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A review of behavioural and physiological responses of sheep to stressors to identify potential behavioural signs of distress

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Abstract

This paper discusses the potential for using observations of behaviour to recognise distress in sheep. The term distress is used to describe situations in which an animal is likely to be suffering, and is indicating this by overt behavioural signs. Literature on the behavioural responses of sheep to procedures that induce a physiological stress response is reviewed. This approach is based on human analogy and the assumption that physiological changes can be used to differentiate between stimuli that induce an emotional response in sheep and those that do not. The degree to which the behaviour of sheep in certain situations represents, at least in part, an expression of emotional behaviour, or whether it can be fully explained as a functional response to a specific situation, is a fundamental and unresolved question in ethological and psychological studies. Therefore, the validity of compiling a list of objective common behavioural indicators of distress in sheep will be contentious. However, it is important to be able to recognise and deal with suffering, and the use of behavioural methods for the identification of distress in sheep is a practical welfare issue. There is a need for further research to identify indicators of distress in sheep, but in the meantime it would be reasonable to make the judgement that, in some circumstances, sheep that are found to be vocalising, panting, and/or showing markedly increased locomotory activity could be experiencing distress.

Keywords: *animal welfare, behaviour, behavioural indicators, distress, sheep, stress*

Introduction

This paper discusses the potential for using observations of behaviour to recognise distress in sheep. However, as Rushen (2000) indicates, this is not a simple issue: "The attractiveness of behavioural indices of stress lies in the fact that they are quicker and appear to be technically easier to obtain than physiological measures. In addition they are considered to reflect more directly the animals' feelings or emotions ... until we understand more of the causal mechanisms underlying the behaviour we will not be able to use behavioural indices of stress with any confidence." However, those responsible for the care of sheep, the 'on-farm' assessment of sheep welfare and the administration and enforcement of animal welfare legislation have a practical need for methods for the recognition of pain, distress and suffering in sheep. The literature has been reviewed to identify the potential behavioural signs that could be used to recognise distress in sheep and their limitations. The meaning of the term 'distress', the value of using simultaneous measurements of physiology and behaviour to identify emotional responses of sheep to stimuli, and some reasons why behavioural responses to stressors are unlikely to be non-specific and consistent are discussed. Published literature that has reported changes in the behaviour of sheep while the sheep were experiencing changes in plasma cortisol concentration and heart rate are summarised, and from this literature some potential behavioural signs of distress in sheep are identified. Finally, it is cautioned that further research is required before even these limited numbers of potential behavioural signs of distress can be validated.

Distress

The terms distress, pain and suffering are often used together, for example in animal welfare legislation, because in many situations the physiological responses (eg changes in the plasma concentrations of cortisol and catecholamines and changes in heart rate) that occur while animals experience these subjective states cannot readily be distinguished. The types of physiological measurements used to assess stress and some of the methodological difficulties associated with their use have been reviewed by von Holst (1998), Cook *et al* (2000) and Mellor *et al* (2000). In evaluating stress, physiological responses have limited use outside controlled laboratory environments (Moberg 2000). This paper will be confined to the behavioural recognition of distress arising from psychological and physical stimuli that are not associated with obvious injury. The term distress will be used to describe situations in which an animal is likely to be suffering, and is indicating this by overt behavioural signs (Ewbank 1985). Selye (1976) described two types of stress, namely, eustress (from the Greek *eu* or good)

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and distress (from the Latin *dis* or bad). Depending on the conditions, stress is associated either with desirable or undesirable effects. When the stress response threatens an animal's welfare, the animal can be considered to be experiencing distress (Moberg 2000). In an attempt to clarify the different types of stress response, Sanford *et al* (1986) differentiated distress from short-term, adaptive physiological stress by proposing that during distress detrimental effects to the animal can occur, and that the animal is likely to be aware that it is making an increased effort to respond to a stimulus. The differentiation between a response that involves a conscious recognition of a negative emotional experience and one in which the animal is unaware of having to make a homeostatic response to a stimulus has significance to studies of animal welfare. If an animal is not aware of the response, there is no short-term effect on its welfare. Therefore, in this review the term 'distress' is used to imply that an animal experiencing distress is consciously experiencing a negative emotional state.

