BIOETHICS SYMPOSIUM: The ethical food movement: What does it mean for the role of science and scientists in current debates about animal agriculture?1

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ABSTRACT: Contemporary animal agriculture is increasingly criticized on ethical grounds. Consequently, current policy and legislative discussions have become highly controversial as decision makers attempt to reconcile concerns about the impacts of animal production on animal welfare, the environment, and on the efficacy of antibiotics required to ensure human health with demands for abundant, affordable, safe food. Clearly, the broad implications for US animal agriculture of what appears to be a burgeoning movement relative to ethical food production must be understood by animal agriculture stakeholders. The potential effects of such developments on animal agricultural practices, corporate marketing strategies, and public perceptions of the ethics of animal production must also be clarified. To that end, it is essential to acknowledge that people’s beliefs about which food production practices are appropriate are tied to diverse, latent value systems. Thus, relying solely on scientific information as a means to resolve current debates about animal agriculture is unlikely to be effective. The problem is compounded when scientific information is used inappropriately or strategically to advance a political agenda. Examples of the interface between science and ethics in regards to addressing currently contentious aspects of food animal production (animal welfare, antimicrobial use, and impacts of animal production practices on the environment) are reviewed. The roles of scientists and science in public debates about animal agricultural practices are also examined. It is suggested that scientists have a duty to contribute to the development of sound policy by providing clear and objectively presented information, by clarifying misinterpretations of science, and by recognizing the differences between presenting data vs. promoting their own value judgments in regard to how and which data should be used to establish policy. Finally, the role of the media in shaping public opinions on key issues pertaining to animal agriculture is also discussed.

Keywords: animal agriculture, antibiotics, ethics, environment, media, welfare

INTRODUCTION

In the United States, debate continues about the social responsibility and overall sustainability of the current prevailing model of intensive, large-scale animal agriculture. Popular press depictions of this model ubiquitously represent it as “factory farming,” the term coined in 1964 by Ruth Harrison in her book Animal Machines, which suggests modern agriculture is irresponsible, unsustainable, unpalatable, and unsafe (Harrison, 1964). Concerns about the well-being of animals, food safety, worker health and safety, and negative environmental impacts are typically cited as supporting evidence of the inherently unethical nature of factory farming (Fraser, 2001). Unsurprisingly, grassroots efforts to promote alternative forms of animal production are underway.

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The evolution of a new ethical food movement is now evident in what appears to be rapidly growing numbers of food activists: locavores, animal protectionists, environmentalists, and members of the human health community opposed to conventional animal agriculture. The rise of such “ethical consumerism,” defined by Singer and Mason (2006) as an interest in the way in which food is produced, the practices employed, and a concern for low environmental impact, high animal welfare, and optimal worker conditions, is considered to be increasing, particularly in developed Western nations. Consumers in such countries are therefore drawn toward food production systems that fulfill their perceptions of environmental stewardship, which tend to favor extensive production systems supplying niche markets with labels including “traditional,” “organic,” “natural,” and other attributes (Harper and Makatouni, 2002) that imply that they are de facto ethically and scientifically superior. Survey data from Oregon State University (Raab and Grobe, 2005) indicate that consumers associate organic production with positive attributes such as “chemical-free,” “healthier and more nutritious,” “earth-friendly,” and “fresh.”

Accordingly, those charged with policy-making and legislation in regard to animal agriculture currently face pressure to either defend and uphold existing animal agricultural practices or make decisions aimed at appeasing those who criticize conventional agriculture and seek to promote alternative production practices (Mench et al., 2008). For example, individual states and private industry in the United States have been pressured to move toward alternative forms of housing that permit greater freedom of movement for animals. Such systems are often represented as more ethically and socially responsible than conventional confinement systems (Croney and Millman, 2007; Croney and Anthony, 2010). This, however, oversimplifies the complex nature of determining what constitutes socially acceptable, sustainable food production practices. In this regard, clearly the welfare of farm animals is a key issue that requires due consideration. However, myriad other factors alluded to earlier (e.g., food safety and access via affordable pricing, well-being of workers, economic security for food producers and rural communities, and environmental soundness) are inextricably linked with animal care and welfare decisions that must also be taken into account. Changes in any of these dimensions inevitably affect the others, making it essential to fully comprehend the broad impacts of decisions based on assumptions about which of these factors takes priority over others.

Further compounding the issue is the fact that policy makers, who require sound scientific information on which to base their decisions, are likely to encounter overwhelming amounts of information in some areas, shortages in others, and conflicting interpretations of the existing science (Croney and Millman, 2007; Swanson, 2008). Consequently, it may become difficult to sift through the available science and determine the extent to which claims made about conventional and alternative agriculture are accurate, and which of the embedded issues are most important to address because they are significant drivers of decisions on food animal production and processing. Recently, concern has grown that those attempting to regulate US farm animal production may discard science entirely in favor of making concessions intended to appease certain stakeholders. This approach has many troublesome implications.

It is therefore critical to address what appears to be growing public demand for a different model of production while ensuring that decisions are scientifically and ethically grounded, and that there is a holistic understanding of the consequences of these decisions on animals and society. To do so, it is important to understand the bases of the ethical food movement, and the roles of key entities, including scientists, various stakeholders, and the media in establishing acceptable practices and food policies.

