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Review

General Principles for the welfare of animals in production systems: The underlying science and its application

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ABSTRACT

In 2012, the World Organisation for Animal Health adopted 10 'General Principles for the Welfare of Animals in Livestock Production Systems' to guide the development of animal welfare standards. The General Principles draw on half a century of scientific research relevant to animal welfare: (1) how genetic selection affects animal health, behaviour and temperament; (2) how the environment influences injuries and the transmission of diseases and parasites; (3) how the environment affects resting, movement and the performance of natural behaviour; (4) the management of groups to minimize conflict and allow positive social contact; (5) the effects of air quality, temperature and humidity on animal health and comfort; (6) ensuring access to feed and water suited to the animals' needs and adaptations; (7) prevention and control of diseases and parasites, with humane euthanasia if treatment is not feasible or recovery is unlikely; (8) prevention and management of pain; (9) creation of positive human–animal relationships; and (10) ensuring adequate skill and knowledge among animal handlers. Research directed at animal welfare, drawing on animal behaviour, stress physiology, veterinary epidemiology and other fields, complements more established fields of animal and veterinary science and helps to create a more comprehensive scientific basis for animal care and management.

Introduction

In 2012, the 178 member nations of the World Organisation for Animal Health (also known by its French acronym Office International des Epizooties, OIE)[1] adopted 10 'General Principles for the Welfare of Animals in Livestock Production Systems' to guide the development of specific standards for various animal species (OIE, 2012). Although stated in simple terms, the General Principles draw on half a century of rapidly increasing scientific research relevant to animal welfare.

Animal welfare science emerged as an interdisciplinary field of research in the 1970s (Duncan, 1970; Wood-Gush et al., 1975; Dawkins, 1977). The initial stimulus for this work came from public concern over the welfare of animals kept in the then-new confinement production systems. Early research that explicitly addressed animal welfare was largely based on the fields of animal behaviour (Broom and Fraser, 2007) and stress physiology (Broom and Johnson, 1993), but the relevance of many other fields was quickly recognized. These include veterinary epidemiology, environmental physiology, environmental design, comparative psychology and studies of the behaviour of animal handlers, along with conventional fields such as nutrition and microbiology (Fraser, 2008; Mellor et al., 2009; Appleby et al., 2011).

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[1] See http://www.oie.int/en.

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Although the research was originally intended to resolve problems in confinement production systems, many of the scientific methods and findings have proven applicable to animals in a wider range of circumstances. The General Principles were designed to capture and summarize the key insights arising from this research. This article uses the General Principles as a framework to illustrate the broad range of science relevant to animal welfare and its application to animal welfare standards and practices.

1. Genetic selection should always take into account the health and welfare of animals

Genetic selection has been used for millennia to improve the production traits of agricultural animals. Research on animal welfare complements this work by identifying and mitigating often-unintended health and other consequences of genetic change, and by identifying ways that selection can improve animal welfare.

Despite the gains in animal productivity that have been made, genetic selection for extreme production or physical traits can result in abnormalities that impair normal biological functioning. For example, genetic selection for 'double-muscling' in beef cattle breeds such as the Belgian Blue has led to greater risk of dystocia because fetal size is too large for the pelvis of the cow (Murray et al., 2002). Among dairy cattle that have been highly bred for milk yield, high milk production is associated with an increased incidence of fertility problems and metabolic disorders, such as ketosis (Erb et al., 1985).

Osteoporosis is widespread in commercial laying hens because genetic selection for high rates of egg laying have led to excessive loss of bone calcium that is repartitioned to egg shells (Whitehead, 2004; Webster, 2004). Osteoporosis increases the risk of fractured bones in caged birds when they are handled and in non-cage systems when hens fall or sustain injuries during flight (Lay et al., 2011).

The breeding of pigs for rapid growth and carcass leanness has led to increased osteochondrosis and leg weakness, and to changes in muscle composition that can impair the ability to withstand environmental stresses (Rauw et al., 1998). Piglet viability is also affected through reduced physiological maturity at birth, and concurrent selection for prolificacy has resulted in greater numbers of litter-mates competing for teats (Edwards, 2002). Selection of pigs for rapid muscle deposition has also been linked to 'tail-biting', whereby pigs chew or bite the tails of others in the group to the point of causing injury (Breuer et al., 2005).