There is no direct way of identifying an emotional state, such as distress, in an animal. Ethological approaches can be used to understand and interpret behavioural responses of sheep to distress; for example, Dwyer (2004, pp 269-281, this issue) discusses how the risk of predation may have influenced the behavioural responses of sheep to stressors. Some emotional states in animals, for example fear, can be investigated by subjecting the animal to a behavioural or psychological test involving exposure to a stimulus and then characterising its behavioural response either as positive, indifferent or negative (Desire *et al* 2002). An understanding of the underlying biological mechanisms associated with the behavioural expression of an emotional state can be useful in the interpretation of behaviour. Ramos and Mormede (1998) consider that an emotion involves a change in the psychological state of an animal and is a subjective experience or feeling associated with behavioural and physiological changes that are generated by non-ordinary situations. One way of assessing the value of behaviour in recognising distress is to examine the relationships between physiological and behavioural responses to stress.

Ewbank (1985) proposed that the following criteria should be fulfilled before a clear relationship between stress/distress and behaviour could be demonstrated: the stressor(s) must be identified and ideally quantified; the physiological responses must be quantified and ideally correlated with the stressor level and the degree of behavioural change; the behavioural changes must be obvious, fully described, and measured; and damage to the physical and/or psychological well-being of the animal must be demonstrated. This approach is supported by Ramos and Mormede (1998), who consider that the measurement of behavioural and neuroendocrine variables that typically change in stressful situations, in spite of all of the difficulties (see below), is one of the few tools available and the approach most commonly adopted to assess the level of emotional activation of an animal. Although behavioural responses can result from the administration of hormones such as corticotropin-releasing hormone and adrenocorticotrophic hormone (ACTH) (Ruckebusch & Malbert 1986; Johnson *et al* 1992, 1994), there is not always a clear relationship between the physiological and behavioural responses of animals to stressors (Mellor *et al* 2000). In addition, some of the stimuli that result in physiological changes such as cortisol excretion may be considered aversive, for example isolation, and some may be considered pleasurable, for example sexual activity (Rushen 1986). Therefore, physiological measurements cannot definitively identify negative emotional states in animals. The general approach taken in this review is based on the assumption that sheep are capable of experiencing the negative emotional state of distress (Desire *et al* 2002 present arguments to support the concept that farm animals can experience emotional states), and that for at least some of the time when sheep could be experiencing distress this is associated with the same types of physiological changes (eg cortisol excretion and changes in heart rate) that occur when humans report that they are experiencing distress (Lundberg & Frankenhaeuser 1980; Morgan *et al* 2002).

If it could be shown that a sheep was responding to an environmental change with physiological changes similar to those observed in humans when they are experiencing distress, this at least would provide a means for characterising situations in which sheep are showing a biological response that may indicate an emotional response to the stimulus. This physiological response is useful evidence when attempting to differentiate the behaviour of an animal that could be experiencing distress in response to a stimulus, from behaviour shown either when the stimulus has no effect on the animal or when it results in a behavioural response that does not involve a subjective experience. However, animals can also experience physiological responses, such as changes in plasma cortisol concentration and heart rate, in situations where a subjective experience is unlikely to be taking place, for example during anaesthesia (Taylor 1998). In addition, it is also possible that a sheep could be experiencing distress and changed behaviour even if there is no change in plasma cortisol concentration or heart rate.

Variations in stress responses between animals

The 'non-specific' responses to stress proposed in Cannon's Flight or Fight Reaction (Cannon 1939) and Selye's General Adaptation Syndrome (Selye 1936, 1946, 1976), do not occur in all situations (Mason 1971), and it is recognised that both the physiological and the behavioural responses of animals to the same stressor can vary markedly (Moberg 2000). For example, Baldock and Sibley (1990) found variations both in physiological (heart rate responses) and behavioural (frequency of vocalisations) responses of ewes to 20 mins transportation in a trailer. The ewes' ranks in terms of their behavioural response showed little correlation with their ranking on the basis of increases in heart rate.

Variation in responses to stressors can arise for several reasons and at each stage of the stress response. Moberg

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(2000) identified three stages in the stress response: recognition of a stressor, biological response or defence against the stressor and the consequences of the stress response. Moberg's model provides an explanation for why a sheep might respond to a stimulus with a given behavioural response on one occasion, but the same sheep or another sheep might respond to the same stimulus with a different behavioural response on another occasion. If the sheep does not recognise the stimulus as a stressor it may not change its behaviour at all. It may recognise the stimulus as a stressor, but not change its behaviour in order not to draw attention (eg in response to a predator). If it does adopt a behavioural response to a stressor, the behavioural response itself may deal with the potentially harmful effects of the stressor; for example, the sheep could move away from the stimulus and the subjective experience of distress either would cease or not be initiated.