THE ROLE OF SCIENCE AND SCIENTISTS IN CURRENT ANIMAL AGRICULTURAL DEBATES

Perhaps the most common response to socio-ethical concerns raised about contemporary large-scale animal agriculture is that policies must be based on science. Such statements imply that science is rational, objective, and value-free, whereas ethical considerations are emotional and perhaps meritless (Croney and Anthony, 2010). However, it is well documented that scientists often fail to recognize the role of values in their decision-making and assessments of risk (Tannenbaum, 1991; Fraser, 2003), and that decisions about value-laden concepts such as animal welfare or other contentious issues facing animal agriculture cannot be made on the basis of science alone (Tannenbaum, 1991; Thompson, 1993; Fraser, 2000; Lackey, 2007). The view that science alone can and should inform policy also fails to acknowledge the constraints of science. Although science can help to gauge the risks of decisions, such as the effects of using antibiotics in food animals, it cannot decide what level of risk is acceptable for the various stakeholders that are affected (Swanson, 2003). In other words, questions about how we should care for animals or the environment fall outside the purview of pure science and into the realm of applied ethics (Croney and Anthony, 2010). The kinds of issues we address in this paper can be thought of as “wicked” problems, which are problems that pose ambiguities in terms of underly-
ing definitions, lack clear standards for solutions, and involve significant disagreement among stakeholders (Swanson et al., 2011).

In addition, the role of the scientist in establishing contemporary food policy requires deliberation. Increasingly, animal scientists and their work are co-opted into policy debates in ways that can lead to polarization and further confusion on key issues. Such problems are compounded when scientists, special interest groups, and others misrepresent relevant findings by “cherry picking” the existing literature on a topic, omitting findings that contradict their views, overemphasizing results that support their positions, or misrepresenting the data and its interpretation. In this regard, scientists may become complicit in promoting a particular agenda. Some may advance to openly advocating for their personal positions on issues, a pattern that is increasingly seen and sometimes encouraged (Marris, 2006; Scott et al., 2007) even though many view this behavior to be inappropriate. Nevertheless, it is a potential conflict of interest to try to present unbiased science and also advocate for a personal policy preference (Mills, 2000), so unless the scientist is transparent and honest in such an endeavor, the risk of unethical behavior is great.

Consequently, the ability of scientists (and scientific information) to become constructive contributors to policy information may be undermined if the science presented is replete with policy preferences reflective of personal values (Lackey, 2007). Care is especially needed when scientists are asked to present data on contentious subjects in which conflicting values, ideologies, and priorities are embedded (Lach et al., 2003; Pielke, 2004; Lackey, 2007). Given these concerns, some scientists may resist becoming involved in policy and public debates. In fact, many are reluctant to contribute to ongoing discussions beyond publishing their work in scholarly journals (Lach et al., 2003). Involvement with policy issues by inexperienced young scientists may be especially risky because loss of perceived credibility and objectivity is high if they are not clear about the roles of both science and policy (Lackey, 2007). Untenured scientists are particularly vulnerable when they present perspectives that may be unpopular or not clearly justified.

Lackey (2007) suggests that scientists must be clear about the boundary between scientific knowledge and value judgments. Although scientists should promote the importance of technical information, they must also be aware that, especially in a pluralistic society, scientific information represents only one of many elements or ways of knowing with regard to policy deliberations (Thompson et al., 2011). Thus, the scientist who chooses to advocate personal policy preferences has a responsibility to ensure transparency by acknowledging that they have moved beyond a purely scientific role. Lackey (2007) notes that in “playing the role of policy advocate, be aware that your values and preferences inherently are no more (or less) important than other participants in the policy debate. To do otherwise is to corrupt both the political process and scientific enterprise (p. 16). Expanding further, Nelson and Vuetic (2001) observed that, “Justified advocacy is a policy position whose argument is clearly and thoroughly presented. Transparent advocacy occurs when advocates advance arguments they believe are sound and valid. That is, they do not use arguments they believe may affect policy at the expense of arguments they believe to be sound and valid” (p. 10).

Scientists should have a role in helping to develop sound policy by providing clear and objectively presented information. Doremus and Tarlock (2005) assert that scientists have an obligation to objectively address misrepresentations or inaccurate interpretations of science, especially when these are used to provide support for policy development. However, it is essential that the role of scientists as honest brokers of truth be upheld, particularly at times when special interest groups may simultaneously present incomplete, inaccurate, polarized versions of science. Failure to provide a balanced analysis of inaccurate information may be seen by some as facilitating misinformation, which is an ethical problem for university personnel or those in positions of responsibility in the government. As debate rages in several key areas of animal agriculture, such as animal welfare, the use of antibiotics, and environmental impacts of different production systems, it is essential for scientists to retain objectivity, and in so doing, retain their credibility. As stated by Nelson and Vuetic (2001), there is a difference between science and advocacy, which should be duly noted and maintained. Scientists must, therefore, avoid inadvertently helping to marginalize their roles and the role of science in policy development by participating in the misuse of data.

**ANIMAL WELFARE WHAT ARE THE SCIENTIFIC AND ETHICAL ISSUES?**

Like the other topics discussed in this paper, animal welfare is not just a scientific issue. It is also a social issue that involves consideration of people’s attitudes about the appropriate treatment of animals. Scientists can evaluate the welfare of animals in different housing systems or under different management conditions by measuring various aspects of the animals’ behavior, physiology, health, and productivity. However, the interpretation of the relative importance of these measures is ultimately based on values (Fraser, 1995). Because of this, well-informed and well-intentioned people can legitimately disagree about the implications of scientific findings. For example, producers tend to weigh information about production and
health more heavily than information about behavior, whereas animal protection groups tend to focus on behavioral outcomes. Thus, producers will often favor housing systems that promote good health and production status even if those systems involve a significant degree of restriction of animal movement, whereas animal protection groups generally favor more extensive housing systems, even if these involve some cost to the health status or productivity of the animal. Scientists themselves can also disagree about the implications of various measures. Fraser (2003) describes a recent example involving 2 groups of scientists reviewing essentially the same literature on the use of gestation crates for sows, but arriving at 2 different conclusions about their acceptability. The key difference in this situation was not a difference in science, but a difference in values and how those values affected the risk-assessment process carried out by the 2 groups.

