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1 **Opinion paper: Is there a role for breeding for welfare improvement?**

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3 S.P. Turner, J. Conington and C.M. Dwyer

4 *Animal and Veterinary Sciences Research Group, SRUC, Kings Buildings,*  
5 *Edinburgh, EH9 3JG, UK*

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7 Corresponding author: Simon Turner. Email: [simon.turner@sruc.ac.uk](mailto:simon.turner@sruc.ac.uk)

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9 **Introduction**

10 Increasing global demand for animal products produced with ever greater efficiency  
11 makes it unlikely that the pressure placed on livestock industries and therefore the  
12 animals themselves will diminish in the foreseeable future. Increasing affluence and  
13 awareness of welfare issues by societyconsumers may drive improvements in  
14 welfare standards, but this ~~can't be assumed and~~ may be regional rather than global  
15 in impact. Some complex welfare problems in intensive production systems, such as  
16 tail biting in pigs and feather pecking in hens, have existed for decades, have  
17 significant negative impacts on economic and environmental sustainability but have  
18 known solutions that are too costly for many producers to implement. Other welfare  
19 challenges, such as poor health control or high neonatal mortality in extensively  
20 managed systems, persist because management options for their mitigation are  
21 limited. Still other welfare challenges have been exacerbated in the past by  
22 imbalanced selective breeding on a narrow range of economically important traits,  
23 most notably in the dairy and broiler industries. Considerable variation exists  
24 between animals in their expression of negative welfare outcomes (e.g. in  
25 aggressive behaviour in pigs; Figure 1). Selective breeding leads to permanent and

26 cumulative change, and breeding for appropriately targeted traits has the potential to  
27 benefit welfare without negative economic impacts or the requirement for major  
28 management change. This article will focus on three examples of welfare problems  
29 that have persisted for many decades and are tolerated as routine within current  
30 production systems, but which have the potential for improvement via selection.  
31 These examples are diverse and present ethical dilemmas, each to a different  
32 extent, with regard to the acceptability of using selection to improve welfare. The first  
33 example (improving lamb survival) is the least controversial of the three examples.  
34 The second (improving sheep resistance to foot infections known as 'footrot') is likely  
35 to benefit welfare but major improvements ought to be achievable on some farms  
36 without recourse to breeding through better prophylactic and therapeutic health  
37 management. The final example (reducing pig aggression) deliberately seeks to  
38 reduce expression of behaviours that are an integral part of the repertoire shown by  
39 all pig breeds and wild boar~~natural behaviour~~ since housing systems that minimise  
40 this problem are not economically feasible.

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## 42 **Lamb survival**

43 Worldwide pre-weaning lamb mortality averages 15-20% with nearly 50% of lamb  
44 deaths occurring on the day of birth. Death through starvation and hypothermia is  
45 likely to be prolonged (Dwyer, 2008). This represents a major welfare, economic  
46 and environmental burden in an industry that is a cornerstone of regional economies.  
47 Despite considerable research, the mortality rate has not improved in recent  
48 decades and management options to protect or treat neonatal lambs are typically  
49 limited in extensive production systems. Neonatal lamb vigour and ewe maternal  
50 behaviour have been shown to be major determinants of survival. Lamb vigour is

51 easy to record, has a higher genetic correlation with survival than ewe maternal  
52 behaviour and is a moderately heritable trait with high genetic variance (e.g. reduced  
53 ability to suck; heritability 0.32, SE 0.04; Matheson *et al.*, 2012). Furthermore, it, and  
54 is not genetically correlated with lamb growth. The heritability compares favourably  
55 with that the heritability of traits currently under selection in the global sheep industry  
56 (e.g. fecundity; heritability 0.16) meaning that it ought to be technically possible to  
57 selectively breed for improved lamb survival. Simple scores for lamb vigour, sucking  
58 ability and lambing ease have been developed and are measurable by farmers, and  
59 are able to accurately estimate genetic propensity for survival. Uptake of new  
60 innovations by the sheep industry is constrained by labour availability and the poorly  
61 integrated nature of the industry. However, developing scores for lamb vigour in  
62 partnership with farmers has resulted in their use now ~~These tools are now~~  
63 beginning ~~to be used~~ on commercial farms.

64

## 65 **Footrot**

66 Lameness caused by virulent footrot strains of the anaerobic bacteria *Dichelobacter*  
67 *nodosus* is a debilitating, painful hoof infection. Footrot is endemic in the major  
68 sheep-producing countries with wetter climates such as the UK and Ireland, with  
69 prevalence levels of footrot hoof lesions of between 13 and 23% and actual  
70 lameness of between 8-10%. Infection can be prevented and controlled by careful  
71 hygiene for housed ewes, foot-bathing, promptly treating affected ewes and  
72 separating them from the main flock until they are cured. There is undoubtedly a  
73 role for better awareness of its diagnosis, prevention and control strategies, but  
74 efficient management can be problematic even on well-managed farms. Footrot  
75 resistance is heritable (heritability 0.15-0.25; Raadsma and Dhungyel 2013) and is

76 associated favourably with number of lambs reared and unfavourably with lamb  
77 liveweight gain. Simple 5-point scoring methods exist and are being used in some  
78 countries to provide phenotypic data on affected hooves for use in sheep breeding  
79 programmes to reduce footrot prevalence (Raadsma and Conington, 2010).