Intense genetic selection can also contribute to abnormal behaviour in birds. Selection of broiler chickens for fast growth has resulted in increased appetite (Siegel and Wisman, 1966), such that birds kept for breeding need to be feed-restricted to prevent obesity and reproductive failure (Mench, 2002; de Jong and Guémené, 2011). Birds on such limited diets show signs of chronic hunger, including pacing, stereotyped pecking, and excessive water intake (Savory and Maros, 1993).

Despite such challenges, there are positive examples of genetic section being used to promote animal welfare. In pigs, active selection against the 'halothane gene' has reduced stress-susceptibility and malignant hyperthermia (Wendt et al., 2000). Breeding dairy cattle for disease resistance, ease of calving and fertility can improve animal welfare, while arguably giving better economic returns than breeding for high milk production alone (Lawrence et al., 2004). Techniques such as quantitative trait locus mapping provide new opportunities to select against problematic behaviour, such as feather-pecking in chickens (Jensen et al., 2008). The application of group selection to reduce social behaviour problems in laying hens has resulted in strains that can be kept in cages with minimal pecking damage (Muir and Craig, 1998). These same methods can reduce aggression and competition for feed (Bell et al., 2004; Thogerson et al., 2009). Genetic selection can also help to eliminate the need for painful procedures. For example, selective breeding of cattle for the 'polled' (hornless) allele avoids the need for surgical dehorning (Stookey and Goonewardene, 1996).

Good animal welfare also requires a satisfactory match between genetics and the environment. In tropical and sub-tropical environments in Asia and Africa, indigenous breeds of chicken perform better than commercial lines because of their greater tolerance for high temperatures and tropical diseases (Dana et al., 2010; Dessie et al., 2011). Similarly, cattle indigenous to the tropics (*Bos indicus*) are well adapted to hot, humid environments and exhibit resistance to tropical diseases, including trypanosomiasis (Mirkena et al., 2010). In contrast, European breeds (*Bos taurus*), when introduced to the tropics because of their high milk yield potential, tend to have higher mortality rates and poorer reproductive performance than indigenous breeds because of their more limited ability to adapt to tropical climates, feeds and diseases (Pearson de Vaccaro, 1990; Huertas et al., 2009). Breeding programmes have sometimes been used to improve the environmental fit of animals to such climates. For example, the Charbray and Santa Gertrudis breeds of beef cattle (crosses of *B. indicus* with Europe-sourced breeds) have been bred to suit hot environments (Porter, 2002).

2. The physical environment, including the substrate (walking surface, resting surface etc.), should be suited to the species and breed so as to minimise risk of injury and transmission of diseases or parasites to animals

Some of the earliest welfare concerns regarding production animals arose from an apparent mismatch between the animals' adaptations and the environments in which they were kept. Various research methods, including veterinary epidemiology (Ekesbo, 1966), have been used to explore how an animal's environment influences its health.

Some environments contribute directly to injuries. Pigs in many confinement systems are kept on concrete floors which can cause pressure injuries, especially over bony protuberances such as the shoulders (Herskin et al., 2011). Leg injuries in suckling piglets appear to be caused by both abrasion and build-up of frictional heat when piglets scramble for access to the sow's udder on floors that do not provide sufficient traction (Phillips et al., 1992). 'Slatted' floors (with openings to allow feces to fall below) can cause hoof lesions, especially if slat dimensions and quality are inappropriate for the size of the animal (Kilbride et al., 2009).

Hoof disorders of dairy cattle in confinement systems are more likely on concrete (slatted or solid) floors than rubber floors (Fjeldaas et al., 2011). In pasture-based systems cows often traverse long distances (2–10 km per day) to reach the milking parlour; such travel can increase the risk of foot injuries and lameness, particularly when the terrain is rough and uneven (Martino et al., 2011).

Laying hens can develop several kinds of foot injuries related to the surfaces on which they stand and walk (Lay et al., 2011). Ulcerative pododermatitis is seen most often in hens housed in litter-based systems because of the presence of wet litter and feces. Hyperkeratosis is more common in birds held in cages; contributory factors include poor galvanizing of the cage floor and steep floor slope (Tauson, 1998; Weitzenbürger et al., 2006).

Environments can further compromise animal welfare if they promote the multiplication and spread of pathogens and parasites. Pathogens in soil, bedding and feed are important in the occurrence of listeriosis (*Listeria* spp.) and coxiellosis ('Q Fever', *Coxiella burnetii*) in sheep (Mearns, 2007; Scott, 2007). On dairy cattle farms, contamination with bacteria that cause mastitis tends to