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Proceedings of the
**IAHA Video-Conference
 on Organic Animal Husbandry**

21. and 22. September 2020

linked to the 20th Organic World Congress of IFOAM 2021

**Organic Animal Husbandry systems –
 challenges, performance and potentials**



*Otto Schmid, Marion Johnson, Mette Vaarst, Barbara Früh (Eds.)
 September 2020*

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 Sector group of the International Federation
 of Organic Agriculture Movements

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<http://www.ifoam.org/en/sector-groups/iaha-animal-husbandry-alliance> and Organic Eprints



IAHA Video-Conference Organic Animal Husbandry Systems on 21. and 22. September 2020
linked to 20th Organic World Congress 2021

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Video Conference Programme

IAHA Video Pre-Conference on “Organic Animal Husbandry systems – challenges, performance and potentials” on 21. and 22. September 2020

linked to the 20th Organic World Congress of IFOAM 2021

Monday morning 21. Sept. 2020, 9.00 - 13.00 h

Registration and link to join the meeting sent out 3 days prior			
Day 1		9.00	Everyone joins meeting for 9.15 am CET (Central European Time)
9.15	9.30	Otto Schmid	Welcome and instruction
PLENARY			
9.30	10.15	Mette Vaarst	Potentials, challenges and visions for future European organic animal farming & overview from Core organic animal projects
Dairy and Pigs systems		Moderators: Otto Schmid and Chris Atkinson	
10.15	10.30	Alessandra Nicolao et al	Which compromise between milk production and cow-calf contact in dairy systems?
10.30	10.45	Madeline Koczura et al	Is dairy calves grazing behaviour influenced by cow calf contact experience
10.45	11.00	Caroline Constancis et al	Risk factors for Cryptosporidium oocyst shedding in dairy calves reared with nurse cows in organic farms.
11.00- 11.30 Coffee break			
11.30	11.45	Mette Vaarst et al	Dam-calf contact systems as a future for organic dairy farms? Actor perceptions and experiences inform the debate
11.45	12.00	Caroline Constancis et al	Performance and health status of dairy calves reared with nurse cows, a 2-year study involving 3 cohorts
12.00	12.15	Eva Salomon et al	Ammonia emissions from outdoor fattening pigs on concrete pad – a farm case study
12.15	12.30	Cäcilia Wimmer et al	Transdisciplinary approach to improve concrete outdoor runs for organic pigs: Identification of innovations
12.30	12.45		<i>Open discussion</i>
13.00 Close of Day 1 Otto Schmid			

Tuesday morning 22. Sept. 2020, 9.00 – 13.00 h

Day 2 9.00 am everyone joins meeting for 9.15			
9.15	9.30	Otto Schmid	Welcome and Housekeeping
Parasites, replacement of synthetic inputs and mixed farming Moderators: Mahesh Chander and Marion Johnson			
9.30	9.45	Veronika Maurer et al	Replacement of anthelmintics, antibiotics, and synthetic vitamins in organic animal husbandry – the contribution of the Horizon 2020 project RELACS
9.45	10.00	Kristin Maria Sørheim et al	Extract of Norwegian spruce bark against Eimeria spp. in lambs
10.00	10.15	Balogun Ade-deji et al	Evaluation of optimum liquid dilution rate and storage period for Marshall rooster semen extended with tris egg yolk orange juice extender
10.15	10.30	Marc Moraine et al	Pathways of sustainability in organic mixed livestock farms are based on local embeddedness: case studies in France and Belgium
10.30	10.45	Lisa Schanz et al	Animal welfare on organic mixed livestock farms across 7 European countries
10.45	11.00	Severin Hübner et al	Are there any benefits to keeping young cattle and broilers on the same pasture
Coffee break 11.00-11.30			
11.30	11.45	S.K. Kumar et al	Ayurvedic understanding of herbal formulation for Mastitis
11.45	12.00	Marion Johnson	Rongoa pastures, native species for health, conservation and culture
POSTERS (3 mins talk, 1- 2 mins questions) Moderator: Barbara Früh			
12.00	12.05	Lindsay Whistance	OK-Net EcoFeed: working towards 100% organic and regional feed for monogastrics in Europe
12.05	12.10	Marc Gràcia	EU project Life Polyfarming
12.10	12.15	Mariateresa Lazzaro	Securing organic animal and plant breeding through a common cross-sector financing strategy
12.15	12.20	Tove Serup	Does Phenol rich feed ingredients or seaweed reduce diarrhea in organic piglets?
12.20	12.25	Balogun Ade-deji et al	Effect of dilution rates and preservation period on microscopic semen quality of liquid stored Marshall rooster semen with plant-based extender
12.25.	12.30	Katharina Heibüchel et al.	Behavioural observations of sows and piglets in a pen with outdoor run for free farrowing
12.30 - 13.00 Wrap up and thanks Otto Schmid and Mette Vaarst			
13.00			Closing of video-conference

Main organisers with contact persons

IFOAM Animal Husbandry Alliance

- <https://www.ifoam.bio/en/sector-platforms/iaha-animal-husbandry-alliance>
- Contact person: Otto Schmid, Chair of IFOAM Animal Husbandry Alliance, otto.schmid@fibl.org

In collaboration with

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- **ITAB & INRA** (France) as Organic World Congress organisers
 - Contact: Frédéric Rey Frederic.Rey@itab.asso.fr
- **EU-Core Organic Projects**¹.
 - Project GrazyDaiSy - Dairy cattle meet their natural needs through grazing, dam-rearing and health support
http://projects.au.dk/fileadmin/user_upload/grazydaisy_leaflet_web.pdf
Contact: Mette Vaarst, project coordinator GrazyDaiSy, DK, mette.vaarst@anis.au.dk
 - Project ProYoungStock - Promoting young stock and cow health and welfare by natural feeding systems, <https://www.proyoungstock.net/>
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 - Project MIX-ENABLE - MIXEd livestock farming for improved sustainABiLity and robustnEss of organic livestock <http://projects.au.dk/coreorganiccofund/research-projects/mix-enable/>
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 - Project POWER - Power to strengthen welfare and resilience in organic pig production
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- **Other EU-Projects under Horizon 2020 Programme**
 - Project Organic-PLUS - Pathways to phase-out contentious inputs from organic agriculture in Europe <https://organic-plus.net/>
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 - RELACS – 'Replacement of Contentious Inputs in Organic Farming Systems', <https://relacs-project.eu>
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¹ CORE Organic Cofund is a collaboration between 26 partners in 19 countries/regions on initiating transnational research projects in the area of organic food and farming. CORE Organic Cofund has initiated 12 research projects. Read more at the CORE Organic Cofund website: <http://projects.au.dk/coreorganiccofund/>

Organising committee and scientific advisory board

Organising Committee:

- Otto Schmid (IAHA Chair, Switzerland)
- Marion Johnson, UK / BHU Future Farming Centre NZ www.bhu.org.nz/
GoodEarthGreatFood, NZ (IAHA Steering Group)
- Chris Atkinson, Soil Association, Bristol, United Kingdom (IAHA Steering Group)
- Mette Vaarst, Aarhus University, Denmark
- Anet Spengler & Anna Bieber, Research Institute of Organic Agriculture, FiBL, Switzerland
- Barbara Früh, Research Institute of Organic Agriculture (FiBL), Switzerland
- Antoine Roinsard & Catherine Experton, ITAB, France
- Marc Benoit, INRA, France

