Practical uses of risk assessment method in animal welfare

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Introduction

The measurement of the welfare of animals is a complex of established quantitative physiological values, experienced though subjective judgements of behaviour and a range of ethical considerations. A whole complex of issues such as management skills, management systems and genetics has been shown to have significant effects on welfare outcomes (Hemsworth and Coleman, 1998). “Animal-based measures” are now becoming an important aspect of the assessment of the overall welfare of animals (Whay *et al* 2003).

Many current published methods of measuring overall welfare carefully define some aspects of welfare but ignore others. These have often been an *ad hoc* collection of inputs (infrastructure, systems, genetics and management skills) mixed with animal-based measures or outcomes (indicators of poor welfare such as foot lesions, skin damage or stereotypic behaviour) (Scott *et al* 2003). This mixture of inputs and animal consequences in welfare indices may confuse the measurement of welfare. Indices of welfare are also prone to biases due to the views of experts on whose opinions they are often based.

The extent and expectations of welfare research and its funding are significantly increasing and there are, as with other areas of animal research, groups or individuals who specialise in particular areas of welfare research. If researchers and funders were able to identify the issues which would have the largest effects in improving overall animal welfare then limited research funds would be able to be allocated in line with formulated priorities.

The welfare of a group of animals can be analysed from the standpoint of a set of inputs such as that mentioned above, which have probabilities of producing a set of outcomes which in turn have consequences (or impacts) for the animals. A probability and consequence framework could be used to assess animal welfare risks in the same way that risk assessment is used to analyse import or food safety risks.

As well as being used to prioritise research and measure overall welfare, this framework could also be used to communicate issues of welfare risk using existing procedures of welfare communication used for other risk assessment systems. This may assist to label products more accurately with information about the animal welfare of the systems under which they were produced.

The need for more formal frameworks for animal welfare analysis and assessment is also influenced by recent international developments. The Office International des Epizooties (OIE), which is the world organisation for animal health, has traditionally developed international animal health standards. The OIE has now moved to develop and publish international standards for animal welfare as well (OIE, 2004). Such international standards in animal welfare are based on scientific evidence. Accordingly, improvements in our ability to analyse animal welfare under varying scenarios will assist both in the development and further refinement of standards, as well as in their verification.

Assessing the overall animal welfare outcomes of different approaches to the problem will require the comparison of events that challenge the animal's welfare in different ways and at different times in the animal's life. There is good quality quantitative data on the probability and impact of these individual challenges, but there has been no way to objectively compare the welfare outcomes of these different strategies.

This paper uses a simplistic semi-quantitative example of the risk assessment methodology to compare two different issues affecting the welfare of pigs.

The paper also uses existing data to assess the welfare impacts associated with the issues of flystrike and mulesing, using the epidemiologically-based risk assessment approach. This study does not propose to assign absolute welfare values to the breech strike management scenarios or make any absolute findings on the comparative welfare effects of mulesing. There is considerable data on the responses of sheep to mulesing, alternative approaches to mulesing, and flystrike. This paper provides an example of using existing data in a risk assessment framework, elucidating the benefits of this approach in comparing welfare outcomes.

Methodology

Concept

Using the risk assessment framework, the risks to animal welfare outcomes could be assessed from current knowledge and could also highlight the need for further research. This approach is similar to the framework used to assess risk in food safety or the risk of importing some unwanted agent.

The frameworks used in these other disciplines provide the flexibility needed for the practical use of this methodology in the animal welfare field. The effects of inputs (infrastructure, management or genetics) to a system where animal welfare is being assessed will be well understood in some cases and less well understood in others. The likelihood of these effects occurring can be estimated quantitatively in cases where the probabilities of an adverse effect have been measured or it can be expressed qualitatively when the probability of an outcome has been less precisely measured.

Probability estimates may be qualitative (e.g. high, medium, low); semi-quantitative (including ranks scores and assigning probability ranges to qualitative categories); and quantitative (involving predictive models of reality, where these can be developed). Qualitative risk assessment is more rapid, uses fewer resources, but may be less useful for the ranking of different welfare issues or when economic decisions are to be made. Quantitative assessment requires more accurate information, is more useful for decision making but may detailed information on a large number of the elements of the overall welfare of animals in a particular system are being assessed or ranked. Semi-quantitative probability assessment may prove more useful when assessing a number of welfare risks, because it allows risks where knowledge is sparse to be ranked simply and risk where knowledge is detailed and quantitative to be categorised to reflect more detailed information but also allow it to be combined with poorly understood risks for comparisons or ranking of issues.