**What did They just Say? the (Mis)Representation of Science in Debates about Animal Welfare**

There have been numerous attempts to develop quantitative methods for animal welfare risk assessment (Swanson et al., 2011), but ultimately all of these still involve value judgments. In addition, animal welfare science is a relatively new discipline, and there is much that is still unknown or contradictory (Dawkins, 1997). This means that there is significant scope for scientific information to be misrepresented to advance particular agendas. This misrepresentation can take (and has taken) many forms. Among these are presenting opinions of scientists or other experts but using selective quotations that have been filtered so that they appear to support the perspective of the advocates even though the experts themselves are on record as having a more nuanced or sometimes an entirely different point of view; presenting a scientific opinion but adding extreme and emotive language that was not used by the scientist; and ignoring papers, reports, conclusions, or expert opinion that do not support the desired policy outcome while exaggerating the scientific evidence supporting that outcome.

The irony for scientists involved in these kinds of contentious debates is that their work and opinions seem to matter; various organizations now routinely commission or produce scientific reports to bolster their claims [e.g., reports on various topics on the website of the Humane Society of the United States (HSUS); http://www.humanesociety.org/]. In addition, academic experts are considered by the public to be highly credible sources of information about farm animal welfare, more credible than producers or animal advocacy organizations (http://www.foodintegrity.org/page/research). This means that parties that may be less trusted value having scientists make their case for them. As previously discussed, scientists should be, but are not always, transparent if they choose to take an advocacy role. The danger in the current climate surrounding animal welfare, however, is that scientists may be perceived as advocates of a particular view even if they are not. Ultimately, such perceptions can only serve to undermine the role and credibility of scientists as purveyors of information in any animal welfare policy-making process.

How, then, can scientists effectively address such misrepresentations and inaccuracies and find an appropriate role for science in the farm animal welfare policy debate? This question is made more complex because of the lack of any kind of established national animal welfare decision-making framework in the United States. Unlike in Europe, there is no national or federal regulation of the housing or management of animals on commercial farms. Instead, the predominant approach has been market-driven, involving niche marketing of “humanely raised” products, producer standards and certification, and auditing programs by retailers (Mench, 2003; Mench et al., 2008). Although pressure on retailers from animal advocacy groups stimulated the development of many of the retail programs, scientists were typically influential participants in developing many of the standards underpinning these programs (Mench, 2003; Mench et al., 2008); one could argue that this scientific information was sometimes not well enough balanced by the input of other critical stakeholder groups.

Although this market-based approach has been very successful in driving change, it is not a perfect driver. Niche marketing programs tend to appeal to a relatively small percentage of consumers, and at present there is a great deal of variation among retailers and commodities with respect to the level of detail, the enforcement, and the transparency to consumers of their animal welfare standards. With regard to retail programs, changes also tend to be somewhat conservative because of the shared economic interests of producers and retailers.

Frustrated with the scope and pace of change, and with the obstacles to the introduction of federal regulation, animal advocacy groups began initiating state-by-state regulation, generally using voter initiatives (Mench et al., 2008). This approach has certainly led to dramatic change, but also a patchwork of conflicting standards, animosity among stakeholders, and litigation. This is nowhere more evident than in the current situation regarding housing of egg-laying hens (Mench et al., 2011). The first major state ballot initiative affecting hen housing was California Proposition 2, which, when passed in 2008, laid out a performance standard that stated that hens had to be able to fully extend their wings without touching each other or the sides of their enclosures. This resulted in heated debate and impending lawsuits related to how much space producers will be required.
to provide and even what types of housing systems will be allowable as of the 2015 effective date. Agreements made more recently in Michigan and Ohio to forestall similar ballot initiatives further complicated the issue, resulting in a requirement of a minimum of 1.0 square feet of usable floor space per hen in Michigan (http://www.legislature.mi.gov/documents/2009-2010/publicact/pdf/2009-PA-0117.pdf), and on average, 67 in² for hens kept in battery cages or open floor systems in Ohio (Ohio Department of Agriculture, 2011). Given that the hens are of the same strains and used for the same purposes, there is no scientific justification for these differences in standards.

Even more troubling, as of 2011, although the rules of the Ohio Livestock Care Standards Board (created in 2008 via an animal industry-led ballot initiative) prohibit new egg facility applicants from using conventional cage systems, existing facilities that use such cages are not only permitted in perpetuity, but are also allowed to expand (Ohio Department of Agriculture, 2011). Although this standard results from implementation of an agreement between Ohio commodity groups and the HSUS, the basis for its recommendation is unclear. If, for example, there is scientific consensus indicating that conventional battery cages do not afford acceptable levels of hen welfare, then allowing producers already using such cages to not only maintain, but also expand their use is logically inconsistent. If, as discussed previously, science should help inform our perspectives on our ethical obligations to animals, then it would follow that if science indicates that conventional cages substantially harm hen welfare, the morally correct action would be to phase out their use by all egg producers. The problem, however, is that science does not in fact show that cages are “bad” for birds. What it does indicate is that cages offer some welfare benefits in terms of hen health, but infringe on other aspects of hen welfare, particularly in terms of allowing hens to perform their natural behaviors (Lay et al., 2011). It would seem, therefore, that the standard derived in Ohio (and the different decisions arrived at in other states) primarily reflects not value-free science, but the latent value systems of the decision makers and political realities specific to each set of negotiations or interactions with activist groups and the public. These situations raise disconcerting implications for broadly addressing similar questions across the United States.

