Potentials, challenges and visions for future European organic animal farming

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Key words: resilience, breeding, diversified, multi-species, foraging agro-forestry, mother-infant contact, protein feed

Abstract

There is a serious need for significant and fundamental improvements to the way we currently produce and consume food if we are going to respond meaningfully to the enormous global environmental challenges that face us. The role of animal farming in particular is faced with the challenge of balancing their potential positive contribution to our food system within an effective circular economy while ensuring that the animals on our farms exist as living, sentient beings that are treated in ways that allow their lives, from their perspective, to be worth living. This paper draws on evidence from a recently published book[3] on organic animal farming as well as one recent and five on-going research projects across Europe funded via the H2020 ERA-net project, CORE Organic Cofund[4]. The presentation discusses the following approaches to future sustainable organic animal farming: 1) integrating diversified multi-species systems; 2) developing sustainable foraging, agroforestry and pastoralism; 3) finding new potential for home grown protein feeds; 4) adopting resilience as a core of health principle and developing strategies to significantly lower or phase out the use of antibiotics; 5) emphasising appropriate breeding and breeds, including multipurpose breeds; and 6) enabling enhanced mother-infant contact.

Throughout we emphasise diversity as a key element for the future development of organic animal farming. Adopting innovations such as those described, that are guided by ethical principles, can offer multiple practical contextual applications and improved opportunity for sustainability. However, it is abundantly clear that there are no current farming systems that can be considered sustainable without the adoption of relevant supporting policies and the wider society undergoing fundamental changes in the way we demand, consume and waste food.

Introduction

In organic agriculture, animals are considered as living sentient beings and a key aim should be to enable, from the animal's perspective, a life that is worth living. This implies that humans should provide the necessary conditions that allow farm animals to meet their natural needs. However, achieving this aspiration can potentially conflict with what can be considered an overarching goal of efficiently providing food for humans whilst also trying to meet wider sustainability objectives, such as reducing green-house gas (GHG) emissions and promoting bi-

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[3]Vaarst, M. & Roderick, S. 2019. Improving Organic Animal Farming. BurleighDoods Series in Agr.Sci. 46. Pp. 390.

[4]GrazyDaiSy: http://projects.au.dk/coreorganiccofund/core-organic-cofund-projects/grazydaisy/
MixEnable: http://projects.au.dk/coreorganiccofund/core-organic-cofund-projects/mix-enable/
FreeBirds: http://projects.au.dk/coreorganiccofund/core-organic-cofund-projects/freebirds/
POWER: http://projects.au.dk/coreorganiccofund/core-organic-cofund-projects/power/
ProYoungStock: http://projects.au.dk/coreorganiccofund/core-organic-cofund-projects/proyoungstock/

odiversity. Nevertheless, with reference to the organic principles, we are strongly guided towards finding solutions and synergies that have multiple aims. Values that are adaptable and relevant to different contexts and embrace diversity and resilience can guide developments towards husbandry practices that break with the 'one-size fits all' conventional intensification of farming that places undue pressure on animals as well as humans. The aim of this paper is to explore several options for better, healthier and more welfare friendly animal farming for the future. The paper draws on evidence from a recently published book on organic animal farming[2] and outputs from five current European research projects funded via the H2020 ERA-net project, CORE Organic Cofund[3] and one recently completed CORE-organic Plus project[5]. Across these multiple sources of knowledge, we have re-iterated the idea that diversity is a key to sustainable animal farming. This diversity can be viewed from a range of perspectives, whether it be with regard to the promotion of biodiversity within farm ecosystems, meeting multiple aims and objectives, offering differing production strategies that respond to variable climatic or economic conditions, or various species and breeds with adaptive qualities. Diversity gives depth and value to organic animal farming and its surrounding socio-ecological environment. Although not necessarily unique to organic farming, we see diversity as almost a precondition to success in achieving a key aim of being a part of nature. Differences between farms also stimulate inspiration and insights, providing new developmental pathways, innovations and solutions for local and global environmental challenges.