Semi-quantitative risk assessment

As a simple illustrative example to compare the welfare consequences of poor skills in stockpersons who manage pregnant sows with keeping pregnant sows in stalls for their entire pregnancy. Then in Table 1 comparing the average welfare effects of 2 issues using physical and behavioural welfare effects illustrates possible Probability and Impact Scores at the individual animal level. The Probability estimate could be based on research data (the likely percentage of sows on an average farm affected by the issue). The Impact Score could be based on a ten scale estimate of the seriousness of the issue. This could be based on expert opinions (Whay *et al* 2003). This gives a Scaled Welfare Indicator Value (SWIV) for the physical and behavioural effects of confinement in Sow Stalls of 0.2 X 8 = 1.6 and 0.5 X 7 = 3.5. This can be averaged for this issue to give an estimated SWIV of 2.6. This can be compared to an average SWIV of 2.1 for Poor Stockperson Skills. In reality there are many more effects of these issues making the comparison more complex. However, other issues can be averaged similarly to these issues and the SWIV similarly calculated.

Table 1. Probability and Impact Score for two issues associated with welfare problems in pig production.

Welfare Effect	**Issue**	**Probability**	**Impact Score**	**Scaled Welfare Indicator Value**
	Sow Stalls			
Physical Effect	Lameness	0.2	8	1.6
Behavioral Effect	Bar biting	0.5	7	3.5
Average SWIV				**2.6**
	Poor Stockperson Skills			
Physical Effect	Low Immunity	0.1	6	0.6
Behavioral Effect	Fearfulness	0.7	5	3.5
Average SWIV				**2.1**

Quantitative risk assessment

Quantitative assessment requires more accurate information, is more useful for decision making but requires detailed information on a number of the elements of the overall welfare of animals in a particular system are being assessed or ranked. One such example where high quality data exists is in the effects of mulesing, a surgical procedure in which two strips of skin are cut from the hindquarters of Merino lambs in order to remove wool-bearing wrinkled skin to increase the perineal bare area and reduce the risk of breech strike throughout the sheep’s life.

A risk assessment framework is demonstrated for three management scenarios: 1) conventional surgical mulesing; 2) no mulesing with unselected animals; and 3) no mulesing with animals selected for a higher flystrike resistance after 10 years of flock selection.

The animal stress response data for use in the risk assessment framework were obtained from Paull et al (2007, 2008) for surgical mulesing with and without pain relief. This source included conventional surgical mulesing and controls as common treatments. Animal stress response data for flystrike were sourced from Colditz et al (2005). Data on the relative risk of flystrike for mulesed and unmulesed sheep was obtained from Counsell (2000). Data on the relative flystrike risk for sheep with and without 10 years of flock selection for breech strike resistance were obtained from genetic estimates arising from a genetic selection project at CSIRO (Smith, personal communication). The data used thus represented the mean animal response to the procedure or selection.

Selection of welfare indicators

For each type of welfare challenge to the sheep (mulesing and flystrike), welfare indicators were chosen that each represented a single systemic response to the challenge. Thus, for mulesing the welfare indicators were the physiological stress-responsive hormone cortisol, the inflammatory marker haptoglobin, abnormal behaviour following the procedure, and changes in animal bodyweight.

The welfare impact of the mulesing operation was examined over both acute and sub-acute timeframes. The welfare indicators for the acute period were cortisol (0 to 6 h) and abnormal behaviour (for a 12-h period on day 1), whereas the welfare indicators for the sub-acute period were cortisol (6 to 72 h), abnormal behaviour (during days 2 and 3), haptoglobin concentration (mean on day 3 and duration of haptoglobin increase) and bodyweight change (between days 1 and 7).

For fly strike, cortisol was used as an indicator of physiological stress, haptoglobin data as a marker of tissue trauma and inflammation, changes in behaviour, and weight change. Data on cortisol, haptoglobin and body weight were obtained from Colditz et al (2005). Although Colditz et al (2005) did not measure animal behaviour, their study recorded changes in body temperature which we used as a comparison in this study.