Several exogenous factors affect how an animal perceives a stressor and the type of biological response initiated by an animal. On the basis of exogenous factors identified by Moberg (1985), examples from the literature of how the physiological and/or behavioural responses of sheep to stressors vary with these factors are given below:

Experience: Habituation to a stimulus can influence the behavioural and physiological response; for example, repeated daily removal of lambs from ewes can result in a reduced plasma cortisol and vocalisation response in the ewes (Cockram *et al* 1993).

Genetics: Some breeds are more susceptible to certain stressors than are others and there are many individual variations in the stress response within breeds; for example, Le Neindre *et al* (1993) found variation in the behavioural response of Merinos d'Arles, Romanov and crossbred ewes to an open-field (novel environment) test.

Sex: Connolly *et al* (1976) described how the behavioural responses of rams to the presence of a coyote predator differed from that of ewes.

Age: Moberg *et al* (1980) found that day old lambs did not struggle or vocalise during restraint whereas older lambs did, and that the latency for younger lambs to move in an open-field test was greater than for older lambs.

Physiological state: Stages in the reproductive cycle, pregnancy, parturition and lactation result in physiological changes that may alter or modify the stress. For example, Poindron *et al* (1997) found a decreased behavioural response to social isolation in peri-parturient ewes compared with non-pregnant ewes.

Differences in how an animal perceives a stressor and/or differences in response styles to a stressor offer a potential explanation for why some sheep respond to some stimuli, whereas others may not, and why different sheep may show a completely different type of behavioural response to the same stressor. Two distinct types of stress response have been identified: a flight–fight response (as described by Cannon [1939]) and a conservation–withdrawal response. The conservation–withdrawal response is associated with immobility, decreased response to environmental stimuli and increased adrenal corticoid activity (Henry 1976; Koolhaas *et al* 1999). An animal faced with a situation in which it perceives no way to cope, or in which its efforts to cope do not succeed, is likely to adopt the conservation–withdrawal pattern (Moberg 1985). Syme and Elphick (1982) identified three distinct behavioural categories of response to social isolation in sheep: agitation, vocalisation and unresponsive, which might be the result of active and passive coping strategies. The heart rate responses of the sheep in these categories ranked: agitated > vocal > unresponsive.

Behavioural and physiological responses of sheep to management/husbandry procedures

The behavioural responses of sheep associated with management/husbandry procedures and with environmental stimuli that also induce a physiological stress response are summarised in Tables 1a–c; however, no attempt has been made to differentiate between stress and distress. Ewbank (1985) suggested that the behavioural responses to stress could consist of a quantitative and/or qualitative change in the normal behaviour of the animal and the occurrence of 'abnormal' behaviour. In Tables 1a–c, behaviours associated with stress have been categorised either as a change to the time-budget of the posture and maintenance activities of sheep, or the occurrence of 'abnormal' behaviours that have the potential to be behavioural indicators of distress in sheep. Where there was a significant change in the plasma cortisol concentration, heart rate or behaviour in response to the stressor this is indicated as follows: '**I**' significant ($P < 0.05$) increase and '**D**' significant ($P < 0.05$) decrease; and where no change in the variable was reported this is shown as '**0**' ($P > 0.05$). Many reports in the literature do not include detailed quantitative behavioural observations (often these are descriptive reports within the paper) and others have not included statistical analyses relevant to this review. Changes in behaviour indicated either as an increase (i), a decrease (d) or no change (0) will not have been subjected to relevant statistical analysis. In these cases an increase was indicated as 'i' where the authors reported either the occurrence of a behaviour that was not previously observed or an increase in frequency, intensity or duration of a behaviour. Similarly, a decrease was indicated as 'd' where the authors either no longer observed a behaviour that was previously observed or reported a decrease in the frequency, intensity or duration of the behaviour. A '0' to indicate no change was used where the authors specifically recorded that there was no change in the behaviour. Some behavioural changes may also not have been shown by all sheep (eg i0 indicates that this particular behaviour increased in some sheep, but in others there was no change in the behaviour). All potentially useful behavioural observations have been included to indicate behaviours that have the potential to be used as indicators of distress and not as evidence that they have been shown to be reliable behavioural indicators of distress/stress.

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Table 1a Behavioural and physiological responses of sheep to stressors: isolation and separation.