**Incorporating Science into Social Debates on Animal Care and Welfare Policy: How Can We Improve?**

When controversial issues within animal agriculture become litigious or driven by voter initiatives, direct scientific input into the policy process can effectively become marginalized, although scientists may have an indi-rect role. For example, to forestall further ballot initiatives and litigation, the United Egg Producers (UEP) and the HSUS recently agreed to seek federal regulation to ban the use of conventional cages (see http://www.unitedegg.org; http://www.humanesociety.org). This UEP/HSUS agreement contains provisions for ammonia concentrations, beak-trimming, molting, and euthanasia that were already part of the UEP Guidelines and were based on a literature review and recommendations by a scientific committee (Bell et al., 2004). The agreement allows enriched (furnished) cages, which will also be allowed in Europe after their 2012 conventional cage ban (Mench et al., 2011), and which have been endorsed by an European Union (EU) scientific advisory committee on hen welfare (http://www.laywel.eu). However, the stocking density that will be allowed in these cages under the UEP/HSUS agreement is less than the EU standards and appears again to be based on a political compromise rather than on scientific evidence. The lack of broad stakeholder representation into these kinds of agreements also can create a situation in which single-issue drivers, like animal welfare, force major changes in production systems without full consideration of the sustainability or consumer acceptability of those changes.

Given the current climate, scientific input into farm animal welfare policy in the United States would benefit greatly from the development of some kind of national mechanism for facilitating stakeholder input into the process of standards development or regulation. This would lead to a more open, consultative effort as well as a more broad-based approach that encompasses various aspects of sustainability (Swanson et al., 2011). Other countries have such mechanisms. For example, Canada and Australia have national codes of practice written by committees composed of producers, consumers, scientists, veterinarians, government representatives, non-governmental groups, and other appropriate stakeholders. The EU regularly seeks scientific input on animal welfare as part of its policy-making process by providing funding in targeted areas of need, commissioning expert reports, and holding stakeholder meetings to discuss proposed regulation. In this way, scientists are appropriately integrated into the policy process as one of the important stakeholders.

Regardless, on the issue of animal welfare, it is clear that no single factor or entity should be relied on to derive acceptable practices. Further, science alone cannot drive policies. However, to avoid the appearance that science alone has driven policy when other factors are also at work, as seems to have occurred with some recent hen housing legislation in the United States, it is imperative that authorities clearly convey the basis for their decisions, including the value systems and other factors that underlie them.
ENVIRONMENTAL ASPECTS OF LIVESTOCK PRODUCTION: WHAT ARE THE SCIENTIFIC AND ETHICAL ISSUES?

As farming systems and practices continue to come under increased scrutiny by stakeholders within the food production system, it is crucial for producers to demonstrate their commitment to environmental stewardship to maintain balance within the 3 interlocking components of sustainability: environmental stewardship, economic viability, and social license to operate (Klopfier, 2003). It is widely understood that improving efficiency reduces expense, resources, and waste; however, the US consumer often considers efficiency to have negative connotations when applied to food production (Capper, 2011a). As such, a growing challenge for animal agriculture is to address these concerns by demonstrating alignment between efficiency of food production and environmental sustainability.

As an example, niche marketers often target consumers who perceive extensive production systems as being earth-friendly by making claims about the environmental sustainability of their products. However, whole system analyses have demonstrated that, for example, the environmental impact of grass-fed beef production is considerably greater than that of contemporary feedlot beef systems (Capper, 2012; Pelletier et al., 2010) and that the move toward greater intensity of livestock systems has mitigated the carbon footprint (Capper et al., 2009; Capper, 2011b). A gap exists in either communication of this information to consumers or in their acceptance of the message.

The portrayal of the environmental impact of animals is also worth examination. Scientific consensus indicates that climate change is occurring as a consequence of increased quantities of greenhouse gas build-up within the atmosphere (Oreskes, 2004). The extent to which this is caused by anthropogenic activities is subject to considerable debate. Yet, even if the climate change argument is dismissed, there can be no doubt that the global population increase of more than 9 billion people predicted by 2050 will put considerable pressure on natural resources, specifically land, water, and fossil fuels.

In this regard, livestock production is often vilified and represented as a major, if not the primary, contributor to resource use and greenhouse gas emissions. The importance of reducing both resource input and waste output to mitigate the environmental impact of livestock production cannot and should not be underestimated. This is particularly crucial in areas where natural resources are scarce due to population demand or where resources have been affected by human activity to the extent that they are not usable for animal or human food production or maintenance of viable wildlife populations. Concerns, for instance, about the effects of exporting Western methods of livestock production in semi-arid climates, where water resources are scarce and where cultural and other important social factors may be infringed upon, must be given due consideration and be appropriately addressed.

It is important to recognize that all foods have an environmental impact, which varies according to resource use and waste output from the food production process. Decisions about which foods can and ought to be produced to meet global demands, irrespective of political instability that prevents food production and distribution or that results in a high poverty level, therefore, must be based on sound scientific as well as ethical assessment, rather than on ideology or simplistic representations of the issues involved.

For example, it is tempting to assess individual foods or food groups simply on the basis of carbon footprint, water use, or energy use per unit of food produced and to rank them accordingly. However, assessment on a unit weight or volume basis fails to account for the ultimate purpose of food consumption: to nourish. Thus, the environmental impact of foods should be compared on the basis of the nutrients that they provide within the human diet, with account taken of the by-products also produced for human or animal use. Consider, for instance, a recent report by the Environmental Working Group (2011a), which stated that beef has a carbon footprint of 27.0 kg of CO₂-equivalents per kilogram of consumed food compared with tofu (2.0 kg of CO₂-equivalents per kilogram of consumed food). Upon release of these results, media coverage concentrated on the suggestion that vegetarian diets were an environmentally superior choice and that reducing meat consumption (for example, via the “Meatless Mondays” campaign) would have beneficial environmental effects. In contrast, Smedman et al. (2010) compared the carbon footprint of various beverages and expressed the results as an index of nutrient density over greenhouse gas emissions. Within that study, milk had the highest ranking as a beverage choice with an index of 0.54 compared with 0.28, 0.25, and 0.001 for orange juice, soy drinks, and red wine, respectively. These indices illustrate that without due regard for the nutrient value of foods, comparing them on the basis of a single metric (e.g., carbon footprint), becomes meaningless. As a result, any policy derived solely on the basis of such singular considerations could be problematic.