Further assumptions were made on the typical duration of natural flystrike infections of sheep, based on the data of Counsell (2000) who also categorised fly strike risk for different areas depending on the climate, the size of the farms and the farming system. These areas are termed the high rainfall zone, the wheat sheep belt zone and the pastoral zone. We assumed that in the pastoral zone and wheat sheep belt, the farmers check sheep once a week, so flystrike would be detected after a maximum of 7 d of visible infection. So, we assumed that in these two zones, flystruck sheep underwent 10 days of actual infection while in the high rainfall zone, we assumed that the sheep would be checked twice a week and when treated, cortisol returned to baseline within 1 d, haptoglobin within 3 to 5 d, and pyrexia within 2 d.

Cortisol data were linearly adjusted to align with the mean data in Paull et al (2007) and were expressed as cortisol increase above recognised baseline (20 nmol/l; Paull et al 2007; 2008). Table 2 presents the values for the welfare indicators used in the risk assessment framework for the mulesing. Table 3 presents the values for the welfare indicators used in the risk assessment framework for flystrike.

Scaling of welfare indicators

For each welfare indicator, a scaled welfare indicator value (SWIV) was calculated on a linear and continuous 10-point scale. For variables ranging from a potential 0 value to a measured maximum in the source references (haptoglobin, cortisol and abnormal behaviour), the SWIV was calculated by scaling the value for a particular procedure against the rounded maximum value measured across all the reference papers.

Because the impact of a procedure is also reflected by the duration of the animal’s stress response, SWIV were also calculated for the duration of increases in cortisol and haptoglobin and the duration of changes in behaviour.

Table 4 presents examples of the scales for SWIV for cortisol and bodyweight change. Table 5 presents the actual SWIV used for the different mulesing scenarios, and Table 6 presents the SWIV for flystrike. The *Impact* of a particular challenge (e.g. mulesing) was then calculated as the mean of the SWIV (Tables 5 and 6).

Calculation of severity of welfare challenge

The severity of welfare challenge (SWC) for a particular situation was defined as

$$SWC_x = Impact_x * Pr(x),$$

where Pr(x) was defined as the probability of challenge x occurring. Therefore, the probability of mulesing for mulesed animals was 1, but the probability of flystrike varied according to farming zone and mulesing status. The benefits of flock selection for breech strike resistance were incorporated as a 25% reduction in the incidence of flystrike after 3 generations of selection (i.e approximately 10 years).

The SWC was calculated for mulesed, unmulesed and unmulesed selected animals. Because mulesing only occur during the first year of life, but flystrike can occur every year, the SWC was calculated both for mulesing and equivalents, and for the lifetime of the animal (assumed 5 years), whereby SWC_lifetime = (SWC_mulesing * 1) + (SWC_flystrike * 5).

Table 2. Values for welfare indicator variables used in the risk assessment framework for mulesing procedure

		Mulesing	**No mulesing**
Acute phase	Cortisol Peak increase (nmol/L) Mean increase (nmol/L) Duration of increase (h)	 115 59 6	 0 0 0
	Abnormal Behaviour day 1 (% of time)	19.7	0
Subacute phase	Cortisol Mean increase (nmol/L) Duration of increase (h)	 31.4 66 (6 to 72)	 0 0
	Haptoglobin Day 3 increase (mg/mL) Duration of increase (h)	 2.4 72	 0 0
	Abnormal Behaviour day 2 to 3 (% of time) Duration of increase (h)	12.9 72+	0 0
	Weight change day 1 to 7 (g/day)	-147	+87

Table 3. Values for the welfare indicator variables used in the risk assessment framework for flystrike.

		Pastoral zone	**Wheat-sheep zone**	**High rainfall zone**
Breech strike wih detection by farmer after 5 days in HRz, 10 days in Pz and in WSz (of infection)	**Cortisol peak (nmol/L)**			
	increase (day 4)	189	189	189
	average increase (day4-9)	157.6	157.6	129.3
	time	6 days duration	6 days duration	3 days duration
	Haptoglobin peak (mmol/L)			
	value (day 9)	4.5	4.5	3.2
	average (day 3-15)	2.85	2.85	1.83
	time	13 days duration	13 days duration	8 days duration
	Abnormal Behaviour			
	time (high rectal Temp)	9 days duration	9 days duration	6 days duration
	Liveweight change (g/day)			
	first week	-374	-374	-374

Table 4. Scaled welfare indicator variables for cortisol and bodyweight change.