Stressor	Physiological stress response		Posture		Maintenance behaviour				Potential behavioural indicators of distress					Reference
	Cortisol	Heart rate	Stand still	Locomote	Sleep/rest	Eat	Drink	Ruminate	Vocalise	Eliminate	Foot stamp/paw	Rear	Head alert	
Social isolation									i					Torres-Hernandez & Hohenboken (1979)
		I							i					Syme & Elphick (1982)
	I								i					Bobek *et al* (1986)
	I						**D**							Parrott *et al* (1987)
		I		i					i					Baldock & Sibley (1990)
	I			**I**					**I**					Lyons *et al* (1993)
	I	**I**	**I**	**I**	**D**		**0**	**D**	**I**	**0**	**I**	**0**	**I**	Cockram *et al* (1994)
				I					**I**					Boivin *et al* (1997)
				I					**I**	**0**		**I**		Poindron *et al* (1997)
Separation of	**0**		**I**		**D**	**0**		**D**	**I**	**0**	**0**	**0**	**I**	Cockram *et al* (1993)
lamb from ewe	**0**								**I**					Orgeur *et al* (1998)
	I													Rhind *et al* (1998)
Separation of ewe from lamb									**I**					Orgeur *et al* (1998)

I: Significant increase in physiological variable or behaviour. **D**: Significant decrease in physiological variable or behaviour. **0**: No change in physiological variable or behaviour. Increase (i) not supported by relevant statistical analysis.

Potential behaviours indicative of distress

Rushen (2000), in his overview of some of the issues involved in the interpretation of behavioural responses to stress, argued that: (1) until the motivation and neurological bases for the types of behaviours described above is understood, our ability to use behavioural indicators of stress will be limited, (2) behavioural responses during stress are performed to help the animal deal with the stress, and the types of responses are often specific for a particular type of stressor, and (3) it is unlikely that there are general behavioural stress responses that animals show regardless of the type of stressor. In addition, Moberg (2000) considered that the large number of factors that influence how an animal perceives a stimulus as a threat to its homeostasis and affect how it organises its response to the stressor, ie early experience, genetics, age, social relationships and human–animal interactions, cannot be taken into account outside a laboratory, and therefore the evaluation of stress in a flock of sheep would not be possible.

With the above reservations, some of the behavioural signs summarised in Tables 1a–c merit further discussion of their potential as behavioural indicators of distress. The main behavioural responses to a range of stressors that have been identified in other species are: increased immobility and increased locomotion, decreased sleeping/resting and increased alertness, decreased eating and drinking, and increased vocalisation and elimination (Archer 1973; Johnson *et al* 1992). The frequent reporting of these behavioural changes in the literature on sheep, the frequent reporting of more species-specific behavioural signs, such as the occurrence of foot stamping/pawing, and the frequent reporting of increased respiration rate as the homeostatic response to increased air temperature were used as the basis for selecting potential behavioural signs of distress for further discussion.

Sheep are likely to show many of the behavioural signs described in Tables 1a–c in a variety of circumstances, and none of the behavioural signs can be considered to be indicative of distress alone. Some behavioural signs are likely to be context-specific and many will also occur in situations that are not aversive or distressing to sheep. Each of the behavioural signs could be interpreted in more than one way.

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Table 1b Behavioural and physiological responses of sheep to stressors: human, dog, novelty and restraint.

Stressor	Physiological stress response		Posture		Maintenance behaviour				Potential behavioural indicators of distress					Reference
	Cortisol	Heart rate	Stand still	Locomote	Sleep/rest	Eat	Drink	Ruminate	Vocalise	Eliminate	Foot stamp/paw	Rear	Head alert	
Human		**I**		i									i	Baldock & Sibley (1990)
				D					**D**					Romeyer & Bouissou (1992)
Dog				d					d		i			Torres-Hernandez & Hohenboken (1979)
Human & dog		**I**		i										MacArthur *et al* (1982)
		I		i									i	Baldock & Sibley (1990)
Novel object	**I**		**0**	**I**					**I**	**I**				Romeyer & Bouissou (1992)
Novel environment	**I**								i					Moberg & Wood (1982)
									i	i		i		Le Neindre *et al* (1993)
				I										Bowers *et al* (1993)
	I		**0**			**D**	**D**	**I**						Done-Currie *et al* (1984)
Novel environment & noise				i					i					Moberg *et al* (1980)
Novel social group		**I**		i					i					Baldock & Sibley (1990)
Restraint	**I**								i					Moberg *et al* (1980)

I: Significant increase in physiological variable or behaviour. **D**: Significant decrease in physiological variable or behaviour. **0**: No change in physiological variable or behaviour. Increase (i) or decrease (d) in behaviour not supported by relevant statistical analysis.