Suggested strategies for future development of European organic animal farming

*1) **Integrating diversified multi-species systems***

Diversity at the farm level, in terms of breeding two or more animal species on the same farm, has the potential to improve three dimensions of sustainability: environmental soundness, economic viability for farmers and social acceptability by being respectful of animals. The CORE Organic COFUND project MixEnable (2018-2021) is assessing the sustainability and robustness of mixed animal systems and comparing their performance with those of specialised farms. Different feeding habits among different livestock species reduce competition for feed and increase resource use efficiency. While sheep, for example, are more selective than cattle, co-grazing of cattle and sheep leads to a more homogeneous defoliation pattern and butterfly species density has been observed to be up to six times higher compared to when sheep graze alone. This illustrates that biodiversity benefits from patch grazing behavior of different animal species and the divergent local vegetation dynamics following this. Abundance and diversity of six groups of above-ground and below-ground organisms (plants, herbivorous insects, predatory insects, soil bacteria, fungi and nematodes) have been shown to be higher under co-grazing (Wang et al., 2019).

Grazing systems including multiple species also tend to have higher productivity per unit area than specialized systems (D'Alexis et al., 2014; Veysset et al., 2020). This was seen in co-grazing systems with heifers and sows where total animal weight gain per ha was higher (by 140-250 g/day for heifers and 42-61 g/day for sows) than in single-species grazing systems (Sehested et al., 2004). Much research has shown that combining different livestock species on the same farm also takes advantage of the host specificity of most pests. Results from the MixEnable project show that guardian animals co-grazing with vulnerable species can support

[5] OrganicDairyHealth, http://projects.au.dk/coreorganicplus/research-projects/organicdairyhealth/

a significant reduction of predation. It was concluded in these studies that it was paramount to implement local and context relevant farming practices, such as appropriate stocking rate during grazing, so as to avoid undesirable effects such as competition for feed between species. Likewise, if the organic farms with mixed animal species display limited integration between farm components, the practical benefits and synergy will also be limited.

2) Pastoralism, agroforestry and sustainable foraging which can integrate pigs, pasture and trees

Natural, pasture-based and more extensive production is sometimes viewed and criticized as inefficient, although there is more and more evidence and recognition that these systems represent a form of food production that is not dependent on excessive fossil fuel usage and offers a vast carbon storage capacity. Whilst these types of production systems are generally considered most suitable for ruminant animals, there are also significant opportunities for integration of pigs and poultry. Here, we take the case of pasture-based pig systems to demonstrate the potential for sustainable animal farming that complies with the organic principles. They represent high-value meat production with low use of antibiotics, although intensive outdoor pig farming in northern Europe can face serious challenges in terms of excessive nitrogen (N) and phosphorus (P) losses to the soil due to excessive inputs of supplementary nutrients and high animal densities. The risk of nutrient losses is elevated due to the pigs' characteristic rooting behavior destroying the vegetative cover. A consequence is that pigs are frequently fitted with nose-rings and this raises animal welfare concerns. An alternative to stationary grazing are mobile systems with frequent new or extended areas. The CORE Organic Cofund project POWER (2018-2021) works with radically different systems evaluating animal welfare, environmental footprints and resilience from a range of mobile pig pasture concepts. In outdoor pig fattening, 'strip foraging' has been shown to be a successful measure to reduce nutrient inputs from feed and to avoid nutrient 'hot spots', and in pregnant sows, rotational grazing improved grass recovery during wet periods (Kelly et al., 2002). As pigs prefer to forage 'ungrazed/unrooted' areas over a previously used area, it is likely that mobile systems combined with 'strip-foraging' will stimulate pig forage intakes compared to stationary foraging concepts.