Scientific Advisory Board for Pre-Conference (Review Committee)

- Members of Organising Committee (see above)
- Mahesh Chander, Indian Veterinary Research Institute, Izatnagar, India
- Muazzez Comert, Izmir University, Turkey (Member Steering Group of IAHA)
- Angela Escosteguy, Brazil (Member Steering Group of IAHA)
- François Labelle, Canada (Member Steering Group of IAHA)
- Nitya Ghotge, Anthra, Pune, India
- Annegret Kongsted, Aarhus University, Denmark
- Guillaume Martin, INRA, France
- Ulrich Schmutz, Coventry University, United Kingdom

Introduction

Otto Schmid, IAHA Chair

It is a great honour to open this video-conference on behalf of the IAHA, the IFOAM Animal Husbandry Alliance (IAHA), who is organising this conference in collaboration with FiBL Switzerland, ITAB France, INRA France, several EU Core Organic projects, GoodEarthGreatFood from New Zealand, IFOAM – Organics International and ICROFS in Denmark.

The main theme of the conference is “Organic Animal Husbandry systems – challenges, performance and potentials”, taking into account the diversity of organic and sustainable animal husbandry systems. Particular attention has been given to dairy and pig systems, parasites and the replacement of inputs. The Video Pre-Conference 2020 will be an opportunity to discuss the projects with colleagues from other parts of the world and to learn from each other’s perspectives and experiences.

The Video Pre-Conference has been organised with project coordinators of five European Union CORE ORGANIC livestock research projects and other EU funded organic projects. They have been offered a platform to present their preliminary research results.

We hope that in 2021 IAHA we can conduct a real physical meeting in Rennes in September 2021 linked to the IFOAM Organic World Congress (OWC) 2021. We are planning pre conference excursions. We have already received and reviewed a lot of interesting papers for this pre-conference, which should take place on 6th and 7th September 2021 before the OWC.

The IFOAM Animal Husbandry Alliance is an informal network of individuals and organizations interested in strengthening the development of organic animal husbandry around the world. IAHA was founded during the 2nd IFOAM Animal Husbandry Conference, September 2012, in Hamburg. IAHA is supported by the IFOAM World Board and Secretariat in Bonn. In the past the main activity of IAHA was to organize a pre-conference linked to the IFOAM Organic World Congresses, in 2014 in Istanbul and in 2017 in India. In 2020 a physical pre-conference should have taken place in September 2020 in Renne, but it was postponed by one year due to the Covid19 pandemic. However, IAHA decided to conduct a video-conference over two half days to be able to present at least some of the on-going work in Organic Animal Husbandry.

This very rich and diverse programme was only possible thanks to a strong engagement of the organising committee (Otto Schmid, Marion Johnson, Mette Vaarst, Catherine Experton, Barbara Früh) and the support of the IAHA Steering Group. We very much acknowledge the support by members of the Scientific Advisory Board, which helped to review the papers (see list of members on page 7).

A special thanks go to Jessica Gearing, who did the English language check at FiBL and Stefanie Leu from FiBL for the registration, Bettina Billmann for the IAHA newsletters and Alijca Klaus and Simon Kufferath from IFOAM international office in Bonn for the website support, and Janne Krabsen from ICROFS for help with formatting the proceedings. And we also would like to thank all the speakers.

Furthermore, we want to thank the IFOAM – Organics International (Ececutive Director Louise Luttkholt, Thomas Cierpka) and FiBL in Switzerland (Directors: Knut Schmidtke, Marc Schärer und Lucius Tamm) for their support

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Potentials, challenges and visions for future European organic animal farming

Mette Vaarst¹, Stephen Roderick², Guillaume Martin³, Stefan Gunnarson⁴, Anet Spengler Neff⁵, Anna Bieber⁵, Anne Grete Kongsted⁶

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 book³ 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 Cofund⁴. 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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³Vaarst, M. & Roderick, S. 2019. Improving Organic Animal Farming. BurleighDoods Series in Agr.Sci. 46. Pp. 390.
⁴GrazyDaiSy: <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 farming² and outputs from five current European research projects funded via the H2020 ERA-net project, CORE Organic Cofund³ and one recently completed CORE-organic Plus project⁵. 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 Uni-

versity). 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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Which compromise between milk production and cow-calf contact in dairy systems?

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Key words: dairy calves, cow-calf contact, milk production, growth of calves, behaviour

Abstract

In organic dairy farms, cow-calf contact is encouraged until weaning and requested by society. However, farmers question this practice, especially because of the loss of marketable milk. At INRAE experimental farm 'Herbipôle', we tested two different suckling strategies on animal performance and behaviour. A 14-cow 'Classic' rearing system (C group) was compared during 14 weeks to two suckling systems. In the C group, calves were separated from dams immediately after birth and fed with an automatic milk feeder until weaning. In the 'Dam' group (D), dam-calf contact was allowed from birth to weaning, between morning and evening milking. In the 'Mixed' group (M), calves were kept with dams until three weeks (as in D group) before being separated and reared as in C group. All calves were weaned at about 11 weeks. On average, over 14 weeks, D and M cows produced 25.1% less milk at parlour than C cows; milk fat content was 3.6 g/kg lower in D group compared to C and M, and milk protein content was intermediate between C and M. After 11 weeks, D-calves weighed 20.5 kg more than C and M calves. Cows and calves both vocalised for one week after separation or after weaning. All calf vocalisations were at a maximum during the first four days. Cows' vocalisations were less notable when calves were removed after three weeks compared to 11. In conclusion, a three-week suckling period seems better for farmers' income and cows' distress, but it induces stress for calves at both separation and weaning, without benefit on growth.

Introduction

In organic dairy farms, cow-calf contact is encouraged until weaning and requested by society (Agenäs et al. 2017). However, calves are usually fed natural milk until 12 weeks, instead of maternal milk as suggested by the organic guidelines, due to being separated from their dam shortly after birth. Long-term cow-calf contact can promote animal welfare and improve health and growth of calves (Roth et al. 2009). By contrast, a short contact period decreases the marketable milk loss for the farmer and is believed to reduce stress at separation. The aim of this study was to investigate a rearing system that would represent the best compromise between cow-calf contact, animals' performance and stress at separation or weaning.

Material and methods

The experiment took place in 2019 at the INRAE Herbipôle experimental farm (DOI: <https://doi.org/10.15454/1.5572318050509348E12>), located in Marcenat (F-15114, 45.30°N, 2.84°E, 1080 m a.s.l.). All procedures were approved by the local animal ethic committee and followed the guidelines for animal research of the French Ministry of Agriculture and all other applicable national and European regulations.

