BIOETHICS AND DNA DIAGNOSTICS IN ANIMALS – ARE THERE LESSONS TO BE LEARNED FROM GENETIC TESTING IN HUMANS?

I. Tammen and H.W. Raadsma

Reprogen. Faculty of Veterinary Science, University of Sydney, Camden, NSW 2570

SUMMARY

Publications in the field of human genetics often include or focus on ethical considerations of genetic research and DNA diagnostics. Although similar ethical dilemmas exist in relation to DNA testing of animals, these appear to be discussed less frequently in the scholarly literature. This paper is an attempt to identify similarities and differences in ethical concerns about genetic testing when applied to either the human or animal context. Considering the greater debate in humans, there are likely lessons to be learned on how to approach specific ethical dilemmas. Within animal applications the issue of commercialization and public access to knowledge is likely to attract the great ethical debate. This paper is not aiming to prescribe what is 'right' or 'wrong' about genetic testing of animals but hopes to instigate awareness of ethical dilemmas and prompt further discussion within our profession and with breeding organisations, animal breeders, animal owners as well as the public.

INTRODUCTION

A recent publication in Nature Biotechnology titled 'Most gene test sales are misleading' (Wallace 2008) has provided some motivations for this paper. Our experiences as researchers and educators in animal genetics have been an even greater inspiration, particularly as our research has been focused on the molecular characterisation of inherited disorders and productive traits in livestock.

Researchers, service providers, animal owners and breeders as well as the public are well aware of the many ethical dilemmas in animal DNA testing (see examples in Table 1); however, a systematic approach to deal with these complex issues seems to be lacking. We propose that 'comparative' bioethics can be helpful to identify, clarify and approach ethical dilemmas in animal genetic research and more specifically in animal DNA testing. In the following, We will briefly define bioethics, summarize key information about DNA diagnostics, draw on human literature to summarize key ethical concerns in DNA diagnostics, briefly discuss how these can be seen to relate to animal genetics and conclude with some suggestions on what lessons can be learnt from human approaches.

WHAT IS BIOETHICS?

Bioethics represents a recently developed category of practical ethics, which deals with the application of ethics in the context of biological sciences. Ethics in its simplest definition can be understood as the study and philosophical framework of what should be done, or the study of how we should live in relation to others. Different systems or theories of ethics co-exist, and they generally agree that ethics requires systematic approach, is prescriptive, universalisable and of overriding importance (Kerridge *et al*. 20.05). Ethics is largely concerned with human flourishing and well-being; however, depending on the theory of ethics animals are considered to be of similar or lesser value. Kerridge *et al.* (2005) highlight the importance for professionals to actively engage in ethical discourse, they caution that no single approach can ever describe or resolve complex ethical dilemmas and thus conclude that ethics is about ongoing, respectful, transparent interdisciplinary discourse. Although no single ethical theory has emerged to dominate this discourse, principle-based approaches have been seen as very useful in providing a flexible

framework in such discussions (Kerridge *et al.* 2005). Balancing of four fundamental principles (identified as justice, autonomy, beneficence and non-malfeasance) is the basis for shared moral reflection and provides a framework for context specific action guides (Beauchamp and Childress 1994). Mepham (1996) has applied and modified this principle-based approach by proposing the use of an ethical matrix to engage with the complex and controversial issues in animal biotechnologies and to assist with the development of regulatory frameworks.

DNA DIAGNOSTICS

Genetic testing is also a relatively new field in the discipline of genetics, and recent improvements in technology and the broadening of applications have resulted in DNA testing being widely used in humans and animals. Traditional applications of DNA testing include direct and indirect DNA tests for inherited diseases/traits with Mendelian inheritance and 'genetic fingerprinting' for parentage testing and forensic studies. Genetic testing has been invaluable in many research fields such as anthropology and conservation genetics. More recent developments have lead to commercialisation of DNA tests for complex traits and multifactorial diseases as well as tests for the identification of breed or race. In addition, DNA tests are used for the detection of pathogens and species identification in animal derived food products.

Consequently 'DNA testing' can not be understood as a single entity – there are differences in regards to technologies used for genotyping, differences in the types of genetic variation that are detected, differences in nature of application, and most importantly differences in relation to the conclusions that are drawn from the genotyping results. Most DNA tests are recognised as accurate with a low probability of failure or misclassification if performed in accordance within technical standards (e.g. SCAHLS 2008, Standards Australia 2005). However, as methodologies to derive conclusions from genotyping are becoming more complex, the validity and/or accuracy of some of the interpretations of DNA tests have been questioned (e.g. Gollust *et al.* 2007; Wallace 2008).