Even greater opportunities for sustainability can be achieved when pigs are integrated into silvo-pastoral systems. Compared to grass, well-established energy crops like poplar and willow persist, despite pig rooting, and have a deeper root system with larger nutrient uptakes especially in the early spring (Jørgensen et al., 2018). In winter seasons when nutrient uptakes are low, cut and chopped tree biomass left on the soil (carbon addition) may reduce nutrient losses (Eschen et al., 2007). This paves the way for an outdoor production with un-ringed pigs and low nutrient losses. Additionally, the trees provide the pigs with shade, shelter and a more stimulus-rich environment (Jakobsen, 2018). Although integrating energy crops proved beneficial, it was evident that a few rows of trees (20% tree cover) were insufficient to counteract the excessive nutrient inputs in high animal density paddocks (Manevski et al., 2019) and to avoid severe sunburn of pigs (Jakobsen, 2018). On the other hand, tree cover of more than 50% combined with a low animal density (70% of current practice) indicated a promising approach (Jørgensen et al., 2018). The best paddock management and design to reduce the risk of nutrient losses and optimise animal benefits is still unknown. This is especially regarding how to combine integrated systems with un-ringed pig behavior and permanent pastures so as to avoid the considerable nutrient losses following annual ploughing of grassland (Eriksen, 2001) and to improve carbon sequestration. These issues will be investigated in the upcoming EU H2020 project 'Multi-actor and transdisciplinary development of efficient and resilient MIXED farming and agroforestry systems' (MIXED, 2020-2024; coordinated by Aarhus University). For other animal species, there are many possibilities to integrate animals into pasture-based and multi-functional systems, such as chickens within orchards and cattle within natural landscapes. The CORE Organic project FreeBirds seeks to optimise free-range chicken production so as to meet health and environmental concerns, by stimulating different ways of utilising the range area and integrating birds with other farm operations. Clearly, for ruminants there is a long history of animals being allowed to exhibit their natural behaviors through foraging on natural grasslands. Pastoralism under European conditions can be understood as the use of extensive grazing on rangelands for animal keeping. During the last years, discussions on how to integrate pastoral systems in Europe (and elsewhere) in our understanding of organic agricultural approaches have increasingly taken place, among others because they call for wider perspectives of landscape, social, ecological and food systems in relation to organic agriculture. Some of these systems can be understood as 'organic by default', and contribute significantly to carbon sequestration, biodiversity and wildlife conservation as well as providing societal benefits to many communities (Roderick, 2019).

3) Finding new potentials for home grown protein feeds

The issue of homegrown protein feed crops is relevant for all animal species in organic production, and many organic farms rely on imported protein sources even though there are many good possibilities to grow protein feeds, even under Nordic conditions. With proper management, forage crops have the potential to make a substantial contribution (50-100 %) to amino acid requirements of pregnant sows (Studnitz et al., 2019), thereby reducing paddock N surpluses due to lower inputs of N from supplementary feed. Although the potential is lower in lactating sows and fattening pigs because of high nutrient requirements for milk production and growth, respectively, there are indications that forage crop protein intakes can substitute a proportion of the feed N inputs in paddocks for lactating sows and fattening pigs (Studnitz et al., 2019). For poultry the opportunities may include access to protein sources from naturally occurring insects within the range, as well as the prospect of producing farmed insects as a source of poultry feed as a component within a circular economy. In farming systems with ruminants, there are multiple options to grow conserved and grazed high protein crops.

The use of concentrates in ruminant feeding is limited on organic farms and is most pronounced in Switzerland, where 90% roughage is mandatory (95% in 2022; Bio Suisse regulation). It is essential that ruminants are well adapted to the forage grown on the organic farm and to local grazing conditions, which also emphasise the need for organic dairy cow breeds to be site-related. Researchers at FiBL have developed a tool to measure site-relatedness of dairy cattle breeding at a farm level (download: bioaktuell.ch/tierhaltung/rindvieh/zucht). Future EU legislation on organic farming will also emphasise a higher percentage of home-grown or regionally grown feed, which raises a further issue of competition between animal feed crops and those grown for human consumption. If animal feeds high in protein are to be locally grown, there needs to be greater integration with animal production systems that include efficient utilisation of animal manures and the soil fertility building elements of crop rotations i.e. effective use of leguminous plants.

A general reduction in animal production to mitigate climate change, and new ways of integrating multiple species of animals within crop rotations for human food, may lead to generally more well-balanced food and farming systems whilst also providing animals with better opportunities to meet their natural needs through grazing nutrient- rich forage crops. Smith and Williams (2019) discuss how organic farming systems with animals actually presents a more resource efficient farming approach with less GHG emissions, when performance is measured based on land area measurements. However, the authors also highlight the potential for improvements of organic animal farming with regard to, for example, balancing the protein and energy component of animals' diets to ensure the lowest possible emissions, supported by appropriate breeding and efficient grassland management.

4) Adopting resilience as a core of health principle and developing strategies to significantly lower or phase out the use of antibiotics

Resilience is a core concept in organic farming at all levels, including the farm, system, herd and individual level. Organic animal farming relies on the system's ability to recover and adapt to external 'stressors' such as changes in feed prices, climate, legislation and disease outbreaks. The extent that adaptations are required will of course be dependent not only on the design of the system and the characteristics of its components (e.g. the breed, housing, management), but also on the nature and magnitude of the stressors. On organic farms in particular, being more exposed to natural elements, we may see considerable variation between farms in both the response and the impact, perhaps more so than in more protected industrialized systems. Research to assess system resilience is a particular challenge in relatively short-term projects, particularly when we consider the length of natural cycles. In the POWER project described above, a framework for evaluating system resilience in organic pig systems across Europe is being developed based on stakeholder inputs. Organic pig producers are asked to point out possible future scenarios/perturbations from their point of view and how they consider their farming system's ability to cope and to adapt to these "stressors" through changes in farm structure or management.