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During 14 weeks after calving, performance and behaviour of three groups of 14 cows and corresponding calves were compared. Cows groups were balanced according to breed (Holstein or Montbéliarde), lactation rank, date of calving, and milk index. The 42 cows were housed in the same free-stall barn, divided into three pens. They calved regularly from 12 February to 5 May and moved to the milking parlour each day at 6:30 and 15:30. They were fed *ad libitum* with a mixed ration (59% 1st-cut hay; 32% 2nd-cut hay; 9% concentrate), plus 2 kg/d of concentrate per cow. From the 5 May, cows were grazing day and night and received 2 kg/d of concentrate. In the Control group (**C**), calves were separated at birth and received at least two litres of fresh colostrum with a feeding bottle (or thawed and reheated if the quality was <24% Brix, measured by refractometer). Calves were housed in individual pens for seven days and bucket-fed bulk milk twice a day. They were thereafter placed in a collective straw-bedded pen with a hay rack and received bulk milk and concentrate by automatic feeders according to a feeding plan (*milk: 6 to 9 kg/d from wk1 to wk3; 10 kg/d from wk4 to wk6; 9 to 3 kg/d from wk7 to wk10 – concentrate: 0.2 to 2.0 kg/d from wk3 to wk10*). In the 'Dam' group (**D**), calves spent five days after birth in individual calving pens with their dam and received colostrum directly from their dam. Thereafter, D-calves were housed in a collective straw-bedded pen next to their dam. From 9:00 to 15:30, calves had free access to the D-cowshed where they were suckled by the dams. From 15:30 to 9:00, the separation gate was closed but calves could see their dam. Calves had free access to a hay rack and a bucket of concentrate. In the 'Mixed' group (**M**), calves were reared as calves of the D group until 3 weeks of age, before being separated and reared as calves of the C group. The day of separation, calves were moved to a remote pen, and cows stayed in the collective barn with the remaining dam-calf pairs.

Five male calves of each group were removed from their respective pen after 21 days of age, to be sold. Remaining calves were weaned when they weighed about 100 kg (corresponding to 11 weeks of age, on average) and were moved to collective pens. Separation of males for selling, separation of M-calves from their dam and weaning took place in waves every two weeks during the Tuesday morning milking.

Individual milk yield was measured twice a day at the milking parlour with DeLaval flow meters. Milk fat and protein contents were determined weekly on four consecutive milkings by mid-infrared spectroscopy and milk somatic cell count (**SCC**) was measured by epifluorescence on two consecutive milkings. This allowed for calculation of the average individual milk yield and composition by week of lactation. Calves were weighed at birth and then weekly until 14 weeks. We observed the behaviour of calves and cows at separation (M group) and at weaning (except C-cows), during one week: the day before the separation/weaning (Day0), the day of the separation/weaning (Day1), and on days 2, 4 and 7. Calves and their respective dam were observed twice a day at the same time, in the morning and in the evening, during two periods of 5 min to note if they vocalised or not.

The data were analysed using the MIXED procedure of SAS software. The model for milk included the effects of the cow (random factor), rearing group (Classic, Dam or Mixed), breed (Holstein or Montbeliarde), parity (primiparous or multiparous), week of lactation (repeated factor), date of calving, and the group*breed and group*week interactions. For the analysis of calves' weight around weaning (week 11, on average), the model included the effects of rearing group, breed, calf sex, date of birth, birth weight and the group*breed interaction. Finally, we calculated the daily percentage of animals that vocalised, by group and by type of animal (calf or cow).

Results

Milk yield at parlour of M-cows was similar to that of D-cows until the separation of calves (week 4). From there, production increased to reach that of C-cows on week 9 (Figure 1). Milk yield at parlour of D-cows increased after the weaning of the last calves (week 12) to reach that of M- and C-cows. Over 14 weeks, M- and D-cows produced 20.5% and 29.7% less milk

at parlour than C-cows (Table 1). Milk fat content was lower in D group compared to C and M groups (-3.6 g/kg, on average) and protein content was lower in C group compared to D group (-1.0 g/kg; $P=0.089$) and M group (-1.6 g/kg; $P=0.011$). Milk SCC was not significantly different between the three groups.

Until four weeks of age, the growth of the three groups of calves was identical (616 g/d; Figure 2). Between weeks 5 to 11, D-calves had a higher growth (1139 g/d) than M and C-calves (845 and 875 g/d). At 11 weeks of age, around weaning, D-calves weighed on average 20.5 kg more than M- and C-calves (120.3 vs 99.5 kg, on average ; $P<0.001$). After weaning, the growth of D-calves dramatically slowed down (266 g/d between weeks 11 and 14) whereas C- and M-calves were less impacted (641 g/d on average). On week 14, D-calves still weighed 8.9 kg more than M- and C-calves ($P<0.05$).

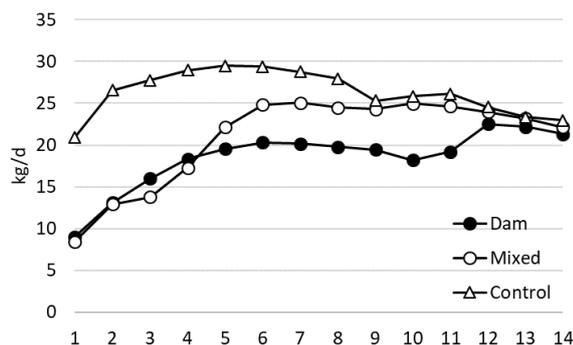


Figure 1. Average daily milk yield at parlour by week of lactation

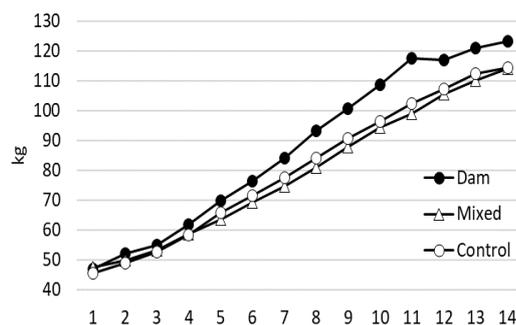


Figure 2. Average weight of calves by week of age

Table 1: Average milk yield and composition during the first 14 weeks after calving, according to the rearing group (adjusted values)

	Control	Mixed	Dam	P-value
Milk yield at parlour (kg/d)	26.3 ^a	20.9 ^b	18.5 ^b	<0.001
Milk fat content (g/kg)	37.2 ^a	36.3 ^a	33.2 ^b	0.007
Milk protein content (g/kg)	29.9 ^a	31.5 ^b	30.9 ^{ab}	0.034
Milk Somatic cell count (log ₁₀ /mL)	4.73	4.82	4.84	0.817

^{a-b} Means within a row with different superscript letters differ at $P<0.05$

After separation, in M and D groups, the percentage of cows and calves that vocalised was the highest on days 1 and 2 (54% and 91% on average for cows and calves, respectively), then it decreased regularly until Day7 (Figure 3). From Day1 to Day7 it was higher for D-cows (6.7-point) and calves (14.7-point) compared to M-cows and calves. After weaning, the percentage of calves that vocalised was the highest on Day2 (94%, on average), then it decreased regularly until Day7 (Figure 4). On Day1, this percentage was two times higher for D-calves (93%) than for C- and M-calves (46%, on average). Conversely, on Day7, the percentage of calves that vocalised was more than two times higher in C group (42%) than in D and M groups (15%).

Discussion

Compared to a classic rearing system of dairy calves, both suckling systems affected production: less milk was collected at the parlour, with a lower fat content in the case of very late separation, and a higher protein content. This loss is higher (764 kg by cow; adjusted

value) than the amount of milk consumed by the same number of calves fed bulk milk with an automatic feeder (396 kg by cow; raw data).