Locomotion

Locomotory activity could be interpreted in several ways; for example, as an attempt to escape, which could reflect fear; or as a search for conspecifics, reflecting social motivation, or exploration, and a low level of fear. The opposite response to locomotion — immobilisation — is seen in some sheep in response to stressors. Immobilisation may reflect docility and an absence of fear, or it may reflect a high degree of disturbance and nervousness (Romeyer & Bouissou 1992).

Sleeping/resting, eating, drinking and ruminating

The review indicated that these maintenance behaviours (except for increased drinking in hot environments) can be suppressed by several aversive stimuli. The ability to recognise a reduction in these maintenance behaviours during periodic inspections of sheep will be limited, but stockmen, veterinary surgeons and others use the occurrence of these maintenance behaviours as part of a judgement that sheep are not affected by aversive conditions (Gay 2000).

Vocalisation

Most of the literature cited on social isolation and exposure to a novel environment reported increased vocalisation. However, when lambs are separated from the ewe at weaning, increased vocalisation could indicate distress or simply that the animals are attempting to communicate and identify each other to assist in reuniting (Shillito-Walser & Alexander 1980; Lynch *et al* 1992). Orgeur *et al* (1998) recorded a greater frequency of vocalisation towards the end of a separation period than at the beginning, suggesting that in this circumstance vocalisation might be part of an emotional response. Also, increased high-pitched vocalisation reported in response to separation has been interpreted primarily as a stress response to separation, and low-pitched bleating has been interpreted as a recognition signal. The reduction in vocalisation in the presence either of a human or a dog is likely to be an anti-predator and possibly a 'fearful' response, which overrides the increased vocalisation reported in many other aversive situations (Romeyer & Bouissou 1992).

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Table 1c Behavioural and physiological responses of sheep to stressors: environmental temperature and transport.

Stressor	Physiological stress response		Posture		Maintenance behaviour			Potential behavioural indicators of distress					Reference
	Cortisol	Heart rate	Stand still	Locomote	Eat	Drink	Ruminate	Vocalise	Pant	Foot stamp/paw	Shiver	Respiration rate	
Cold temperature	**I**	**0**											Graham *et al* (1981)
(0 to –17°C)										i	i		Webster *et al* (1969)
		I									0	**D**	Schaefer *et al* (1982)
Hot temperature												i	Blaxter *et al* (1959)
(32 to >44°C)									**I**			**I**	Hales (1973)
									i			i	Hales & Brown (1974)
						i						i	Guerrini *et al* (1980)
	D					i							Guerrini & Bertchinger (1982)
												i	Stafford Smith *et al* (1985)
			I		**D**	**I**	**D**						Paranhos *et al* (1992)
									i				Parrott *et al* (1996)
												i	Riesenfeld *et al* (1996)
Road transport		**I**						i0					Baldock & Sibley (1990)
								0					Buchenauer (1994) cited by Knowles (1998)
										i			Schmiddunser (1994, 1995) cited by Knowles (1998)
	I	**I**	**I**	**D**			**D**	0	i				Cockram *et al* (1996)
Sea transport					d	d			i				Black *et al* (1994)

I: Significant increase in physiological variable or behaviour. **D**: Significant decrease in physiological variable or behaviour. **0**: No change in physiological variable or behaviour. Increase (i), decrease (d) or no change (0) in behaviour not supported by relevant statistical analysis.

Foot stamping

Foot stamping is also likely to be a defensive behaviour in response to a perceived predator (Houpt 1998). Some sheep successively defend themselves against coyotes by facing, threatening with foot-stamping and showing intention to butt (Connolly *et al* 1976).

Elimination, alertness and rearing

Defecation, urination and increased alertness (identified as a raised head) have been reported as 'fearful' type responses in a number of species, and rearing could be regarded as escape behaviour (Romeyer & Bouissou 1992; Frid 1997).

Torres-Hernandez and Hohenboken (1979) considered that although vocalisation, foot stamping and eliminative behaviour were useful as measures of emotional responses in sheep, their usefulness was limited. In response to social isolation with and without the presence of a dog, these behaviours were observed at too low a frequency and were expressed by too small a percentage of the sheep to be sensitive measures of emotional response.