Resilience is also a key concept that influences our perception of health, in that it encompasses much more than just the absence of disease, rather being a reflection on an animal's ability to respond and react to the environment in which it lives. Health, as expressed in the organic principles, is the maintenance of physical, mental, social and ecological well-being that can be characterized by immunity and regeneration as well as resilience. In the organic principles, health is described as comprising the physical and mental well-being of individual animals, their social well-being that gives them opportunities to carry out social and group interactions and ecological well-being with respect to animals' interaction and mutual benefit within landscapes e.g. silvo-pastoral systems. This points to our responsibility as humans towards animals: to understand their natural needs, organize the surroundings to enable these to be met, and at the same time be ready to intervene to prevent or stop suffering. Whistance (2019) highlights the responsibility of being a good stockperson to include empathetic and careful handling, as well as creating systems in which animals can manage their own well-being and needs. The relative resilience of an individual or group of animals will influence the occurrence of disease. While the EU organic regulations allow antibiotics to be used in animal production, their prophylactic use is banned and reducing dependence on therapeutic use is encouraged along with a strong emphasis on health and welfare promotion. The organic approach is attuned to the 'One Health' approach to animal health in that *'It is inextricably linked to the environmental health, as animals and humans inhabit the same air space, access the same water sources, and require food derived from land and water*" (Murtaugh et al., 2017, p.12). IFOAM formulated the organic health principle as health for every living organism up to planetary level, as 'one and indivisible'. This can be regarded as a very ultimate version of 'One Health'.

The actual use of antibiotic drugs in European organic animal farming compared to conventional animal husbandry is not comprehensively documented (Mie et al., 2017). However, scattered studies indicate that the antibiotic use generally is substantially lower in organic compared to conventional systems, especially for pigs (approximately 5-to-15-fold higher) (L, 2006, Wingstrand et al., 2010). Previously, it has been postulated that a reduced need and use of antibiotics in organic livestock production will diminish the risk of development of antibiotic resistance (Aarestrup, 2005), and this has also been demonstrated with regard to resistant E coli in organic pigs compared to conventional pigs (Jensen and Aabo, 2014). Likewise, antibiotic resistance was found to be less common in organic pigs compared to conventional pigs in France, Italy, Denmark and Sweden (Gerzova et al., 2015, Osterberg et al., 2016). Sapkota et al. (2014) found that the withdrawal of prophylactic use of antibiotics, when poultry farms were converted from conventional to organic production standards, led to a decrease in the prevalence of antibiotic-resistant Salmonella. Resistant bacteria may be transferred within the production chain from farm to fork (Leverstein-van Hall et al., 2011). Furthermore, it was found that organic pork and chicken meat was less likely to contain resistant bacteria (Smith-Spangler et al., 2012).The lower use of antibiotics leads to less environmental risk and as well as to decreased risk for antimicrobial resistance, as identified and discussed by Jespersen et al. (2017) who, based on 25 years of research in organic animal farming, concluded that organic herds often were shown to have a lower level of antibiotic use. They concluded that this was one important way in which organic agriculture contributed to the public goods: namely the organic farming practices led to a lower risk to the society.

5) Emphasising appropriate breeding and breeds, including multipurpose and local breeds

In Northern Europe, it is common practice to use the same high-yielding breeds in organic production as in conventional animal production and this is a key challenge given the priority placed on natural elements of life, including outdoor living, longevity, natural behavior and species-specific feeding. It is impossible to standardize the animal breeds best suited for organic farms, as there is likely to be significant interaction with the surrounding and variable weather, landscapes, available feeds and other natural factors. Instead, given the diversity of situations in which we keep animals, we should be considering a range of animal profiles that can thrive under specific prevailing and local farming conditions. The breeding goals for animals on organic farms will be different to conventional agriculture. In organic agriculture, robust and locally adaptable animals, that can fully utilize local resources, are needed. For pigs and poultry, this issue was illustrated by the ban on synthetic amino acids in organic systems, which reduced the yield potential of conventional hybrids (Eriksson et al., 2010). Poultry farming provides an extreme example of how breeding programs for high yield has created two types of animals: egg layers and broilers with very fast growth for meat production. Padel (2019) discusses the problem from an organic principle perspective, using the example of using cockerels produced from egg-laying systems, as well as other initiatives designed to promote dual purpose chicken breeding.