80

## 81 **Pig aggression**

82 The majority of commercially farmed pigs experience regrouping into new social  
83 groups at least once in order to house animals together of similar weight and to  
84 ensure available buildings are used to maximum capacity. Fighting to establish new  
85 dominance relationships can be intense and can lead to many skin lesions. The  
86 quality of behaviour performed is similar to that performed between wild boar, but the  
87 quantity of aggression is typically greatly increased in commercial production due to  
88 the sudden grouping of animals of similar competitive ability and in close proximity in  
89 an environment that prevents escape. Low-cost, labour efficient methods to reduce  
90 aggression have minimal benefits and the avoidance of regrouping is economically  
91 unviable for many producers. Large variation exists in aggressiveness (Figure 1)  
92 and some aggressive behavioural traits have heritabilities only slightly below that of  
93 growth rate (e.g. duration in reciprocal fighting; heritability 0.43 SE 0.04; Turner *et*  
94 *al.*, 2009). Recording of skin lesion number and location can provide a rapid  
95 estimation of the genetic propensity of pigs to engage in damaging reciprocal fighting  
96 (e.g. genetic correlation with count of lesions to the front third of the body 0.67, SE  
97 0.04; Turner *et al.*, 2009). However, recording lesion numbers for all selection  
98 candidates remains a barrier to implementation. ~~and~~ ~~e~~Current effort to understand  
99 the genomic architecture of aggressiveness may provide the means to avoid routine  
100 phenotyping and facilitate implementation of selection.

101

102 **Future perspective and conclusion**

103 Modern breeding tools will increase the accuracy of selection whilst facilitating the  
104 improvement of traits that are difficult or costly to routinely record. With this, the  
105 feasibility is being enhanced of using selection alongside improved management to  
106 make positive progress in addressing some of the most intractable welfare problems.

107 The remaining barriers to implementation vary by industry and trait, but share  
108 common themes. Better estimation and communication of the total economic and  
109 non-economic costs associated with specific welfare conditions is required to  
110 motivate change. Phenotyping costs, even in the genomic era, will remain  
111 prohibitive unless rapid but sensitive indicator traits are developed similar to those  
112 given in the examples above. Lastly, the correlated consequences for economic and  
113 other welfare-relevant traits needs to be assessed for most of the welfare traits that  
114 may be targeted for improvement. These barriers need to be addressed in  
115 partnership with the breeding industry and farmers. To realise benefits in welfare,

116 selection of animals that are more able to thrive in commercial production systems  
117 must not simply allow management to deteriorate such that the net outcome for the  
118 animals remains unchanged. With modern breeding techniques comes the attendant  
119 risk of accelerating unwanted change and a need to fully assess the correlated  
120 consequences for the animals. To return to the example of pig aggression, we have  
121 shown that reduced aggressiveness is not associated with activity levels or a  
122 tendency to lose fights, but are yet to probe the affective state of pigs that do not  
123 engage in fights. It is plausible that these animals do not feel the motivation to fight,  
124 are better able to avoid unnecessary fights or are afraid of fighting, each of which  
125 have different implications for their likely affective state. Whether selection will be

126 successful and justifiable will probably have to be assessed on a case by case basis.  
127 Examples exist in which progress has been made in simultaneously benefitting  
128 animal welfare and economic productivity through broader breeding goals, for  
129 example through the Profitable Lifetime Index in the UK dairy industry that places  
130 selection pressure on resistance to mastitis and lameness in addition to production  
131 traits. The decision on whether to target welfare traits through breeding is likely to  
132 be easier for some cases (e.g. neonatal survival) than others (e.g. complex social  
133 behaviours) and to be acceptable to different degrees by retailers and consumers.  
134 However, where economically feasible management solutions and legislation alone  
135 have proved incapable of improving long-standing, routine and serious welfare  
136 issues, selective breeding may have a future role alongside continued efforts to find  
137 effective management solutions.

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151 of aggressiveness and the relationship with injuries under more stable social conditions.

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156 **Figure 1** Frequency distribution of the number of fresh skin lesions present on pigs  
157 24 hours after regrouping into new social groups. The number of lesions has been  
158 genetically associated with involvement in reciprocal and non-reciprocal aggressive  
159 behaviour (Turner *et al.*, 2009).

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