Defining animal breeding objectives and strategies within the framework of Responsible Research and Innovation (RRI)

I. Olesen[1*], A. Kettunen[1], G.K. Rosendal[2] and H.M. Nielsen[3]

[1] Nofima, P.O. Box 210, NO-1431 Ås, Norway; [2] The Fridtjof Nansen Institute (FNI), PB 326, NO-1326 Lysaker, Norway; [3] Center for Quantitative Genetics and Genomics, Aarhus University, Blichers Alle 20, 8830 Tjele, Denmark; * ingrid.olesen@nofima.no

Abstract

Rapid changes and innovations in food production are prompted by the increased demand of sustainably produced food, while addressing concerns of climate change and environmental impacts. To address complex societal issues, research and innovation policies, research bodies often request a framework for Responsible Research and Innovation (RRI) to be applied for developments of new science and technologies. In addition to the individual researchers' and key actors' thinking and reflections in farm animal breeding, there is a need to look at mechanisms affecting ethical and social aspects of animal breeding at an institutional level. In this article we exemplify and discuss how breeders can define animal breeding objectives and develop technology strategies within the RRI framework to contribute more efficiently to sustainable animal production.

Introduction

Food production systems need rapid changes and adaptations to respond to the increased demand for sustainably produced food, while addressing the concerns of climate change and environmental and societal impacts. Commercial and idealistic interests push for various short and long-term objectives and strategies using new technologies in food production. We need to produce more food, more effectively, while respecting and responding to international agreements such as UN goals for sustainable development and the UNFCCC and its Paris agreement on climate change. Adopting new breeding technologies, such as gene editing, may contribute to food security. This has prompted a need for a more open dialogue between scientists, policy makers and the public. In response, EU research and innovation policies and research bodies have developed a framework for Responsible Research and Innovation (RRI) to be applied when developing new science and technologies (EC, 2014). In Von Schomberg's (2012) definition, RRI is "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products".

Animal breeding programs can be viewed as continuous innovation processes as breeders are usually in a constant process of applying new (gene) technologies and methods. In addition to a focus on individual researchers' and key actors' thinking and reflections, there is a need to look at mechanisms affecting social and ethical consequences of animal breeding at an institutional level. In line with the framework of RRI, Olesen *et al*. (2000) concluded that "important prerequisites for breeding programs for sustainable production are appropriate governmental policies, awareness of our way of thinking, and a more communal worldview informed by a subjective epistemology and a holistic ontology." Hence, breeding objectives and strategies, informed by holistic assessments and more awareness among the actors, can facilitate socially accepted breeding programs contributing more efficiently to sustainable production meeting the current challenges of the environment, climate and the food system.

The objective of this article is to exemplify and discuss how animal breeding objectives and technology strategies can be defined and developed within the RRI framework.

The framework and requirements of RRI

RRI is a dynamic and iterative process inviting representatives of "all" relevant stakeholders into a dialogue regarding the research/innovation process and its outcomes. RRI aims to align technological processes with societal values, expectations, and concerns. RRI can be seen as an additional layer through which societal views can be heard and taken into consideration, particularly in situations where the technological and societal developments move too fast for the electorate to affect legislation through voting and democratic means. The RRI process can be compared to traditional hearing processes related to legal acts and may supplement democratic processes. As such, RRI faces the same conflicts over values and distribution in society – how to deal with i) representation and asymmetrical power relations, ii) issues that do not involve win-win solutions, and iii) differences in interpretation of central concepts, as sustainability. In the Research Council of Norway (RCN), RRI includes four dimensions:

1. Anticipation: Active engagement to describe, analyse and openly discuss foreseen impacts and uncertainties that might arise from processes or outcomes of the technology application.
2. Reflexivity: Holistic reflections of (implicit) assumptions of research and innovation (regarding e.g. environmental and distributional effects), uncertainty and lacking knowledge.
3. Inclusion: Invite all relevant stakeholders to contribute with views and opinions on the research trajectory, both on how the research is done and on the outcome.
4. Responsiveness: Willingness to change the trajectory of research if results from above (e.g. stakeholders' feedback) reflect that the research is not likely to meet the desired impact.