The genetic potential for high yield is not an appropriate selection parameter for organically farmed animals and high yielding breeds are generally not well suited to organic conditions. According to van Wagenberg and co-workers (2017) seven out of 11 studies showed that organic dairy cows produced 4.7–32% less milk than conventional cows, while three studies did not find a significant difference. They concluded that this yield gap was due to longer pasture season, less use of high-yielding breeds and lower levels of concentrate in diets. For beef cattle and laying hens, there are not enough studies available to draw general conclusions on yield differences in these sectors (Röös et al., 2018). Therefore, other qualities need to be considered and, as an example of this, two Swiss studies found that well adapted herds had less fertility problems, less veterinary treatments and longer productive lifetimes (Spengler Neff et al., 2012; Selle et al., 2012). Another Swiss study showed that organic dairy cows descending from a natural mating bull had shorter calving intervals and lower somatic cell scores (SCSs) than those produced from an artificially inseminated bull. Almost 70% of the natural mating bulls had been raised and bred in the same region as the cows and 31% on organic farms; so they may have been well adapted to the environment and the feed unlike most bulls for artificial insemination (Spengler Neff and Ivemeyer, 2016). In the CORE Organic Plus project OrganicDairyHealth, Bieber et al. (2019) compared local cattle breeds on organic farms in Austria, Poland, Sweden and Switzerland (2011-2014) with the most commonly used modern dairy breeds within the country. They found a significantly lower milk yield and lifetime production (kg ECM) for local breeds. However, many local breeds showed better fertility (shorter calving intervals, lower number of inseminations) and better longevity, the latter being based on limited data. The authors concluded that the robustness of local breeds can contribute to improved sustainability of organic dairy systems. Another study comparing German and Swedish local and modern dairy breeds in data sets pre-selected for comparable management intensities revealed that the inverse relationship between milk yield and fertility as well as disease occurrence, is more pronounced under intensive production conditions (Sweden) compared to less intensive production environments (Germany, Bieber et al., 2020). The authors conclude that different production intensities within organic farming need to be considered more closely when assessing the performance of local breeds in order to derive practical recommendations as to how to implement European organic regulations with regard to a suitable choice of breeds. Padel (2019) described how initiatives for breeding Holstein cows for high lifetime yield have been taking place in many European countries, and the Dutch organization for Organic Animal Breeding (www.biologischefokkerij.nl) works to increase the breeding animals specifically suited to organic farming.

In organic pig production, the breeds most commonly used are those that are better suited to outdoor conditions rather than the fast-growing, prolific breeds selected for very intensive, industrialized systems. However, piglet mortality remains a huge challenge in indoor and outdoor organic herds, and in the POWER project described above, the possibility to reduce piglet mortality is currently investigated through strategies of genetic selection of females originating from the conventional production and selected for high piglet survival. The selected sows are mated with boars with a high EBV (estimated breeding value) for piglet survival. Their progeny is evaluated under organic conditions for litter size, piglet survival and growth.

Crossbreeding has been commonplace as a breeding strategy on many organic and non-organic farms. Whilst this provides a short-term solution to combining desirable production and functional traits and enabling environmental adaptation, there is also a real risk that an overemphasis on crossbreeding could result in the longer-term loss of both within and between breed diversity. It is important that the organic sector, as well as the wider authorities, recognise this risk and put in place strategies that encourage breed conservation and biodiversity.

6) Enabling enhanced mother-infant contact

The attention in farming on improving the contact between mothers and their infants has increased enormously during recent years, which is illustrated by the fact that an entire session of the IFOAM 2020 conference has been dedicated to this subject. The interest in this aspect represents a fundamental shift from a common understanding of dairy herds focused entirely on milk production for consumers, to production systems which respect the strong motivation of a cow to nurse her calf, as well as meeting the animals' needs for care, inter-generational learning and natural feeding. Giving mothers opportunities to rear their offspring can be seen as a core 'life opportunity' for both mothers and their offspring. Many studies show advantages of mother-infant contact in dairy cows and an increasing number of dairy farmers have shown interest in changing their calf rearing system to dam rearing. This has resulted in an increased need for advice and peer-to-peer learning. Researchers at FiBL have developed a technical leaflet for farmers and advisors (Spengler Neff et al., 2015) and will be translated into several languages (free download from https://shop.fibl.org).