Cortisol increase		Cortisol duration		Weight change	
Cortisol increase (nmol/l)	SWIV_cort.i	Cortisol duration (h)	SWIV_cort.d	Weight change (g/d)	SWIV_wt
0	0.0	0	0.0	+100	0.0
30	1.0	14.4	1.0	+50	1.0
60	2.0	28.8	2.0	0	2.0
90	3.0	43.2	3.0	-50	3.0
120	4.0	57.6	4.0	-100	4.0
150	5.0	72.0	5.0	-150	5.0
180	6.0	86.4	6.0	-200	6.0
210	7.0	100.8	7.0	-250	7.0
240	8.0	115.2	8.0	-300	8.0
270	9.0	129.6	9.0	-350	9.0
300	10.0	144.0	10.0	-400	10.0

Table 5. SWIV for mulesing procedure.

		Mulesing	**Non mulesing**
Acute stress	**Cortisol peak (nmol/L)**		
	increase	3.83	0
	overall increase (time)	1.96	0
	time (peak)	0.41	0
	Average cortisol	**2.07**	
	Abnormal Behaviour		
	% of time (day 1)	9.8	0
	AVERAGE IMPACT	**5.93**	**0.00**
Subacute stress	**High Cortisol (nmol/L)**		
	duration	4.58	0.03
	overall increase (time)	1.04	1.1
	average cortisol	**2.81**	0.57
	Haptoglobin peak (mg/mL)		
	value=average day3	4.8	0
	time	2.3	0
	average haptoglobin	**3.55**	**0**
	Abnormal Behaviour		
	% of time (day 2-3)	6.43	0
	time	3.33	0
	average behaviour	**4.88**	0
	Liveweight change (g/day)	4.94	0.26
	AVERAGE IMPACT	**4.04**	**0.41**

Table 6. SWIV for flystrike.

		Pastoral zone	**Wheat-belt sheep zone**	**High rainfall zone**
Breech strike with detection by farmer after 5 days in HRz, 10 days in Pz and in WSz (of infection)	**Cortisol peak (nmol/L)**			
	increase (day 4)	6.3	6.3	6.3
	average increase (day4-9)	5.25	5.25	5.25
	time	10	10	5
	Haptoglobin peak (mmol/L)			
	value (day 9)	9	9	6.4
	average (day 3-15)	5.7	5.7	3.66
	time	10	10	6.15
	Abnormal Behaviour			
	time	10	10	6.67
	Liveweight change (g/day)			
	first week	9.48	9.48	9.48
	Average cortisol	**7.18**	**7.18**	**5.52**
	Average Haptoglobin	**8.23**	**8.23**	**5.40**
	AVERAGE IMPACT	**8.72**	**8.72**	**6.77**

Table 7.

Estimates of the probability of flystrike for various classes of animal in a typical year.

Animal class	Farming zone		
	Pastoral	Wheat sheep	High rainfall
Mulesed	0.01	0.03	0.05
Unmulesed Young	0.15	0.40	0.70
Adult	0.26	0.44	0.62
Unmulesed selected Young	0.11	0.30	0.53
Adult	0.20	0.33	0.46

Table 8. Severity of welfare challenge (SWC) results for three mulesing and flystrike management scenarios and three farming zones.

	Mulesing	**Unmulesed**	**Unmulesed selected**
Year 1			
Pastoral	10.09	1.72	1.40
Wheat sheep belt	10.26	3.90	3.03
High rainfall	10.33	5.15	3.97
Lifetime			
Pastoral	10.52	10.79	8.20
Wheat sheep belt	11.40	19.33	14.62
High rainfall	11.75	21.85	16.50

Conclusions

By using the risk assessment framework welfare scientists can develop systems which quantify the effects of different parameters on the welfare of production animals. The detailed methodology of these systems then needs to be agreed as it is with import risk analysis, so they can be applied consistently. These systems may then assist in making the science of animal welfare more quantitative, easier to analyse and more accurate to communicate to those wishing to make decisions about aspects of animal welfare.

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