, at which the birds pecked for a food reward. As they understood the relationship, the schedule was gradually increased from one reward per peck (fixed ratio 1) to a random number of pecks from 1 to 39 (variable ratio 20) with a food reward presentation time of 3 s. Response was recorded during a fixed 2 h session each day. When pecking performance was consistent from day to day, testing was started.

A bird was first moved to a control room where the variable ratio 20 schedule had a 30 s "time out period" (corresponding to the vibration period in the later vibration schedule) when they were excluded from responding. Once the bird operated consistently during consecutive daily 2 h sessions, it was moved into the corresponding treatment room. The control and treatment rooms each had similar geometry, arrangement and operant conditioning cages. Birds responded similarly in these two rooms when not subjected to vibration.

The treatment room contained a vibration machine; separate control and treatment rooms were used for horizontal and vertical motion. The vibration machines had hydraulically operated platforms on which the bird cages were mounted. Electronically generated sinusoidal or random narrow band signals controlled the motion of the platform at preset levels of frequency and root mean square acceleration. In these measurements random narrow band motion (0.45 to 0.55, 0.9 to 1.1, 1.8 to 2.2, 4.5 to 5.5, and 9 to 11 Hz) was used since it was more representative of transport vibration and birds found it more aversive than sinusoidal motion [8,9]. In the treatment room, the operant panels gave the birds 3 s access to food on a variable ratio 20 reinforcement schedule and superimposed a fixed ratio 20 passive avoidance (motion) schedule. This exposed the bird to 30 s of motion after every 20th peck. The bird was therefore in conflict between the motivation to a) peck for food and b) avoid motion. It was a passive avoidance technique since the bird itself started the motion (stopping automatically after 30 s) and only continued pecking response started the motion again.

For each vibrational direction (horizontal and vertical), frequency (1, 2, 3, 5, 10 Hz horizontal and 0.5, 1, 2, 5, 10 Hz vertical) and acceleration magnitude (four values), mean values of the number of pecks were obtained for four birds in a completely randomised design. For each direction and frequency, these mean values were related to the acceleration magnitude. Fitted curves, asymptotic to a value represented by the minimum possible number of pecks, were generated for each direction and frequency of the form

$$n = c + ab^{x} \qquad (1)$$

where n is the number of pecks in a 2 h session, a and b are regression coefficients, c is the asymptotic value and x is the acceleration (m/s^2).

These equations were then used to determine a family of seven curves of equal pecking response in the acceleration magnitude, frequency plane. An idealised representative response curve was then obtained for each direction of motion. The same method as used for human contours [10] was adopted with slopes having multiples of 6 dB per octave and corner frequencies at the preferred third-octave centre frequencies. This shape provides the relative acceleration levels at each frequency for the same bird response. Frequency weighting curves were then constructed based on a weighting factor of 1.0 at 1.0 Hz for the vertical direction.

3. RESULTS

Bird Responses

In the control room the number of pecks during the 2 h measurement period was about 3000, decreasing to a minimum of 20 in the treatment room (determined by the fixed ratio 20 schedule) when the motion was completely aversive. Values of the coefficients (a and b) for the curves fitted according to Equation 1 with the asymptote, c, set to the minimum of 20 pecks are given in Table 1. For each frequency, the number of pecking responses decreased as the root mean square acceleration magnitude increased.

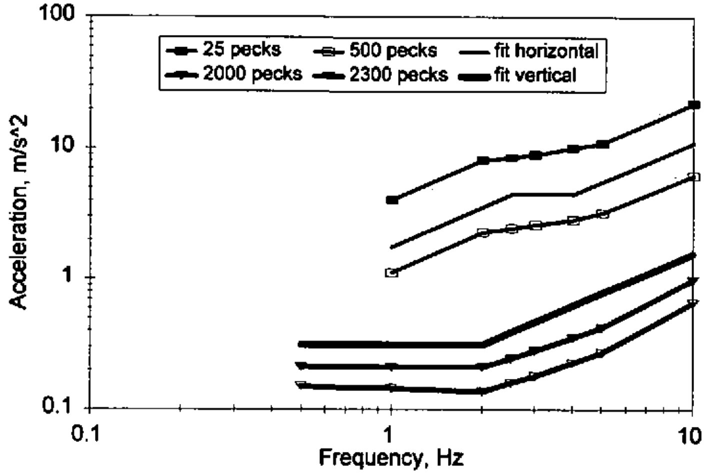
Table 1. Values of coefficients for Equation 1

Direction	Frequency Hz	a	b
Horizontal	1.0	2795	0.205
	2.0	2844	0.456
	3.0	2955	0.486
	5.0	3061	0.557
	10.0	2807	0.750
Vertical	0.5	3310	0.084
	1.0	2348	0.359
	2.0	2998	0.136
	5.0	2954	0.383
	10.0	3012	0.653

Contours of Equal Response

Contours of equal bird response in the acceleration magnitude, frequency plane, constructed from Equation 1 for horizontal responses (25 and 500 pecks) and vertical responses (2000 and 2300 pecks) are given in Fig. 1 where it can be seen that each pair of contours is approximately parallel for each direction of motion.