The Core Organic projects ProYoungStock and GrazyDaiSy explore and develop several aspects of cow-calf contact systems. ProYoungStock focuses on boosting the immune system, decreasing disease, lowering antibiotic use in cow calf contact systems, as well as raising of calves using foster or mother cows. The GrazyDaiSy project is investigating cow-calf behavior with a focus on bonding and de-bonding at pasture, as well as human perceptions, experiences and actions related to cow-calf systems. Both projects include investigating potential synergies and economic and management related consequences of cow-calf systems and collecting knowledge on the diversity of dam rearing systems all over Europe. However, the issue is not restricted to milk production. Despite the markedly longer suckling period compared to conventional pig production (e.g. in Denmark it is seven weeks), health problems at weaning are also a challenge in many organic pig herds. In an effort to improve piglet robustness at weaning, a number of organic pig farms in Denmark successfully implemented ten weeks of lactation within pasture-based systems (Kongsted et al., 2017). In the POWER project, investigations are being conducted on the possibility to induce lactational oestrus in organic sows on pasture by a short-term separation of sows and piglets 4-5 weeks after farrowing. If successful, this will make it possible to wean piglets at a later age while maintaining, or even improving, overall herd productivity and efficiency. The research includes monitoring of pig behavior, feed intake and weaning weight to investigate the effects of separation on sow and piglet.

Poultry are also naturally strongly motivated to protect and bring up their youngsters and the learning between generations remains an area which we do not fully understand. As an example, mother-reared laying hens showed reduced fearfulness later in life as compared to hens reared without a mother (Campo et al., 2014; Edgar et al., 2016), and newly hatched chicks may still benefit from the contact, protection and learning from grown-up hens (Gottlieb, 1965). However, in commercial poultry production, after decades of artificially hatching eggs, there is no 'automatic' direct contact between hens and chicks in their early life, and not even between hens and their eggs. Breeding appears to have eliminated brooding characteristics. However, maternal care has been found to have great importance for the newly hatched chick not only in terms of learning and protection, but also to keep a sufficient body temperature, as well as lowering the risk of developing abnormal behavioral patterns later in life (e.g. feather pecking) (Edgar et al., 2016).

Future sustainable farms with animals?

Roderick and Vaarst (2019) explored a number of perspectives across animal species in organic farming and concluded that many of the key challenges of global agriculture are also organic farming aspirations and that placing emphasis on four broad strategic categories associated with diversity, integration, resilience and communication could contribute significantly to solving current problems in our food and farming systems. It is also necessary to have frank and open discussions about the circumstances under which we involve animals in farming in such a way that allows us and them to make positive contributions to the health of the planet. Organic farming builds on a set of principles and we have highlighted a number of practical examples and strategies that embrace these principles and are focused on the inclusion of animals within our future organic farming systems. Many of the ideas and developments illustrated in the paper are drawn from current research being undertaken across widely different European conditions under the auspices of the CORE Organic Cofund framework. The primary focus has been on the main farm animal species found in Europe, with a particular emphasis on dairy cows, pigs and chickens. However, a number of the perspectives and opportunities could be equally applicable to other species commonly found in other parts of the world. We could also extend the application to other species such as fish and honeybees, especially given the opportunities these bring for truly integrated food systems. Further to this point, referring to farm ‘animals’ rather ‘livestock’ not only frees us from viewing sentient beings as mere commodities, but also enables us to broaden our definition to include those animals of ecological importance that are important contributors to farms, including earthworms, pollinators, birds and other wildlife. On organic farms, these should exist in well-balanced populations to ensure ecologically healthy and resilient farms. Organic animal farming in the future should ensure that it remains context relevant and appropriate to specific farm and environmental conditions. Although not necessarily unique to organic farming, we see the emphasis on diversity as a key to its future development. Adopting strategies such as those described that are guided by ethical principles, can lead to multiple practical contextual applications. However, it is abundantly clear that there are no current farming systems that can be considered sustainable without the adoption of relevant supporting policies and the wider society undergoing fundamental changes in the way we demand, consume and waste food.

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