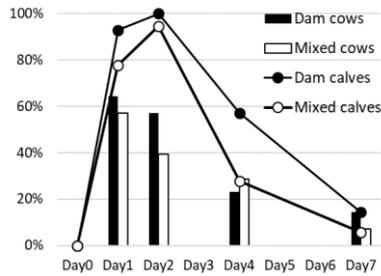


Figure 3. Percentage of animals that vocalised after separation (Day1)

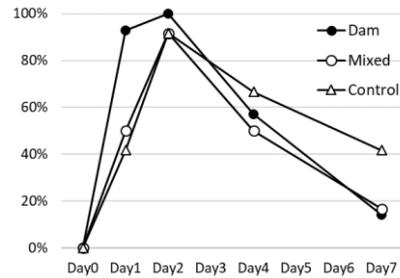


Figure 4. Percentage of calves that vocalised after weaning (Day1)

For a farmer, this difference represents only about 6.1% of the total production of his herd (considering 6 000 kg by lactation). However, a long-term contact with dams improved the growth of calves, which was not the case with a short contact period. This may be due to the stress of the separation combined with the need to cope with the automatic feeder. Separation and weaning are very stressful events for calves because, whatever the group, they all vocalised the following day. Separation seemed less stressful for cows, especially when calves were removed after a few weeks. However, whether at separation or at weaning, some cows and calves still vocalised one week after. In conclusion, a three-week suckling period seems better for farmers' income and cows' distress, but it induces two periods of stress for calves (separation then weaning) instead of one (simultaneous separation and weaning), without benefit on growth. Conversely, the coincidence of separation and weaning after three months induces a strong slowdown of calves' growth.

Suggestions for research and support policies to develop further organic animal husbandry

Rearing dairy calves with their dam until weaning, or at least for few weeks, must be more strongly encouraged in organic farming. For the farmer, marketable milk loss should be compensated by a higher price for a milk labelled "from cows suckling their calves". Further research on the implementation of a gradual weaning, or a weaning without separation, is needed to reduce the stress of both calves and cows.

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Is dairy calves grazing behaviour influenced by cow-calf contact experience?

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Key words: grazing behaviour, herbage selection, dairy calves, experience, cow-calf contact, post-weaning

Abstract

Cow-calf contact is encouraged in organic dairy systems and increasingly requested by consumers nowadays. Rearing dairy calves with their mothers can teach calves how to graze and optimise grass use, as well as improve their welfare and growth. In the present study, we tested the short-term effects of cow-calf contact experience on the grazing behaviour of three groups of eight calves during their first two grazing days after weaning. 'Dam' calves (D) were reared and grazed with their mothers until weaning. 'Mixed' calves (M) were separated from their mothers after three weeks, thus experiencing cow-calf contact but not at pasture. 'Control' calves (C) had never experienced mother's contact (separated at birth) or grazing. All calves started grazing on three similar plots offering heterogeneous vegetation. Scan sampling of calves' activities were performed every 5 min, 6 hours per day (9h-12h and 14h-17h). Proportion of time spent grazing, ruminating and idling were calculated. In addition, for all these activities, the proportion of time calves spent isolated and lying was also calculated. When grazing, observers classified the type of grass chosen by calves (green or dry). Once turned out to pasture, calves from the three groups spent between 55 and 60 % of their daily time grazing; D-calves started grazing immediately (1 ± 4.6 min) unlike M- and C-calves (39 ± 4.6 and 23 ± 4.6 min). The day they were turned out to pasture (Day0), M- and C-calves grazed more dry patches than D-calves. Finally, these differences in behaviour between the three groups were mainly observed on Day0 and disappeared the following day. Consequences on calf's welfare and growth should be further investigated in the long term.

Introduction

In organic dairy farms, cow-calf contact and grazing experience are encouraged. Dairy calves reared with their mothers could learn how to optimise grass use. Pullin et al. (2017) found that lambs grazing with their dam spent more time foraging, were more active, developed long-term feed preferences and learned about aversion to toxic feed more effectively. Dam is the primary social model for young animals, and dominant conspecifics also play an important role concerning grazing behaviour and feed selection (Hessle, 2009). Therefore, dairy calves that learned to graze with their dam might be more efficient in recognising quality herbage when turned out to pasture post-weaning, compared to calves that have never grazed before.

However, it is unclear if this advantage is observed only in the first grazing day or is more persistent. The aim of our work was thus to test if the previous experience of cow-calf contact and early grazing influenced the behaviour of calves on their two first grazing days, and whether calves that experienced dam contact were more sociable.

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Material and methods

The experiment took place in 2019, at INRAE Herbipôle experimental farm (DOI: <https://doi.org/10.15454/1.5572318050509348E12>) located in the Massif central (Marcenat, 45°15'N, 2°55'E; 1150 m a.s.l.). All animal related procedures were carried out in accordance with the guidelines for animal research of French Ministry of Agriculture and all other applicable national and European regulations for experimentation with animals (https://www.recherche-animale.org/sites/default/files/charte_nationale_portant_sur_l_ethique_de_l_expermentation_animale_243579.pdf).

Three groups of eight dairy calves with different experience backgrounds were compared: a group of 'Control' calves (C) that had been separated at birth from their dam and never experienced grazing; a group of 'Dam' calves (D) that had been reared and grazed with their dam until weaning; and a group of 'Mixed' calves (M) that had been separated from their dam at 3 weeks of age and never experienced grazing. All calves were weaned at the age of 11 ± 1 weeks.

Before weaning, D-calves were housed separately from their dams at night and had free access to the dam cowshed during the day. Starting from 5 May, when the calves were 4.6 ± 3.2 weeks old, the day cowshed access was replaced by free access to pasture with the dams. M-calves, until the age of 3 ± 1 weeks, were reared in the same way, except that they did not have access to pasture. From this age until weaning, they were reared like C-calves, *i.e.* in a separate housing and fed with an automatic milk dispenser. D- and M-calves were reunited with their dams after morning milking at 9h and separated before evening milking at 15h30. All calves had access to hay and 0.2 to 2.0 kg/d/calf of concentrate from Week3 to Week11. At the beginning of the experiment, D-, M- and C-calves were respectively 14.9 ± 3.2 , 16.1 ± 2.8 and 15.3 ± 3.6 weeks old. They had been weaned for 30 ± 22 , 33 ± 20 and 33 ± 24 days, respectively.

Calves were turned out to pasture on 22 July (Day0), from 9h to 17h. They grazed on three similar 0.15 ha plots offering heterogeneous vegetation, with permanent access to water. No close visual contact was allowed between the three groups. On each plot, four calves were randomly assigned to two observers who recorded the calves' behaviour by scan-sampling every 5 min, 6 hours per day (9h-12h and 14h-17h), for two consecutive days (Day0 and Day1). Each day, the time taken by calves to start grazing was measured. Then, activities were differentiated into three groups: ingestion (grazing and drinking water), rumination, and idling. The latter comprised 3 further categories: resting (observation, sleep and self-grooming), socialising (allogrooming and domination) and *ad hoc* activities (walk, exploration, stereotypies and vocalisation). When calves were grazing, observers distinguished whether the herbage chosen by calves was green or dry, and the proportion of dry herbage chosen by calves was calculated over the total number of grazing observations. The daily proportion of ingestion, rumination and idling time was calculated as a percentage of total daily observation. The daily proportion of resting time, socialising time and *ad hoc* activities was calculated as a percentage of the idling activities. Furthermore, each time one of the activities was recorded, observers also indicated if the calf was grouped with other calves or isolated, and if it was standing or lying. The daily proportions of time spent in the group and standing were calculated over the total number of observations.