What Did they just say? The Use and Misuse of Science to Frame Environmental Impacts of Livestock Production
Life cycle assessment (LCA) methodology is accepted by most environmental scientists as an accredited process for environmental impact assessment and is prescribed by the United States Environmental Protection Agency for such studies. However, as with any modeling research, the results are entirely dependent on the underlying assumptions. If these are incorrect, the results that emerge are meaningless at best, or misleading. This is particularly dangerous when results are used to guide public policy or consumer opinion. The aforementioned Environmental Working Group report is a good illustration of how methodological errors and assumptions relating to animal productivity may skew results and mislead readers. For example, when comparing the carbon footprint of beef and lamb, the Environmental Working Group (2011b) report did not consider the number of days required to grow a lamb from birth to slaughter weight, nor of the greater prolificacy of sheep (national lambing index of 1.38 lambs per ewe; USDA, 2003) compared with the national beef calving index of 0.87 live calves per cow (USDA, 2009). These are critical factors affecting the environmental impact of any livestock production system because as productivity (e.g., milk yield, litter size, growth rate) increases, resource use and carbon footprint are concurrently reduced (Garnsworthy, 2004; Capper et al., 2008, 2009; Capper, 2012; Pelletier et al., 2010). In combination with the apparent impartiality conferred by the authorship of Environmental Working Group report (as compared with a report from a livestock association or industry), the consumer would, therefore, be led to assume that choosing lamb over beef would have negative environmental consequences. Yet when productivity parameters are considered, the conclusion of the Environmental Working Group (2011a) that lamb has a carbon footprint that is 45% greater than that of beef is biologically implausible.

Similar criticisms can be applied to comparisons of water use by various food production systems executed by the Water Footprint Network (2011). In an article in the National Geographic magazine (2010), the Water Footprint Network’s calculations indicated that beef had a water use of 15,497 L/kg compared with pork (1,270 L/kg), chicken (280 L/kg), or apples (22.1 L/kg). The methodology behind the calculations was comprehensive, accounting for all water use within the production process, including precipitation, consumed water, and polluted water. Yet, the assumptions in the beef model for an industrial production system were based on an animal growing at 0.36 kg/d and therefore taking 3 yr to reach a slaughter weight of 430 kg, which is in contrast with the US average for 2010 of 14 mo at 590 kg of slaughter weight (1.34 kg/d growth rate). Less productive systems wherein cattle take a longer time to reach slaughter weight confer greater water use than more efficient systems. Productivity may be considered to be the major influencing factor in determining resource use for livestock production. For example, the Water Footprint Network’s figure of 15,497 L of water use per kilogram of boneless beef (National Geographic, 2010) is considerably greater than the 3,062 L/kg reported by Beckett and Oltjen (1993). The Beckett and Oltjen study reveals a more thorough understanding of productivity indices within beef production systems and uses published, region-specific data. By contrast, the Water Footprint Network report relies on assumptions with no clear source and that do not relate to actual or predicted data from US beef production systems.

**Incorporating Science into Social Debates on the Environmental impacts**

In summary, mitigating the environmental impacts of livestock production is essential to ensure that those members of the population who choose to consume meat, milk, and eggs can do so in an environmentally sustainable manner. The challenge to animal agriculture in general is to provide accurate data and information to inform the consumer and to identify those sources of information that appear to be scientifically valid, but are based on flawed assumptions. Given the importance of environmental impact research to consumer education and its role in facilitating informed dietary choice, it is also crucial for sound science on such topics to be translated from peer-reviewed scientific journals and disseminated to consumers and decision makers via press releases, media information, and popular press articles that can be easily comprehended by the public.

**THE USE OF ANTIBIOTICS IN FOOD-PRODUCING ANIMALS: WHAT ARE THE SCIENTIFIC AND ETHICAL ISSUES?**

The use of antibiotics in livestock production and their impacts on antimicrobial resistance, food safety, animal well-being, and the environment are vigorously debated today. As the debate spills over into the political arena, scientific principles are often reduced to sound bites augmented by superficial, agenda-driven presentations of selected data. Among the key topics of debate subject to biased interpretation are the impacts of modern production methods on incidence of disease, the quantity of antimicrobials used in animal agriculture, transfer of resistant bacteria and resistance genetics between animals and humans, and in vivo vs. in vitro pharmacodynamic properties of antimicrobials.

Two main positions appear to have emerged regarding the effects of antimicrobial use in livestock production. The first suggests that the use of antibiotics in livestock production has led to resistance to antimicrobials used in
human medicine. This viewpoint further suggests that this increases risk to the human population, and thus, action must be taken to limit and strictly regulate such uses in food animals. The second view indicates that there is resistance to antimicrobials used in human medicine, some of which may be attributable to their use in food animals, but there is little evidence that animal production practices are the major contributor to resistance or that serious harm or risk has been caused to the human population. Therefore, drastic action, such as severely restricting the use of antimicrobials in livestock production, is unwarranted (Turnidge, 2004). The debate over antimicrobial use in food animals does not focus on the legitimacy of the efficacy claims. Rather, the main issue is the perceived displaced risk of antimicrobial use in livestock onto the consumer, and whether the structure of modern animal agriculture is responsible for much of the need for antimicrobial intervention. Given these conflicting views, an obvious question arises for the layperson and the politician alike: which of these positions is accurate? Few issues of contention in animal agriculture better illustrate the concept that when there is sufficient information to support 2 sides of a policy debate, the question then shifts to the realm of ethics (Weaver and Morris, 2004; Croney and Millman, 2007). The subject of antimicrobial use in farm animals represents an area where trust in the information and those presenting it is critical, and where perception of risk is likely to be a strong influencer in forming an opinion and making a decision.