RRI strategies for ensuring animal breeding within RRI

We discuss how breeders can comply with the four dimensions above expected by RCN to facilitate broader public acceptance of breeding schemes, and meet current complex challenges.

1) Anticipation

For analysing, and openly discussing the consequences of a breeding strategy or a breeding technology, an ethical matrix may be applied. Forsberg (2004) argued that public legitimacy is enhanced when the matrix method is applied in a participatory process to discuss various ethical concerns and how to ethically justify application of GMO rape seed. Furthermore, different consumer studies or surveys can be useful to anticipate impacts of different breeding objectives or strategies. For instance, Grimsrud et al. (2013) carried out an internet survey, which indicated a high willingness among Norwegian households to pay an extra tax to improve the welfare of farmed Atlantic salmon through increased resistance to diseases and salmon lice. The ethical matrix method is useful for broadening the range of concerns considered, but will not necessarily provide an agreed policy direction (e.g., on ethical or economic precedence).

2) Reflexivity

Breeders may commit to holistic reflections of the ethical, environmental, and political concerns relating to breeding choices to recognize and take social responsibility. Rosendal and Olesen (2022) discussed barriers to breed for increased lice resistance in Norwegian farmed Atlantic salmon, and factors that may explain the untapped potential of breeding for lice-resistance (market and regulation of breeding technologies). Based on interviews with breeders and farmers, it was concluded that market mechanisms were unsuitable, and policy instruments were not aimed at promoting lice resistance breeding. This gives rise to a paradoxical situation, which is allowing a greater number of stressful mechanical treatments of farmed salmon while the sea lice threat to wild salmon remains unchanged at an unacceptable high level in some

regions. The study illustrated that there is little political willingness to interfere with the privately controlled breeding programmes, that are not transparent regarding some aspects. Social science findings might still have an impact in raising awareness among breeding actors.

3) Inclusion

Stakeholder participation is a central element in RRI, although challenging in terms of sufficient representation and asymmetrical power relations (Barnett & Finnemore, 2004). While traditional stakeholder channels for policy involvement, such as lobbying, have been found to favour powerful actors, the same is largely true for other stakeholder processes (Orsini, 2016).

Effective involvement of some key stakeholders is currently facilitated automatically in cooperative breeding organisations and in integrated companies when key stakeholders (e.g., the farming members' representatives of the cooperative or farming managers of the integrated company) are consulted in decisions on breeding strategies. This illustrates how the organisation structure or business model allows for incorporating views and opinions of farmers and (or) other suppliers in decisions on developments within breeding and their outcome. In Norwegian dairy cattle breeding, the cooperative organisation Geno was particularly successful in implementing health and functional traits in the breeding objective in the early eighties as a response to the farmers' demand for healthy animals (FAO, 2007). Important factors for this success were a close cooperation with veterinarians on health recording and university geneticists as well as early responsiveness to farmers interests. The long-term strategy on sustainable production, rather than a short-term objective on yield only, still makes the Norwegian Red cattle breed competitive nationally as well as internationally.

Nielsen et al. (2006) presented a method to engage stakeholders when defining breeding goals for sustainable production. The method was based on how much, e.g., farmers or breeding organizations are willing to lose in gain in milk yield to improve traits related to sustainable production. Accepting a lower gain in milk yield, allows for increasing the value on e.g. mastitis resistance or reproduction.

These examples could speak in favour of RRI in relation to choices within traditional selective breeding where key stakeholders are relatively easy to identify. Similar representation may be challenging in processes linked to gene technology, with a broader range of issues to be raised.

4) Responsiveness

Responsiveness concerns whether the RRI process affects decision-making processes and technological choices. Stakeholder inclusion may enhance legitimacy but does not resolve which types of knowledge are more valid in the final decision, still to be made by the breeders. Social issues raised during the RRI may be further addressed by a relevant governmental body. Both citizen panel and stakeholder involvement are examples of active engagement of stakeholders in a research project on gene editing in Cardiomyopathy syndrome in Atlantic salmon. A dynamic dialogue between lay people, industry representatives, NGO representatives, different scientists, and the project group include mutual learning activities with citizen panels and stakeholder workshops to build thrust and facilitate responsiveness.