All data were analysed using the MIXED procedure of SAS software. The model included the fixed effects of group (D, M or C), day (0 or 1) and their interaction. Calf was considered as the subject of repetition and day as repeated factor with a compound symmetry covariance structure. Normality of the residuals was checked using Shapiro-Wilk test. Differences amongst least square means were considered significant when $P < 0.05$.

Results

On Day0, when arriving on pasture, D-calves started grazing immediately (Table 1), whereas it took C-calves around 20 min before they actively started to graze. The M-calves needed a

further 20 min. Even though D-calves started grazing earlier than M- and C-calves, over the entire Day0 they did not spend more time ingesting. It seems rather that it gave them more time to ruminate (+5 % in average). In addition, on this day, M- and C-calves grazed about 10 times more dry patches than D-calves. The differences in grazing behaviour observed on Day0 between the three groups were no longer observed on Day1. Indeed, all calves started grazing on average 5 min after arriving on pasture and lost interest in dry patches, which only represented about 2% of their diet.

Table 1: Effects of day, group and their interaction on the time to start grazing, percentage of daily activities, herbage selection and social interaction of calves.

Item	Day	Dam	Mixed	Control	SEM	Group	Day	Group x Day
Time to start grazing (min)	0	1	c 39	a 23	b 4.6	***	***	**
	1	6	c 4	c 4	c			
Daily activities (% of daily total observations)								
Ingestion time	0	55	61	60	2.5	ns	*	+
	1	56	52	55				
Rumination time	0	15	a 8	bc 11	b 1.3	+	***	**
	1	7	bc 7	c 9	bc			
Idling time	0	30	32	30	2.7	ns	***	ns
	1	37	42	36				
Herbage selection (% of ingestion observations)								
Dry patches	0	2	b 29	a 26	a 2.7	***	***	***
	1	0	b 2	b 5	b			
Idling activities (% of daily idling observations)								
Resting time ¹	0	57	47	54	3.8	+	***	ns
	1	74	65	67				
<i>Ad hoc</i> activities ²	0	35	B 49	A 38	3.7	*	***	ns
	1	24	B 29	A 29	AB			
Socialising time ³	0	8	a 3	bc 8	a 1.5	ns	*	**
	1	2	c 6	ab 4	bc			
Proportion of time (% of daily observations) spent:								
Lying	0	16	B 13	B 24	2.2	***	ns	ns
	1	16	B 11	B 28	A			
Isolated	0	17	c 18	c 26	b 2.5	***	**	**
	1	23	bc 16	c 39	a			

***P<0.001; ** P<0.01; * P<0.05; + P<0.10; ns P≥0.10

^{a-c}Means within a variable with different superscript letters differ at P<0.05

^{A-B}Means of group effect differ at P<0.05

¹*Resting time*: observation, sleep, self-grooming

²*Ad hoc activities*: walk, exploration, stereotypies, vocalisation

³*Socialising time*: allogrooming, domination

Regardless of day, the activities of calves during their idling time differed between groups. The D-calves tended to spend more time resting than M-calves (65 ± 2.9 versus 56 ± 2.9 %), with C-calves being in the middle (61 ± 2.9 %). Instead of resting, M-calves had more *ad hoc* activities than D-calves (39 ± 2.5 versus 29 ± 2.5 %), whereas C-calves did not differ from either of the other groups (33 ± 2.5 %). Overall, D- and M-calves showed more gregarious behaviours than C-calves, while the latter spent more time lying (26 % of daily observations) and isolated (33 % of daily observation). This latter difference was even stronger in Day1 than in Day0.

Discussion

Experiencing pasture with dams facilitated calves' grazing behaviour only for a short time, as all differences disappeared after the first day. This study showed that the M rearing system for calves resulted in the longest time to start grazing, whereas D-calves started grazing within the first five minutes on pasture. The M- and C-calves, which only experienced a hay-based diet, with or without the dam, did not particularly avoid dry patches on their first grazing day on the contrary to D-calves. Besides grazing behaviour, dam-calf contact in the early stages of life influenced the social behaviour of calves. Again, while idling, M-calves had the most different behaviour from D-calves in terms of *ad hoc* activities, which means that overall, they spent more time actively walking and exploring, in addition to occurrences of vocalisations. This showed their discomfort in adapting to this new situation, which suggests that further consequences on their behaviour could occur in the long term.

Suggestions for research and support policies to develop further organic animal husbandry

Cow-calf contact in early life did not give a substantial advantage to dairy calves concerning grazing ability. Our results suggest that cow-calf contact and its duration influences more social than grazing behaviour of calves, probably leading to welfare concerns. The latter should be further investigated, as much for calves as for dams.

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Risk factors for *Cryptosporidium* oocyst shedding in dairy calves reared with nurse cows in organic farms

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Key words: *Cryptosporidium*, Dairy calves, Nurse cows

Abstract

*New rearing practices of suckling dairy calves with nurse cows have been recently adopted by farmers but remain poorly documented regarding their impact on calves' health, particularly for cryptosporidiosis. The objectives of the study were to describe the cow-calf rearing system and to assess calf faecal shedding of *Cryptosporidium* spp. oocysts as well as particular risk factors of oocyst shedding related to this practice. Between January and September 2019, the rearing practices of calves were described in 20 farms and 611 calves were sampled between 5 and 21 days of age to quantify faecal oocyst shedding of *Cryptosporidium* spp.*

Rearing usually consisted of a first phase with the dam, followed by an optional phase of artificial milk feeding, and a final phase of fostering by a nurse cow. On average, each nurse raised a group of two or three calves of close age with a fostering age of 8 days on average. The global shedding prevalence of 40.2% was similar when compared to classically reared calves, but the intensity of shedding and the prevalence of diarrhoea appeared to be lower. The identified risk factors for shedding were either non-specific to the nurse cow system (i.e. birth in the middle or end of the calving season vs beginning of the season) or related to this particular system (i.e. artificial milk feeding +/- fostering phase vs only with the dam).

Introduction

French organic farmers increasingly practice dairy farming systems allowing cow-calf contact. One of these systems involves a fostering phase during which two to four calves are suckled by a nurse cow. However, accurate descriptions of this system as well as evaluation of its impact on calf diarrhoea are very few.

Classic management of dairy calves in organic farming consists of separating the calves from their dam within 24 hours after birth, calves being fed with the farm whole milk first in individual pens and then in collective pens with outdoor access before weaning (at 3 months) and turnout. In contrast, the management of dairy calves with nurse cows is characterized by an adoption during the first month of calves' life and the presence of this adult cow during the first year of the calves' life. Calves with nurse cows are therefore exposed to profound changes during the neonatal period that can have consequences on the epidemiology of diarrhoea, particularly cryptosporidiosis, which is the more prevalent infection in calves between 5 and 21 days. The objective of this study was to describe the nurse cow-calf rearing system and to assess the frequency, intensity and the risk factors of *Cryptosporidium* infection in such reared calves.