Concerns in the United States have probably been heightened by the fact that in an effort to mitigate antimicrobial resistance, the European Commission banned the use of antibiotics for the purpose of growth promotion in pig production as of January 2006 (European Commission, 2003). Subsequently, in 2008 the Pew Commission report on Industrial Farm Animal Production recommended banning “the non-therapeutic use of antimicrobials in food animal production to reduce the risk of antimicrobial resistance to medically important antibiotics and other antimicrobials” (Pew Commission on Industrial Farm Animal Production, 2008). In contrast to the EU, the United States has primarily taken the approach of collecting evidence that a problem has occurred before determining its course of action. However, this approach requires resistance to emerge, and some authors have stated that the potential amplification of this early resistance by human antimicrobial use can be problematic (Turnidge, 2004). Given that the European ban on prophylactic use of antibiotics was based on application of the precautionary principle, further pressure is put on US policy makers and members of the lay public to do likewise. Moreover, the potentially broad dispersal of risks across human and animal populations, as well as the environment associated with antimicrobial use, adds another layer of complexity. It is therefore unsurprising that proponents of the judicious use of antimicrobials and those concerned about the perceived risks associated with use of these in intensively reared food-producing animals might promote organic and other alternatively labeled foods as better, more sustainable, or more socially responsible choices. To critically evaluate what US policy ought to be on the use of antimicrobials in livestock production, however, requires understanding of the scientific basis for the debate.

The Use and Misuse of Science in Understanding Risks and Developing Sound Policy Relative to Antimicrobial use in Livestock and Poultry

Chickens, pigs, and cattle reared in large-scale intensive systems in the United States are often exposed to antibiotics for purposes of promoting growth, controlling subclinical disease, preventing clinical disease, and treating clinical disease. As such, a major point of debate centers around whether or not there is sufficient evidence of a smoking gun linking food animal antimicrobials to lack of therapeutic antimicrobial efficacy in humans. Running parallel to this debate is the issue of how much evidence is needed for legislative bodies and regulatory agencies to act in a manner that protects public health.

Understanding the breadth of effects of the use of antimicrobials in animal agriculture requires evaluation of existing risk assessments, resistance surveillance data, and studies related to antimicrobial selection pressures. Unfortunately, significant data gaps exist, and data-gathering mechanisms are sometimes more advanced than our interpretive abilities. As the agency responsible for approval of veterinary antimicrobial drugs, the US Food and Drug Administration Center for Veterinary Medicine (FDA-CVM) has described their current thinking related to microbial safety in the drug approval process in Guidance Documents 152 and 159 (FDA-CVM, 2003, 2011). These documents are pivotal to new antimicrobial drug approval for food animals and demonstrate the components considered in evaluating the use of antimicrobials in food animals.

Guidance Document 152 “outlines a risk analysis, and describes its application as a process for evaluating human food safety with respect to the potential microbiological effect of antimicrobial new animal drugs on food-borne bacteria of human health concern.” In this case, the hazard is defined as human illness caused by an antimicrobial-resistant bacteria attributable to an animal-derived food commodity and treated with the human antimicrobial drug of interest. Guidance 159 outlines proposed methods to establish a microbiological acceptable daily intake based on potential exposure to residues of an antimicrobial drug used in food animals.

A notable deficiency in these 2 documents is the lack of ability to evaluate and consider the benefit of utilizing antimicrobials in food animal production. A balance of
risk vs. benefit is needed in the regulatory process. Lack of consideration here may lead to adverse effects on both animal and human health by restricting or prohibiting antimicrobial use based on a perceived human health risk that is, in fact, less than the adverse effect of removing the antimicrobial from use. In fact, Casewell et al. (2003) noted that the European ban on subtherapeutic antimicrobials has revealed that they played what was probably an important role in prophylaxis that was probably not fully realized. After their withdrawal, deterioration in some aspects of animal health and well-being has been observed, such as increased diarrhea, BW loss, and mortality in young pigs, and clostridial necrotic enteritis in broilers. Further, despite attempts to address additional aspects of husbandry that are pertinent to sustaining animal health, therapeutic use of antibiotics that are also used in human medicine has since increased (Casewell et al., 2003). Troubling occurrences such as these are relevant to US policy development in regard to both scientific and ethical responsibility. 

While attempting to balance the welfare of animals and potential impacts of food animal antimicrobial use on human health in the United States, another portion of the debate has expanded to encompass the contribution of production system design to the potential for disease, which then necessitates the use of antimicrobials.

**Judicious Use?**

Recently, the FDA-CVM has proposed to eliminate most of the uses of antimicrobials for improvement in rate of BW gain or feed efficiency, as outlined in FDA-CVM Draft Guidance 209 (FDA-CVM, 2010). This action assumes that the shortest and longest antimicrobial exposures are primary drivers for resistant subpopulation selection in food animals, and that elimination of these antimicrobial uses would have a substantial impact on reducing antimicrobial resistance in food animals. However, these assumptions are often based on generalized pharmacodynamic principles from other antimicrobial class members or other bacteria or both. Without proper evidence for these assumptions, there is danger of setting a precedent for the future regulation of prevention, control, and therapeutic uses of antimicrobials that is not based on scientific evaluation of risk and benefit, but rather on latent dogmatic assumptions about length and extent of exposure, as well as on political pressure.

An evaluation of the extent and legitimacy of the peer-reviewed literature is beyond the scope of this paper. However, the FDA-CVM Draft Guidance for Industry #209 provides 15 examples of reports from groups that have attempted to come to a consensus on the available data (FDA-CVM, 2010). An example of different views of the data is provided by evaluating the Pew Foundation report on industrialized animal agriculture (Pew Commission on Industrial Farm Animal Production, 2008) and the response of the American Veterinary Medical Association to this report (AVMA, 2009).

