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Trait selection and welfare of genetically engineered animals in agriculture

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ABSTRACT: The release of the Final Guidance from the US Food and Drug Administration on the commercialization of genetically engineered animals has sparked renewed discussion over the ethical, consumer, and regulatory implications of transgenesis in animal agriculture. Animal welfare critiques have focused on unexpected phenotypic effects in animals used in transgenic research, rather than on the health and welfare implications of the intended productivity enhancement. Unless breeding goals are redefined to reflect social concerns, the occurrence and magnitude of undesirable side effects may increase and consumer confidence in the nascent technology may be undermined.

Key words: bioethics, biotechnology, production disease, transgenesis, welfare

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INTRODUCTION

Philosophical, religious, and moral contentions that the genetic engineering of farm animals is intrinsically wrong have been dismissed as spurious and illegitimate (Rollin, 1986). Arguments based on the inviolate character of concepts such as animal integrity tend to fall prey to the naturalistic fallacy, in which "ought" is inferred from "is," and objections to "playing God" are considered similarly irreconcilable with standards of rational argument (Kaiser, 2005). Was it ungodly hubris to bring the *Variola* virus to veritable extinction or "one of the greatest triumphs in medicine" (Centers for Disease Control and Prevention, 2007)? In an analysis of concerns raised about transgenic animals published in *Livestock Production Science*, animal welfare was the only one deemed ethically significant (Sandøe and Holtug, 1993).

FOCUSING ON THE INTENDED CONSEQUENCES

To date, reviews of the welfare implications of farm animal transgenics have tended to focus on the use of in vitro reproductive biotechnologies and the phenotypic effects of the nascent technology on the animals used in research themselves (De Boer et al., 1995; Van Reenen et al., 2001). Random insertional mutations, ectopic transgene expression, and unforeseen epigenetic changes may result in congenital abnormalities and elevated perinatal mortality. Using the most commonly used method, usually only 1% of attempts to create transgenic animals are successful (Whitelaw et al., 2008), an order of magnitude less that of nontransgenic embryos derived from in vitro fertilization (Dinnyes et al., 2008).

The first report of the successful creation of transgenic farm animals has been used by previous critics as the primary example for more than 20 yr to condemn this practice on animal welfare grounds. The Beltsville pigs were engineered at a USDA research station in Beltsville, MD, to express human GH to boost productivity (Hammer et al., 1985). A modest improvement in feed efficiency was offset by myriad physical abnormalities. Lethargy, lameness, exophthalmos, skin thickening, and an uncoordinated gait were clinically associated with transgene expression, and postmortem gastric ulceration, severe synovitis, pericarditis, endocarditis, nephritis, and osteochondritis dissecans were among the gross and histopathological changes noted (Pursel et al., 1989). Several animals died during or immediately after confinement in a restraint device, suggesting an increased susceptibility to stress (National Research Council of the National Academies, 2002). Of the 19 pigs expressing the transgene, 17 died within the first year (Pursel et al., 1989).

The technology, however, has dramatically improved since those early experiments. Indeed, a report of regulated homologous GH transgene expression that proved successful without such adverse congenital effects was published as early as the subsequent year (Vize et al.,

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1988). More importantly, though, a reliance on laboratory "freaks" as the centerpiece of welfare critiques overlooks a much larger issue.

A focus on the unintended consequences has drawn attention away from the welfare implications of the intended consequences. It is arguably not the procedures for generating transgenic farm animals that deserve the greatest scrutiny, but instead the stated goals and outcomes. The primary goal set out for transgenic animals for food production has explicitly been to improve productivity (Ronningen, 1995; Pinkert and Murray, 1999) and economic fitness (Dickerson and Willham, 1983). This same priority has been applied historically using traditional methods of genetic selection to the detriment, in many cases, of animal health and welfare, exemplified by dystocia in double-muscled beef cattle, lameness, metabolic disorders, and mastitis in dairy cattle, porcine stress syndrome in pigs, osteoporosis and cloacal prolapse in egg-laying hens, and skeletal and cardiovascular disorders in turkeys and broiler chickens.

MEETING CONSUMER EXPECTATIONS

In a dismissal of the charge that biotechnology leads to the treatment of animals as mere commodities, Sandøe and Holtug (1993) assert that "there is already a tendency to treat animals as mere things in industrial farming." This does not justify further erosion of welfare considerations, but rather is a critical reflection on contemporary practices. One could imagine the public reaction to leaked plans to genetically engineer cattle so large their extraction required surgery or birds so top-heavy they could not mate or so rapidly muscled that the ability of billions to even walk was impaired. Few realize that this is already the case, products of conventional techniques of trait selection (Kestin et al., 1992; Rauw et al., 1998; Sanotra et al., 2001; Uystepruyst et al., 2002; Knowles et al., 2008). As public awareness of the realities of current animal agriculture practices and priorities grows, resistance to further genetic manipulation may follow.

In order for biotechnology companies to recoup their investments and for agribusiness corporations to sell transgenic products, a broad public acceptance is necessary. The most extensive international survey of public perceptions involved 35,000 residents of 35 countries in Africa, Asia, the Americas, Europe, and Oceania. Only 35% of global consumers were in favor of using biotechnology to increase farm animal productivity (Hoban, 2004). In the United States, the percentage of those who found it acceptable to use biotechnology to create faster-growing fish dropped from 32% in 1992 to 28% in 1994 and further to 23% in 2000 (Hoban, 2004). According to a nationwide survey conducted in 2003 by the Pew Initiative on Food and Biotechnology, 58% of Americans even oppose scientific research into the genetic engineering of animals (Pew Initiative on Food and Biotechnology, 2005).