Material and methods

Nineteen commercial organic dairy farms located in western France (Brittany, Normandy, Pays de Loire) and one experimental farm located in eastern France were included in the study. Each farm was visited at the beginning of the study to collect accurate information on the calf rearing method both for replacement and non-replacement calves. Between January

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and September 2019, faeces were sampled by the farmer once from each calf between 5 and 21 days of age (9 to 65 calves per farm). At the time of sampling, calves could be: still with their dam, already fostered, or milk fed by the farmer (an optional artificial milking phase just before being fostered). Faecal *Cryptosporidium* oocysts shedding was evaluated semi-quantitatively according to the method of Henriksen and Pohlenz (1981), with a score of shedding between 0 to 4. Then, to assess risk factors, the outcome variable representing the shedding of *Cryptosporidium* oocysts was coded as a dichotomous variable representing the positive (score ≥ 1) or negative (score = 0) status of each faecal sample. Mixed effect logistic regression models were used with farm as random effect (univariate firstly and then multivariate). Odds ratios (OR) and confidence intervals of 95% (CI95%) were calculated.

In a first data set including all the sampled calves (n= 611), all risk factors investigated were collected at the individual level at the time of faecal sampling and considered in the form of categorical variables: dam parity, birth order in each herd and month of birth, calf characteristics as age, sex, breed, problem at calving (yes/no), colostrum monitoring (yes/no), calf rearing phases, location. On a second data set including the fostered calves only (n=257), factors investigated were fostering-specific variables: nurse cow parity, fostering characteristics (age at foster, time between fostering and sampling, number of fostered calves by the nurse cow and age difference between fostered calves, presence of a *Cryptosporidium* infected calf among calves fostered by the same cow).

Results

Dairy nurse cow-calf rearing systems

Calvings were grouped in winter/spring for nine farms and in summer for one farm, split into 2 periods in spring and in summer for six farms and spread over at least 6 months during the study for four farms.

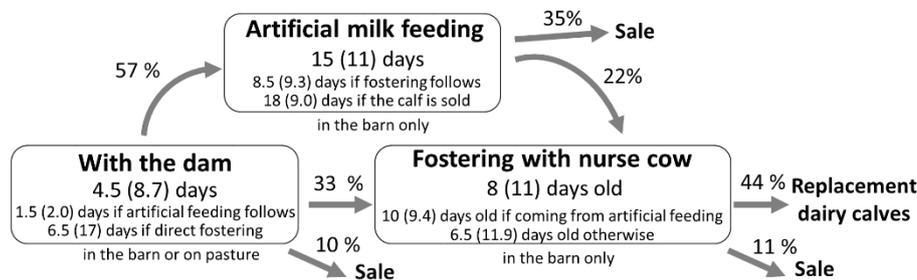


Figure 1. Distribution of replacement and non-replacement dairy calves according to the rearing phases in the 20 organic dairy farms (the durations or ages given in days for each rearing phase are the averages and (standard deviations)).

The rearing practices of the replacement and non-replacement calves greatly varied between farms but consisted basically of three phases (Figure 1): a compulsory first phase with the dam, followed by an optional phase of artificial milk feeding, and a last phase of fostering by a nurse cow i.e. an unmilked lactating cow to suckle calves. The chosen combination of phases depends on the farm and on the intended use of the calf (replacement or not). A nurse cow suckled 1 to 4 calves (2.5 calves on average) and the age difference between fostered calves was 6 days on average. The fostering always started indoors and was carried out either in an individual pen (fostered calves with their nurse, 74% of the calves) or collectively (all the fostered calves with all the nurse cows, 26% of the calves). Non-replacement calves could be sold at each phase.

In this study, 158 cows were assigned to foster the calves. Most of the nurse cows were multiparous (85%), 44% of them being at least in their fourth lactation. The nurse cows were chosen by the farmers because of high somatic cell counts (45%), reduced reproduction performances (17%), milking issues (10%) and lameness (9%). Other criteria included the maternal character of the cow (9%) or some practical reasons such as calving at the right time (5%) or the advanced age of the cow (5%). The fostering was successful on the first attempt for 90 % of the calves. If the cow was refractory, restraint techniques could be used by blocking the cow at the feed fence or with a tether. If this was not enough, a change of nurse was considered. Eleven calves (1.8%) died in this study before they were 25 days old, 2 due to diarrhoea.

Prevalence and risk factors associated with *Cryptosporidium* oocyst shedding

➤ Average calf age was 12 days (sd =3.5 days) at the time of faeces collection. Out of the 611 calves, 246 (40.2%) were tested positive for *Cryptosporidium* oocysts excretion. The positive scores were distributed as follows: 156 (25.5%), 58 (9.5%), 16 (2.6%) and 16 (2.6%) calves with score 1, 2, 3 and 4, respectively. The average score was 0.6 and the median was 0. The within-herd prevalence of calf oocyst shedding varied from 0 to 71% (average 38%). 88 faecal samples (14.4%) were diarrheal, 69% being positive for *Cryptosporidium* oocysts. The within-herd prevalence of diarrhoea ranged from 0 to 32% (mean 14%).

Table 1: Final multivariate mixed effect logistic regression model analyses of factors associated with *Cryptosporidium* oocysts shedding in calves aged 5 to 21 days. (OR= Adjusted Odd ratio, CI= confidence interval, AMF=Artificial milk feeding)

Risk factor	Level	Number	OR	95% CI	P-Value
Birth order	1st third	204	Ref.	-	0.002
	2nd third	204	2.889	1.55-5.38	
	3rd third	203	3.042	1.38-6.69	
Month of calving	January-February	126	7.360	2.52-21.53	<0.001
	March	200	7.282	3.02-17.54	
	April	84	8.381	3.61-19.45	
	Mai-July	102	10.683	4.75-24.05	
	August-September	99	Ref.	-	
Calf location with the dam	Pasture	405	Ref.	-	<0.001
	Barn	206	3.022	1.64-5.58	
Calf rearing phases	Dam only	90	Ref.	-	0,083
	Dam + AMF	244	4.120	1.30-13.06	
	Dam + AMF + Nurse	100	3.561	1.13-11.23	
	Dam + Nurse	177	2.004	0.88-4.57	
Contact with peer calves	No	89	Ref.	-	0.036
	Yes	521	2.620	1.05-6.53	

In the analysis including all calves, the final multivariate model included five potential independent predictors (Table 1). Risk factors significantly associated with *Cryptosporidium* oocyst excretion were: the last two thirds of birth order in each herd, being born between January and July vs August-September, being with the dam indoors rather than outdoors, and being in contact with peer calves. Among the 257 fostered calves, 117 (45.5%) excreted oocysts. In the analysis including only fostered calves, the final multivariate model included only one variable: the presence of a positive peer calf among calves fostered by the same nurse was a

significant risk factor associated with *Cryptosporidium* oocyst shedding (OR = 1.99; 95% CI = 1.05 - 3.77 and P-value=0.035).