Panting and respiration rate

An increase in respiration rate above 40 breaths per min, together with open-mouthed breathing, may be regarded as panting (Silanikove 2000). The main reason for panting in sheep is to increase body cooling by evaporatory heat loss. However, it is possible that sheep also pant in response to psychological stimuli (Wientjes 1992). Under severe heat stress, the respiration rate of sheep can reach 300 breaths per min (Hales & Brown 1974). Silanikove (2000) considered that measuring respiration rate and deciding if a sheep is panting, and qualifying the severity of heat stress according to panting rate (low: 40–60; medium: 60–80; high: 80–200; and severe heat stress: above 200 breaths per min) was the most accessible and easiest method for evaluating the impact of heat on farm animals under extensive conditions. Humans cannot tolerate severe heat

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stress (Nag *et al* 1997; Tikuisis *et al* 2002) and they also show an increased respiration rate when exposed to heat (Riesenfeld *et al* 1996). By analogy, it would not be unreasonable to propose that the increased respiration rate shown by sheep when exposed to high environmental temperatures could be associated with an aversive emotional response.

Conclusions

Given the current state of knowledge, this review has been able to highlight only a limited number of behavioural signs that could be used by those (a) with responsibility for the welfare of sheep, as a signal for further investigation and possible action, and (b) engaged in research, as a stimulus either to validate or refute their usefulness in recognising distress in sheep. The behavioural responses in themselves cannot always be used to distinguish between situations that are harmful or helpful for the sheep. However, where an animal is in the care of a human, the display of certain types of overt behaviour can draw the attention of the carer. On the basis of experience and/or knowledge of adverse outcomes to sheep within the same or similar contexts, the occurrence of vocalisation, panting and/or increased locomotory activity could be used by the carer/inspector as the criteria to intervene to investigate what action is required to safeguard the welfare of the sheep.

The interpretation of behaviour as indicative of an emotional response (such as distress in sheep) has to be based largely on subjective criteria. However, it is not always necessary to restrict behavioural signs of distress to those that may result from the emotional experience. If the physiological basis of an emotional experience, such as heat distress, is understood and the occurrence of a behaviour, such as panting in a hot environment, forms an essential part of the biological response to the stressor, such as increased evaporative cooling to avoid hyperthermia, it is not necessary to speculate that the behaviour (panting) results from the emotional experience, but only that this particular behaviour either precedes distress or occurs simultaneously with (heat) distress. Although there are numerous references in the literature that describe physiological responses of sheep to stressors, few of these contain rigorous behavioural observations. There are also some methodological issues in the types of behavioural studies that have been undertaken that should be considered during future research in this area. It is normal ethological practice to initially make a wide range of observations to draw up an appropriate ethogram and then select a limited number of behaviours to be used for quantitative recording. Many reports on the response of sheep to stressors do not contain sufficient descriptive information on the behavioural responses and report only a limited number of behaviours (often restricted to those used in previous studies). Also, where sheep do not show an obvious behavioural response to the treatment this may not always be recorded. This could result in undue emphasis on the responses of sheep that show more active behavioural signs and less attention paid to the lack of an active behavioural response. This is a particular problem when attempting to identify behavioural responses of sheep during distress, because some sheep may respond to stressors with immobility rather than with an active response (Fraser 1960). Rushen (1990) concluded that "many husbandry procedures clearly do distress sheep to some degree" and "there are a number of very reasonable sounding, and quite possibly correct suggestions about what distresses sheep", but "the number of well-researched facts is very small."

There is a need for research with the specific objective of describing the behavioural responses of sheep to stressors. The research should both describe and quantify the occurrence of unusual behaviours, as well as quantifying normal behaviours such as eating and sleeping that may be disturbed during or after distress. Physiological and psychological measurements should also be made to aid judgements as to whether the behavioural responses are indicative of distress.

Animal welfare implications

The degree to which the behaviour of sheep in certain situations represents an expression of emotion or whether behaviour can be fully explained on a functional basis is a fundamental and unresolved question in ethological and psychological studies. Until further evidence is provided to help answer this question, the validity of compiling a list of objective, common behavioural indicators of distress in sheep will be contentious. However, it is important to be able to recognise and deal with suffering, and the use of behavioural methods for the identification of distress in sheep is an obvious practical welfare issue. Guidelines have been formulated for the recognition of pain and distress in animals (Morton & Griffiths 1985; Sanford *et al* 1986), but, as cautioned by Sanford *et al* (1986), a scoring system for the severity of pain and distress will only have validity if the relative significance of all available indicators has been fully evaluated. Until firmer evidence is available it would be reasonable to make the judgement that, in some circumstances, sheep that are found to be vocalising, panting and/or showing markedly increased locomotory activity (especially if this activity is directed to remove themselves from a stimulus) could be experiencing distress.

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