ETHICS AND DNA DIAGNOSTICS

DNA diagnostics in humans. Genetic testing has been differentiated from other diagnostic testing as genetic information is considered to be ubiquitous, familial and often predictive (ALRC96 2003). These aspects can be seen as key strength of DNA tests, but are also the reason for concern: e.g. DNA can be obtained without knowledge or consent of those tested; DNA tests for an individual can intentionally or inadvertently reveal information about relatives, and predictive information about disease risk can be misunderstood or misused (ALRC96 2003). Detailed analyses have revealed a multitude of ethical issues (NHMRC 2000; Kerridge *et al*. 2005). It is beyond the scope of this paper to discuss these in detail but several topics are listed in Table 1. Debate of these ethical issues has lead to the development of ethical and legal guidelines on how we should deal with some of the emerging issues in this field (e.g. ALRC96 2003; ALRC99 2004)

DNA diagnostics in animals. Are any of the ethical issues in humans genetic testing (Table 1) of relevance in the animal context? Are there any additional issues that need to be considered? In an attempt to answer these questions two issues become evident: firstly, there is no consensus on what the moral status of animals is (e.g. Li 2002), and secondly, issues related to DNA diagnostics in animals are largely about human interactions and relationships – those between researchers, test providers, animal owners, breed organisations and the general public.

We will focus here on ethical questions in relation to humans and not engage in a debate about moral status of animals – not because we consider this of lesser importance, but because such a debate would be beyond the scope of this paper. In Table 1, ethical issues identified in human

genetics are used as a starting point for the identification of ethical dilemmas in animal DNA testing. The table provides examples only and is not an attempt to cover all possible or even common ethical dilemmas. As pointed out in the introduction it is not the aim of this paper to propose solutions to these questions but to encourage awareness and constructive debate, as well as to suggest a framework for improvement of DNA technologies in animal applications.

Table 1. Ethical issues in humans and comparative ethical questions in animal DNA testing

Ethical issues in human DNA testing relate to:	Examples of comparative ethical questions in animal DNA diagnostics
Equity of access	Do all animal owners (in all countries) have access to specific DNA tests? Is it just that some DNA tests for species seem to be more expensive than similar tests in other species? Does dependence on industry funding to develop/commercialise DNA tests create inequity – i.e. are only large breed organisations able to support this?
Allocation of resources	Is spending money on genetic research and testing of animals the best way to improve animal productivity and welfare? Or indeed human well-being?
Consent	Do ethics committees need to consent to non-invasive sampling for research? Who should consent to DNA testing of animals - the owner, the breeder, the purchaser of semen/embryo's?
Privacy / confidentiality / 'The right not to know'	Should breed organisations publish results of DNA testing? Should researchers or breed organisations identity founder animals of inherited diseases? Do animal breeders or breed organisations have 'the right not to know' When selling a DNA tested animal (or semen or offspring of a tested animal) should we notify the buyer of the test results?
Discrimination	What should we do with animals heterozygous for disease alleles – as animal owners, breeders or breed organisations? Does it matter if the disease is lethal, late onset or linked to a favourable allele? Is it fair to 'discriminate' against breeds that have been reported to have an inherited disease / or breeders that have advertently or inadvertently breed an animal with an inherited disease? Should differential rates of insurance apply? Should carriers be banned from shows/ registration in the herd book?
Predictive tests	Do animal owners understand the results of DNA tests – especially for those tests where complex interpretations of genotypes are required and reported? How reliable should these tests be before they can be commercialised? Should tests be periodically updated for predictive capacity as gene frequencies change or additional information becomes available? What role should researchers have in presenting an unbiased objective assessment of their discoveries? Is peer review sufficient?
Gene patenting	Should we patent DNA tests for animals?
Storage of material and information	Should we use samples submitted for diagnostics for future research? If we do – should we inform owners of the results?
Commercialisation & direct–to-consumer marketing	Should we require independent accreditation and/or validation of research before commercialisation? Considering trade secrets and increasingly complex data sets for multifactorial traits/disease is a requirement for independent validations financially viable? Should we regulate / self-regulate marketing? Should we include 'genetic counselling' as a requirement for reporting? Considering that technologies and methods are rapidly evolving what should service providers do if more accurate tests become available or existing tests are identified as misleading?

CONCLUDING REMARKS

We have proposed here to use a 'comparative ethics' approach, where the 'rich' ethical debate in human DNA testing can be used to identify, clarify and approach ethical dilemmas in animal genetic testing in a more systematic approach. Table 1 suggests that this could be a useful approach, as very similar ethical questions exist. The severity of the ethical dilemmas appear to be greater in humans but the issues are possibly even more complex in animal testing, particularly if we consider the debate about moral status of animals.

The recent developments in DNA testing for multifactorial diseases and traits as well as testing for race or breed affiliation for both animals and humans have highlighted concerns about direct-to-consumer marketing, overselling as well as premature commercialisation. In addition to ethical concerns highlighted above, we need to be aware of the great risk that consumer confidence in DNA technologies in general can be lost easily if these new predictive tests don't deliver.

Genetic counselling is not a requirement for animal DNA testing but considering its importance in human diagnostics building up of further capabilities in this area should be encouraged, especially in the context of companion animal testing.

The aim of this paper was not to propose solutions to specific ethical questions but to explore what approaches could be used to do so. Principle-based approaches have proven useful in medical ethics (Kerridge *et al.* 2005) and have already been adapted to the animal context. The ethical matrix has been devised by Mepham (1996) as a framework for rational ethical analysis in animal biotechnologies and could be particular useful in exploring the ethical dilemmas exposed here. This will not lead to simple answers or precise action guides but could frame the debate between researchers, service providers, breed organisations, animal breeders and the public. Such a debate should include the constant review of relevant issues and where appropriate identify where and when additional guidelines, (self-)regulation or even legislation might be needed.

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