Discussion

In this study, 40.2% of the sampled calves shed *Cryptosporidium* oocysts in the faeces. This proportion is similar to that observed in dairy calves classically reared (48%; Castro-Hermida et al. 2002 and 41.5%; Delafosse et al. 2015) or in suckling beef calves (49%; Castro-Hermida et al. 2002). In contrast, the intensity of excretion was markedly lower in our study. Calves excreting a high number of oocysts (score 4) represented 25.1% of the calves in the French classic rearing system (Delafosse et al. 2015) whereas this category represented only 2.6% of the calves in our study. The prevalence of diarrhoeal calves (14.4%) in our study was also lower compared to classically reared calves (52.5%; Delafosse et al. 2015). This result is consistent with the low intensity of oocyst excretion because in young calves, diarrhoea can be associated with the intensity of *Cryptosporidium* excretion (Delafosse et al. 2015).

Calves born in the last two thirds of the birth order and gone through an artificial milk feeding phase were more likely to be infected. Contact between peer calves and especially the presence of an excretory calf fostered by the same nurse was another risk factor. These results emphasize the role of the environment for the contamination, particularly those related to the accumulation of oocysts from previous or contemporary calves facilitating the faecal-oral route of transmission. Moreover, the risk of excreting oocysts increased when the first phase of the calf's life with its dam was in the barn compared to pasture and especially when the calves were born between January and July. This highlights once again the role of the premises used intensively during the winter/spring months with higher densities of calves in the barn and higher infection pressure for calves compared to outdoor situations.

Suggestions for research and support policies to develop further organic animal husbandry

Even if the frequency of excretion was similar to those found in standard rearing systems, it seems that rearing the dairy calves with nurse cows tends to reduce the intensity of *Cryptosporidium* oocyst excretion in neonate calves. We advise farmers to manage the calves as much as possible with adult cows (dam and nurse), thereby avoiding the artificial milk feeding phase, and to promote outdoor calving as long as weather conditions allow (spring-summer calving) as a way to minimize environmental oocyst contamination. In addition, attention should be given to quickly diagnose clinical cases of cryptosporidiosis and to possibly separate diarrheic animals from their peers during collective rearing phases.

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Dam-calf contact systems as a future for organic dairy farms? Actor perceptions and experiences inform the debate

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Key words: Dam-rearing, fairness, natural needs, animal rights, actor perceptions

Abstract

Dam-calf contact systems can be seen to contribute significantly to the physiology and natural behavior of calves as well as of mother cows. From the perspective of organic farming principles, dam-calf contact systems meet many of the aims; however, the separation of calves and cows within days after birth has been generally accepted. Interviews, case studies and on-farm studies across the Netherlands, France, Norway and Denmark showed that dam-rearing can be practiced in a wealth of different systems. When organizing a dam-calf contact system to fit the context and strategies as well as daily practice of the farm, four main angles should be considered: calf, cow, farmers and farming system. The actors described three important qualities in dam-calf contact systems: 1) nutrition, 2) care, and 3) learning. These aspects led the priorities and development of dam-calf contact systems. Following the establishment of a dam-calf contact system, the pleasure of seeing interactions between the dam and her calf motivated farmers to continue the system and encouraged them to observe their animals in new ways. Farmers with no experience in dam-rearing feared the 'loss of control' over the calf.

There was a repeated questioning of 'naturalness' in relation to dam-rearing. Whilst considering the potential of organic dairy systems to encompass such systems, as well as acknowledging the 'naturalness' of cow and calf including their motivation and need to be together, 'unnatural elements' were also highlighted, e.g. the high milk yield, deep udders and big herd sizes in today's dairy sector. Some issues remain currently unsolved for future organic dairy sector to find solutions to, especially the issue of bull calves (often removed from their dam in an abrupt way), and to organize new systems which are friendly and less restrictive for cows and calves at the same time.

Introduction

Dam-calf contact systems can be seen to contribute significantly to the physiology and natural behavior of calves as well as of mother cows. From the perspective of organic farming principles, dam-calf contact systems meet many of the aims but separation of calves and cows within days after birth has been generally accepted. However, the general interest in dam-rearing systems is increasing throughout Europe and the CORE-Organic project GrazyDaiSy was established, among others, with the aim to investigate the possibilities and sustainability of implementing dam-rearing in commercial dairy herds. The project is working closely with practice, with one of the elements in the project being to understand farmers' motivations and learn from experiences in the field. The aim of this presentation is to summarise some of the

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identified perspectives based on semi-structured qualitative interviews of farmers and other stakeholders.

Material and methods

Different types of semi-qualitative interviews (face-to-face and phone, recorded or with responses written down) were conducted in Norway (5 case studies), France (3 case studies) and Denmark (in total 31 interviews of farmers, advisors and researchers). The interviews were analysed first as individual cases and sets of interviews and, after this, across countries together with research interviews from 12 years of studies in the Netherlands on co-calf-systems (Vaarst et al. 2019).

Results

1) Four perspectives across contexts: calf, cow, farmer and system

Interviews and on-farm studies across the Netherlands, France, Norway and Denmark showed that dam-rearing is practiced in a wealth of different systems and four main angles should be considered when organizing a dam-calf contact system to fit the context and work well: calf, cow, farmers and farming system.

2) Meeting the calf's need for nutrition, care and learning

From the calves' perspectives, the dam-calf contact systems contribute significantly to the physiology and natural behaviour of calves as well as of mother cows. Three important qualities in dam-calf contact systems were described from the animals' perspective: 1) nutrition, 2) care, and 3) learning. The priorities and perceptions of the importance of these three qualities substantially influenced the farmers' choices and priorities of systems. For example, if a farmer focused on the nutritional aspect, it could motivate him/her to choose a part-time system with the main purpose of providing the calf with milk and which could be restricted. It could, for example, be a system with two hours access to each other two times daily. On the other hand, if a farmer focused on care and learning, he/she would be motivated towards a more full-time access system, where the cow could guard her calf and the calf could seek shelter and protection with its dam.

Some of the interviewed farmers perceived the calves to be equipped with capacities and skills through learning from the dam and others in the system. They emphasised that this would be adding to their life opportunities and, although such systems require major efforts to organize and manage, they would favour a system where mother cow and calf were together with as little restriction as possible.

3) The mother cow's need

Among some interviewed actors, the needs of the calf seemed to be more in focus and of higher priority than the natural needs and the motivation of the mother cow. This is clear when talking about foster cow systems (where the mother cow is separated from her calf soon after calving). However, no matter which system some of the interviewees discussed, they seemed in many cases to focus most on the benefits of the calf. However, they often could describe how the mother cow reacted strongly to the separation and showed much distress. This could also stimulate an argument for early separation because then bonding had not yet taken place. Silence – both for calves and cows – was described as 'not suffering', whereas calling and 'sounds' were perceived as suffering.

One remarkable aspect of the needs of mother cows was the difference of 'calves to stay in the herd' versus 'calves to leave the herd'. This aspect seemed to raise a general inconsistency in the arguments for or against early separation, including the method of separation. Some of the interviewed farmers explained that they kept their calves with their dams for

weeks to months after birth to meet the natural needs of both calves and cows. However, for some of these cases only female calves were kept in the herd while for the male calves, the calf and the cow had to go through early and abrupt separation. In some cases, the farmers who received the calves had complained if calves had not been accustomed to drinking milk from a bucket and therefore resulted in the dairy farmer separating them from the cow at an early stage. In other cases, the farmers who reared the male calves for veal or meat production had appreciated the sizes and generally good health condition of the calves that had been together with their dam. However, in some of these cases the separation happened abruptly on the same morning where the calf should leave the herd, which caused stressful reactions from the dam who had just lost her calf.