At the same time there has been a groundswell in public awareness and scrutiny over the treatment of animals raised for food, accompanied by an explosion of agricultural animal welfare standards in recent years (Miele and Bock, 2007). According to a 2007 American Farm Bureau-financed poll, 95% of US households surveyed agreed with the statement "It is important to me that animals on farms are well cared for," and, furthermore, 76% disagreed with the statement "Low meat prices are more important than the well-being of farm animals" (Norwood et al., 2007). A 2004 survey from The Ohio State University found that 81% of Ohioans polled agreed or strongly agreed with the statement "The well-being of farm animals is just as important as the well-being of pets" (Rauch and Sharp, 2005).

The Farm Bureau poll found that the majority of surveyed Americans oppose the way hundreds of millions of farm animals are raised every year in the United States. Only 31% agree that "Housing chickens in cages is humane," and 18% agree that "Housing pregnant sows in crates is humane." Three out of 4 Americans agree that they "would vote for a law in my state that would require farmers to treat their animals more humanely" (Norwood et al., 2007), a sentiment reflected in a 2008 Gallup poll recognizing widespread support for the passage of "strict laws concerning the treatment of farm animals" (Newport, 2008).

This emerging social ethic for the welfare of animals in agriculture could be an opportunity, rather than an impediment, for the biotechnology industry. A consumer backlash against biotechnology resulting from an application perceived to worsen the plight of billions of animals in agriculture could undermine confidence not only in the food system, but adversely affect the view of the public regarding medical applications of biotechnology and the science of genomics as a whole (Pew Initiative on Food and Biotechnology, 2005). According to a national survey and focus group discussions undertaken by the North Carolina Cooperative Extension Service, the least acceptable applications of biotechnology appeared to include genetically engineering farm animals for accelerated growth (Mench, 1999). By instead redressing the suffering and welfare concerns caused by conventional trait selection, the biotechnology sector could improve its public image and acceptance, as well as reduce the stigma hindering progress. Examples by which welfare could be improved by biotechnology include the creation of hornless cattle to eliminate painful dehorning practices (Rollin, 1995) and transgenic sex selection in the egg industry to spare hundreds of millions of males chicks in the United States death by maceration, gassing, slow suffocation, or dehydration (Fraser et al., 2001). Concurrently, animal agribusiness could address societal concerns regarding farm animal welfare while potentially expanding its market share.

As the complete genomic sequences of all animals used in agriculture become available, there will be an increasing need for guidelines and guidance as to what is ethically permissible. Rollin introduced the concept

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of conservation of welfare as a guiding principle: When genetically engineering animals, the transgenic animals should be no worse off than their parents were (Pew Initiative on Food and Biotechnology, 2005). Given the volume of current suffering imposed by conventional selection, though, perhaps a remediation principle would be more appropriate than arguing for the status quo. Society could mandate that transgenesis for increased production require that the resulting farm animals be better off than their parents. Equipped with such powerful new tools, animal agriculture could use biotechnology to bring itself more in line with rising societal expectations for farm animal care. Under either guiding principle, the debate over transgenic farm animals may bring to light the excesses of the current breeding paradigm and compel the meat, egg, and dairy industries to revisit practices and priorities so far taken for granted.

CONCLUSIONS

The independent Pew Commission on Industrial Farm Animal Production was formed to conduct a "comprehensive, fact-based, and balanced examination of key aspects of the farm animal industry" (Pew Charitable Trusts and the Johns Hopkins Bloomberg School of Public Health, 2006). The joint project of The Pew Charitable Trusts and the Johns Hopkins University Bloomberg School of Public Health was composed of 15 commissioners, including former US Secretary of Agriculture Dan Glickman, former Assistant Surgeon General Michael Blackwell; James Merchant, then dean of the University of Iowa College of Public Health; and former Kansas Governor John Carlin as chair. After a 2.5-yr examination, its 2008 report concluded, "The present system of producing food animals in the United States is not sustainable and presents an unacceptable level of risk to public health and damage to the environment, as well as unnecessary harm to the animals we raise for food" (Pew Commission on Industrial Farm Animal Production, 2008).

In addition to creating some of the worst global animal welfare problems (Broom, 2000), the productionist paradigm of more is better has resulted in undesirable effects on animal behavior, physiology, and health, as well as genetic diversity and the environment (Fisher and Mellor, 2008), among other sectors. In its report, the Committee on Defining Science-Based Concerns Associated with Products of Animal Biotechnology of the National Academy of Sciences and National Research Council expressed concern that certain animals in agriculture may have already been pushed too far down the welfare/productivity continuum: "Indeed, it is possible that we already have pushed some farm animals to the limits of productivity that are possible by using selective breeding, and that further increases only will exacerbate the welfare problems that have arisen during selection" (National Research Council of the National Academies, 2002). There are currently no statutory or regulatory constraints on what can be done in pursuit of increasing agricultural animal prolificacy (Rollin, 2007).

Given the mass consolidation of animal agriculture, breeding decisions and practices have the potential to rapidly affect the welfare of animals on a global scale, for better or for worse. Currently, musculoskeletal abnormalities, metabolic problems, and immune deficiencies have been viewed as speed bumps on the "road to the biological maximum" (Buddiger and Albers, 2007). Biotechnology could be used to redress some of the inbred animal "illfare," but with the track record of the industry, the addition of transgenetic tools may just reinforce current practices. Given the existing epizootics of production-related diseases associated with traditional techniques of genetic manipulation (Rauw et al., 1998), with the same trait selection priorities genetic engineering may simply make animal suffering more profitable with the potential of adversely affecting the welfare of billions of animals every year (Thompson, 1997).

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