Even when relying on peer-reviewed data, one of the challenges in the interpretation of antimicrobial effects on enteric flora is the use of the “percent resistant” outcome parameter. Reliance simply on the percent resistant in a population ignores overall population effects and may overestimate the effect of an antimicrobial on the prevalence of resistant organisms in fecal flora. The typical evaluation of changes in a proportion of resistant bacteria in an enteric population is well versed in determining the numerator related to the number of resistant bacteria isolated, but very inadequate in determining the appropriate denominator. In other words, we can count the proportion of resistant isolates from a sample (i.e., the numerator) and compare it with the total number of isolates evaluated in the sample (i.e., the denominator), but much additional work is needed to determine the actual numerical changes in the enteric population. An increase in percent resistant bacteria can occur in a sample of a specific enteric organisms without an overall increase in the number of resistant bacteria if the number of susceptible bacteria in the population has decreased. The 2 interpretations are dramatically different in regard to the potential transfer of a resistant organism to humans.

**Incorporating science into social debates on the use of antibiotics in food producing animals: Finding Resolution**

A first-step solution for overgeneralized statements regarding the cause of antimicrobial resistance for human challenges is to relegate discussions to specific pathogens coupled with food animal antimicrobial regimens of concern and the proposed effects on human health. A second step would be for reporters to increase diligence in reporting to avoid perpetuating public confusion about antimicrobial use in food animals. Scientists and veterinarians with expertise on this topic could facilitate such efforts by making themselves and the literature more accessible to members of the media, including summarizing and highlighting areas of contention that are easy for laypersons and decision makers to misunderstand.

Regardless of differing representations of science on antimicrobial use in food-producing animals, the food animal industries cannot move forward as though their practices do not cause any changes in susceptibility profiles. Antimicrobial use can affect bacterial populations, and bacteria can transfer through the food chain. The variables of interest are duration and magnitude of the effect of any susceptibility changes and the ability of these changes to have an impact on our ability to treat infec-
tious disease in both animals and humans. Likewise, the human medical profession must take responsibility for antimicrobial use practices that amplify resistant bacteria and genetics in health care settings. One major step forward might be to increase the dosing accuracy of human patients by dosing adults on a BW basis, rather than accepting the huge variations in antimicrobial pharmacokinetic profiles by dosing a 50-kg person the same as a 100-kg person (Falagas and Karageorgopoulos, 2010).

In summary, the challenge is for all parties to be transparent and truthful when determining the pathogen and antimicrobial pairings of importance, the extent and duration of antimicrobial effects, and the risks vs. benefits of food animal antimicrobial use. Part of this transparency includes being clear about where value judgments are augmenting or replacing evaluation of peer-reviewed data. Einstein addressed this issue when he said, “The significant problems we have today cannot be solved at the same level of thinking we were at when we created them” (Quotations Book.Com, 2012).

**THE ROLE OF THE MEDIA IN CURRENT ANIMAL AGRICULTURAL DEBATES**

Given the limitations many scientists have in communicating effectively directly with audiences (Olson, 2009), understanding the role of the media in conveying messages about key aspects of food production becomes critical. Often, scientists and others blame journalists for sensationalizing social and technological change and, in so doing, igniting controversies. However, journalists are trained to represent all sides, often reducing these to 2 opposing poles for the sake of simplifying the issues for readers. To avoid the appearance of bias, they may portray the opposing views as coequal regardless of what the science says and regardless of whether there are actually 2, 4, or four dozen sides of the issue.

Climate change is a contemporary example in which climate change scientists, representing a widely held scientific consensus, are often portrayed as coequal to climate-change skeptics whose motivations often seem to be ideological. Although many people may hold intermediate ideas on controversial subjects, media coverage tends to focus on the more extreme views and the visible actions of extremists, leaving the casual news consumer to conclude there is no middle ground when this is not necessarily the case.

Increasingly, this paradigm applies to the representation of contentious issues in animal agriculture, such as the effects of antibiotic use in livestock, the implications of current production practices for animal and human health and well-being, and the effects of food animal production on the environment. In particular, the effects of intensive production systems on animal welfare is an issue with inherent potential for polarization, given compelling arguments from differing ethical perspectives (Croney and Anthony, 2010). Agricultural interests and the groups that represent them would, therefore, benefit by better understanding how news media work if they wish to have their point of view be part of the mix.

**What did they say? Agenda Setting and Framing of Issues**

Because the current economic situation in the news business has resulted in reduced numbers of traditional journalists and especially science and agriculture journalists, “information subsidies” increasingly drive the news agenda (Gandy, 1982). Although working journalists may deny this, most news stories probably originate in press releases or other forms of subsidy. The story topics and points of view backed by organized and funded groups, from business and corporate interests to social and environmental activists, tend to get the most attention, a dynamic that is only likely to grow stronger in coming decades.

In turn, the kind of attention a news organization gives a story affects the public agenda, which ordinary news consumers see as important (McCombs and Shaw, 1972; Iyengar and Kinder, 1987), as well as the political agenda, which members of Congress and other politicians see as important. Agenda setting is, therefore, one of the strongest and most easily demonstrated media effects as the news serves to call certain events, issues, and ideas to the attention of media consumers.

In addition, how a story is framed matters. Framing refers to the effects of the way a story is put together on how people think, and it is increasingly popular to suggest that one way for animal agriculture to win consumer support is to more positively reframe the dialog about large-scale farm animal production (Croney and Reynnells, 2008). Thus, one approach has been to present the idea that maximizing food production means more people can be fed, and generally such efficiency increases the economic security of farmers and food security for society. These are legitimate and important concerns. Another way of framing the debate is to propose that because human beings and domesticated animals have coevolved for thousands of years, we have an obligation to advocate for maximizing animal well-being, or at least minimizing animal pain and suffering. But what effect, if any, does this type of framing have on thelayperson?