Breeders can contribute to the public and regulatory discussions as well as to the education of stakeholders about breeding with research-based knowledge on e.g., animal welfare and consumer safety, environmental impacts and need for developing regulations and policies. The prospected opportunities of using gene editing have raised the discussion about softening the

strict GMO regulations, encompassing gene edited products. Recent surveys have shown that most Norwegian consumers are positive towards using gene editing in plants and animals, if it is beneficial to society and contributes to sustainable development (Bioteknologirådet, 2020; Bugge, 2020). Therefore, the bulk of consumers tend to demand GMO labelling for gene edited organisms. By involving consumers in the gene technology innovation processes, the breeding organisations may comply to consumer preferences, and benefit from higher consumer acceptance. For example, breeders can respond by focusing on editing genes improving animal health and welfare or reducing unfavourable environmental impact with documented low risk.

Conclusion

Farm animal breeding programs, implementing new technologies and methods, can be viewed as continuous innovation processes calling for a framework of RRI to ensure consumers' and policy makers' acceptance and further licence to breed. Stakeholder engagement alone may not make innovations responsible or reduce the need for regulating technologies. Hence, the actions of anticipation, reflexivity (regarding assumptions, representation, power distribution, uncertainty and lacking knowledge), and finally responsiveness to all of these are also crucial for breeding programs' responsible outcome. By this, breeding programs can succeed in supporting a sustainable food system, that can meet the current and future complex challenges.

References

Barnett, M., & Finnemore, M. (2004). *Rules for the world: International organizations in global politics*. Ithaca, NY: Cornell University Press.

Bioteknologirådet. (2020). Norske forbrukeres holdninger til genredigering i norsk landbruk og akvakultur. p. 6. In Norwegian with English summary.

Bugge, A.B. (2020). GMO-foods or not: Have there been changes in consumers' views on genetically modified foods from 2017 to 2020? In Norwegian with English summary.

EC. (2014). Responsible research and innovation: Europe's ability to respond to societal challenges. Available at: https://op.europa.eu/en/publication-detail/-/publication/2be36f74-b490-409e-bb60-12fd438100fe

FAO. (2007). Norwegian Red Cattle – selection for functional traits. In: Rischkowsky, B. and Pilling, D. (eds) The State of the World's Animal Genetic Resources for Food and Agriculture. FAO, Rome. p. 399. Available at: https://www.fao.org/3/a1250e/a1250e.pdf

Forsberg, E-M. (2004). ''The Ethical Matrix – a tool for ethical assessment of biotechnology,'' in L. Landeweerd, L-M Houdebine, and R. Termeulen (eds.), BioTechnology-Ethics. An Introduction, pp. 263–270.

Grimsrud, K.M., Nielsen, H.M., Navrud, S. and Olesen. (2013). Aquaculture 372-375: 19-27. https://doi.org/10.1016/j.aquaculture.2012.10.009

Nielsen, H. M., Christensen, L. G., and Ødegård, J. (2006). J. Dairy Sci., 89, 3615–3625. https://doi.org/10.3168/jds.S0022-0302(06)72401-8

Olesen, I., Groen, A.F. and Gjerde, B. (2000). J. Anim. Sci. 78, 570–582.

Orsini, A. (2016). Do Non-State Perspectives Matter for Treaty Ratification and Implementation? The case of the European Consultation on the Nagoya protocol. *Environmental Policy and Governance, 26*(5), 377-393.:10.1002/eet.1712

Rosendal, G.K. and Olesen, I. (2022). Aquaculture 548: 737574. https://doi.org/10.1016/j.aquaculture.2021.737574

Von Schomberg, R. (2012). Prospects for technology assessment in a framework of responsible research and innovation. In M. Düsseldorp & R. Beecroft (Eds.), *Technikfolgen abschätzen lehren. Bildungspotenziale transdisziplinärer Methoden*. Berlin and Darmstadt: Springer VS.