Figure 1. Some contours of equal response and simplified curves for vertical and horizontal motion



Frequency Weighting Contours

Fitted simplified contour shapes (using the criteria described in the methodology) for vertical and horizontal responses are also given in Fig. 1. For horizontal motion, the acceleration contour rises at 6 dB per octave from 1.0 to 2.5 Hz, is constant to 4 Hz and rises again at 6 dB per octave to 10 Hz. For vertical motion, the contour shows constant acceleration from 0.5 to 2.0 Hz from where it rises at 6 dB per octave up to 10 Hz.

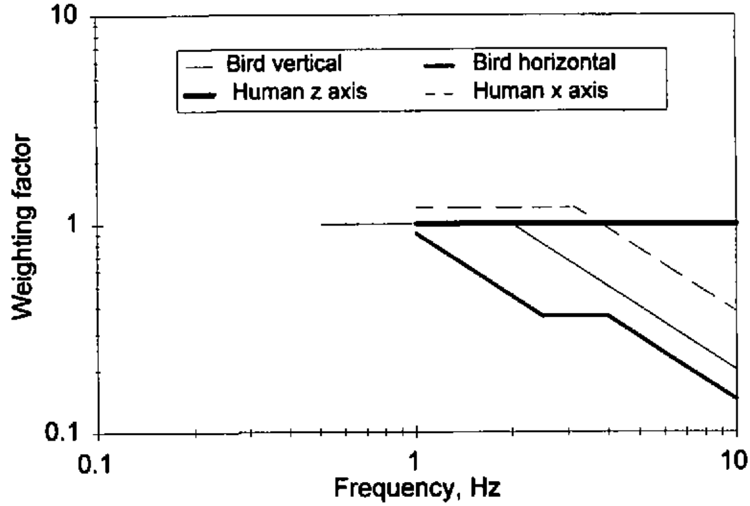
The vertical frequency weighting (related to the aversion of birds) which passes through an arbitrary value of 1.0 at 1 Hz and the corresponding horizontal one (0.9 at 1.0 Hz) are compared to those for the comfort response of humans in Fig. 2.

4. DISCUSSION OF RESULTS

Bird pecking responses decreased rapidly at all frequencies as the acceleration magnitude increased. Most of the measured values fitted Equation 1 well, but where this was not so, provided the curves are used within the measured values, they provided the most appropriate model, based on the nature and constraints of the bird responses.

At the highest aversion level, contours for 25 pecks were selected because this value is close to the minimum possible response of 20 pecks

Figure 2. Frequency weightings for horizontal and vertical motions for bird aversion and human discomfort



(Fig. 1). Thus 25 pecks represents an extremely aversive condition given by frequency (Hz), acceleration (m/s^2) points of (1, 4), (10, 20) and (1, 3), (10, 15) for horizontal and vertical motions respectively. At these levels of vibration, birds adopted one of the fright escape mechanisms of either flight or freezing. At the other extreme, a response contour of 2700 pecks was chosen (arbitrarily) to represent a threshold level of response since it was marginally below the maximum control number of 3000 pecks. Thus the onset of a threshold of response is in the region of frequency (Hz), acceleration (m/s^2) coordinates of (1, 0.025), (10, 0.2) and (1, 0.07), (10, 0.3) for horizontal and vertical motions respectively. The generally parallel nature of the equivalent response contours indicated that there is linearity with increasing acceleration and the shape of the response may be represented by a single simplified curve for each direction of motion.

The selected simplified response curves are a good fit to the data over all acceleration magnitudes investigated. However, other simplified curves could be fitted, for example a constant velocity line of 3 dB per octave fits the horizontal response quite well but does not reflect the higher rate of change at each end of the response as shown by the 6 dB per octave contour of Fig. 1. Using the higher response at each end of the contour is likely to provide slightly greater accuracy for small extrapolations beyond the measured frequency range.

For vertical vibration the weighting factor at 1.0 Hz was fixed at a value of 1.0 to correspond to the region of maximum bird response. Thus the full weighting procedure predicts from any complex motion the equivalent aversion level which would occur for vibration at 1 Hz in the vertical axis. For human response, the weighting value of 1.0 was selected at a frequency of 10 Hz [10], but coincidentally, both vertical and horizontal weightings for both birds and humans are close to 1.0 at 1.0 Hz (Fig. 2).

In comparing the vertical frequency weightings for birds with the human ones (Fig. 2) it may be seen that birds find frequencies above 2 Hz to be much less aversive than the equivalent comfort responses in humans. At all measured frequencies birds find horizontal motion less aversive than the equivalent human comfort responses. Such comparisons are very arbitrary since there is no reason why the two should correspond closely in any respect.

Human comfort response to vibration has been established over the frequency range 0.02 to 100 Hz, but for birds we have only covered the range 0.5 or 1.0 to 10 Hz. Particularly at lower frequencies birds are likely to show considerable aversion to vibration/motion.

The frequency weightings for birds based on aversion have been compared with the human comfort frequency weightings as these are the only other similar data available. Apart from the obvious differences of mass, stance, morphology, age etc between the species there are also differences between the types of response. Aversion measures the extent to which birds attempt to avoid a vibration stimulus and this was imposed for durations of only 30 s intermittently over a 2 h period. Each bird controlled its own exposure to the motion but if it had been imposed continuously for 2 h (thus more closely simulating transport) the birds might have found that certain conditions became increasingly aversive, whilst others, initially very aversive, became less so as they habituated to the motion. This would generate different frequency weighting curves.

5. REFERENCES

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