Although framing can have a short-term effect under some circumstances, opinions are based on underlying values, beliefs, and attitudes that by definition are stable and not quick to change. Thus, trying to get media stories framed in a certain way may not work in the long run because it is difficult to change the underlying worldviews.
that ultimately influence people’s positions on issues. Media frames that connect issue positions with underlying worldviews typically have the strongest influence. Nonetheless, once strong opinions have formed, contrary information may have no effect at all, or may even have an opposite effect from the one intended. Thus, short-term framing effects may be less powerful than they might at first appear and may also be less important than other factors, such as perceptions of risk.

**Lessons from Risk Communication**

For both experts and laypersons, technologies and practices, including controversial ones ranging from nuclear power to genetically modified foods, are generally evaluated in terms of their risks and benefits. Ethical considerations are usually embedded in perceptions of risk and benefit. In the process of passing on information to audiences from various sources, the media often serve as amplification stations (Kasperon and Kasperon, 1996) for risk perception. Risk elements can also be attenuated, but it is not well understood why some risks become exaggerated while others are ignored.

Frustration over observed amplification effects has sometimes produced the conclusion that people who are not scientists or engineers are always risk averse, demanding that technologies be completely risk-free and rejecting those that do not meet this standard. However, this is not true. For example, cell phone transmissions have not been proven to cause damage to humans, but they have not been proven not to, either. If people were always risk averse, even regarding unproven potential risks, why are cell phones almost completely noncontroversial? For cell phones, the answer probably lies in their obvious everyday usefulness in our increasingly mobile society. In contrast, consumer benefits are often not as obvious in other areas, such as food biotechnology. This may explain why so many people appear averse to it (Priest, 2000). Clear benefits easily trump small risks, in the world of public opinion. Sometimes clear benefits trump even substantial risks. Consider, for example, transportation by individual automobile. Riskier than air travel, it is enormously convenient, and often in our society the only convenient option. It is also consistent with the value we place on personal freedom, so we may tend to tolerate or even to deny the risky reality of traveling by car. Yet even this is not a complete explanation. For instance, there appears to be a deep cultural resistance to the manipulation of DNA (i.e., biotechnology; Priest, 2000) that does not apply to the manipulation of engineered systems (e.g., transportation), materials (e.g., nanotechnology), or electromagnetic waves (e.g., cell phone transmissions).

To extrapolate these observations to animal agriculture, stressing the benefits of efficient livestock production is probably a good strategy for winning public support. However, scientific information will not always be enough to change public opinion. For example, it is a common refrain in animal agriculture that the public simply needs to be educated about our practices and the reasons for their existence, with the presumption that acceptance of such practices will necessarily follow (Croney and Reynnells, 2008). The assumption that presenting people with the facts will convince them of a particular point of view is so common that it is referred to in science communication studies as the deficit model of public understanding. In this model, people who disagree with us are assumed to be uninformed, and thus informing them is assumed to be the sure route to making them agree with us. However, little evidence indicates this to be the case (Croney and Anthony, 2010), especially for biotechnology (Priest, 2000; Sturgis and Allum, 2004). In fact, based on analysis of US survey data, although knowledge of biology rises incrementally with educational level, encouragement for biotechnology does not (Priest, 2000). In other words, knowledge is not a strong predictor of attitudes. Public acceptability of a technology not only involves values (Davies, 2008), but also may rest on rule-based ethical reasoning rather than risk-benefit considerations. Consider embryonic stem cell research as an example. Here risk, defined as the probability of a specific harm, to be weighed against benefits, is not the issue. In risk-benefit analysis, a low risk may be acceptable on ethical grounds if it generates substantial benefits; however, for those opposed to embryonic stem cell research, the levels of risk and benefit are irrelevant. Rather, this opposition rests on the belief that it is absolutely unacceptable, for any purpose, to destroy human embryos. It is worth remembering here that the argument for stem cell research may also involve an absolute, but a different one: the assumption that saving human life and reducing human suffering are themselves moral imperatives. Although stem cell researchers and their advocates may use scientific evidence effectively with some audiences, they are unlikely to persuade very many of their active opponents on this basis. Those who oppose certain practices in animal agriculture may be likewise unlikely to be persuaded only by scientific evidence, for similar reasons.

Finally, risk communication research has consistently shown that trust is essential, particularly in relation to the person or organization providing information (Siegrist et al., 2010). Trust can be subdivided into several components, such as trust to tell the truth, trust in the sense of expertise or competence, and trust to share our values when making decisions. Trust to tell the truth speaks to the importance of communication transparency. Trust as competence relates to the role of scientific expertise. It is the third concept of trust, sharing our values, that is likely to be most important in discussions of animal agriculture, however. Moreover, trust is difficult to win and easy to lose. Transparency, openness, and respect for the opinions of others are vital in continuing to
ways of producing food. The need to derive policies about
the diversity of values and beliefs about socially responsible animal agriculture that currently exists in the United States. Scientists must
reflect upon their responsibilities and roles in current policy and public debates about sustainable, ethically responsible ways of producing food. The need to derive policies about animal production that are scientifically grounded demands credible expert contributions that can be easily translated to laypersons dependent on these to make informed choices. However, particularly in regard to highly contentious, polarizing issues, care must be taken to address incorrect, incomplete, or otherwise improper representations of the facts, while refraining from inappropriate advocacy and alienation of key stakeholders.

In addition, members of the animal agricultural community must be cognizant of how to effectively utilize the media to engage different members of the public. Much has been learned since the early days of the “genetically modified food wars” about the importance of good public relations in agriculture, the importance of transparency in dealing with various publics, and the centrality of trust to a healthy relationship between food producers and food consumers. Acknowledging the 2-way nature of public relations is essential. To that end, scientists and other proponents of animal agriculture must better understand the various members of the public whose continued support they seek, whether they speak from the point of view of animal science, agricultural practice, or advocacy.

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