4) *The point of no return?*

Seen from the farmers' points of view, it was remarkable that most farmers who had dam-calf contact systems, were driven very much by the pleasure of seeing it work and seeing the interaction between calves and cows. They articulated how they were touched and impressed e.g. by the mother cow's consistent 'watching over' her calf and the pain of separation. Generally, the farmers had never been motivated by premium prices or consumer demands, but just did it because they found it right, or 'easier' in combination that it brought them other qualities being farmers. In a few cases where there was close contact with consumers, e.g. by having farm shops or being situated in a place where many citizens came by, the farmers mentioned that the positive feedback played a role for keeping the system or justified an extra premium price for the products. However, in one of the Dutch studies, farmers were also interviewed after having left this system again and, among negative aspects, they mentioned diseases, feralisation and the separation process.

5) *It is not easy to change the way of 'being responsible for the calves'*

A group of the interviewed farmers and stakeholders had been introduced to dam-calf contact systems in an excursion to farms with dam-rearing systems. They had not had any prior experience with these systems, so they saw most of it with 'fresh eyes'. They pointed out the need for developing systems which were much more 'friendly' to both cows and calves than some of the systems which they saw, e.g. with slatted floors or with some 'dead ends' in the housing system which they perceived risky for small vulnerable animals. They emphasised the need to develop dairy systems which allowed cows and calves to be together with minimum risk especially for the calves and where the calves could learn about life in a dairy herd (e.g. indoor and outdoor life; and eating solid feed and grass).

Their observations and reactions raised an interesting aspect in the analysis, namely about whether the farmers who had these systems were a bit 'laid back' because they seemed to just leave the care of the calves to the dams. They expressed it in the way that these farmers seemed to 'trust the animals' and wondered about this transition in the way of thinking due to being brought up with the idea that they 'needed to be in constant control of the calf' in terms of e.g. knowing exactly how much milk they had been drinking. Watching these systems and seeing the calves being very bold and robust made them realise that the calves obviously found their way in the system and that completely different skills needed to be activated when taking care of such calves. This pointed to the need for the humans in the system to redirect efforts and focus when observing animals and when spending their time with cows and calves. This was confirmed in the interviews of experienced dam-rearing farmers, who also described that 'it was a completely different way of farming'.

6) *The curious scepticism: how natural is it, and who benefits?*

There was a repeated questioning of 'naturalness' in relation to dam-rearing. Whilst acknowledging that mother cows and calves were strongly motivated and it was 'natural' for them to be together, some farmers also pointed to factors which partly made it 'unnatural' for them. This was especially the very high milk yields of dairy cows which could lead to over-drinking for the calf, or deep udders which made it difficult to drink for the calf. Others pointed to the

fact that daily life in a large dairy herd might not give a new-born calf sufficient peace to rest. Another aspect which was raised, partly in relation to the question of 'naturalness', was whether it was best in the farming system that the calf could find its mother, or the mother find her calf. It was agreed that ideally, both should have as much unrestricted access to each other as possible. However, for practical reasons and due to the fact that there are very few housing systems built to keeping the calves with the cows, compromises often had to be found and either the cow or the calf was restricted to move to the areas of the other. In this way, it was also difficult to 'mimic nature' and both experienced dam-rearing farmers as well as farmers who were curious about the system argued the conflicts in finding 'the ideal system'.

Final discussion

Major efforts are required when organising suitable calf- and cow-friendly dam-rearing systems, and farmer observations must be more careful and intense. This means that a cow-calf system requires the time and effort equivalent to the separated cow and calf systems, but with an attention on different types of activities and focus points. Farmers' trust in their animals' capabilities seems to partly break with some of the animal husbandry qualities that are often considered important when taking care of cows and calves in a system with early separation, such as knowing exactly how much milk each calf is given. 'Being in control' in a cow-calf system relies to a higher degree on being able to observe and judge a complex situation than, for example, on giving the calves exactly the same amount of milk of a specific temperature at the same times every day. This shift from 'being completely in control' to 'trusting that the animals can manage' is identified as key for human learning in these systems as a component of the shifting focus when observing animals and spending time with cows and calves differently.

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Performance and health status of dairy calves reared with nurse cows, a 2-year study involving 3 cohorts

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Key words: dairy calves, nurse cows, gastrointestinal nematodes, performance

Introduction

Since the 1990s, groups of dairy farmers have been set up in many European countries to exchange information about grazing management. Within these groups, organic dairy breeders have experimented with new replacement calf rearing practices, in which some lactating cows are assigned to nurse and suckle 2-4 calves each. In the Mirecourt experimental farm (Grand-Est, France), the foster cow-calf rearing system was designed in collaboration with farmers already involved in this practice and introduced in 2016. However, this management remains poorly documented: zotechnical descriptions and its impact on the calf health are few. The objective of our study was thus to assess the effects of rearing dairy female calves with nurse cows on their growth and health. We focused our study on gastrointestinal nematodes (GIN) infection during the first grazing season when young and adult animals were grazing together and during the second grazing season after weaning. Three cohorts of female animals born respectively in 2016, 2017 and 2018 were followed during two years in the experimental farm.

Material and methods

Three cohorts of replacement female calves born respectively between January and April 2016, 2017 and 2018 were followed for two consecutive years (the first year with nurse cows, the second year after weaning): cohorts 1, 2 and 3 followed respectively during 2016-17, 2017-18 and 2018-19. In the cohort 1, 18 replacement female calves born in 2016 were separated into two groups: nine calves were raised by three nurse cows and nine calves were conventionally raised (artificial milk feeding). Thereafter, in the cohorts 2 and 3, all replacement calves were raised by nurse cows and consisted of 16 calves and six nurse cows in 2017 (cohort 2), and of 23 calves and nine nurse cows in 2018 (cohort 3). The female calves were Holsteins, Montbeliards or dairy crossbreeds and the nurse cows were all pure Holstein or Montbeliard breed. The different sizes of the three cohorts can be explained by the varying number of female calves born each year.

Each animal was weighed at birth and at regular intervals thereafter until two years of age. Weight and daily weight gains were calculated every third month. Reproduction indicators (age at first insemination, number of inseminations, age at first calving) were recorded.

For each grazing season, blood and faecal samples were individually collected four times. The GIN faecal egg count (FEC), expressed in eggs per gram of faeces (epg), was determined in each faecal sample (Cringoli and al. 2017). Individual serum pepsinogen concentrations (units of tyrosine-U Tyr-) indicating digestive lesions related to abomasal worms number were determined according to Kerboeuf et al. (2002). In addition, individual serum anti *O. ostertagi* antibody levels were determined with the SVANOVIR® *O. ostertagi*-Ab ELISA kit procedure

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(Svanova Biotech, Uppsala, Sweden) and results were expressed as optical density ratio (ODR) according to the manufacturer. The Parasit'Sim model was used to calculate, for each cohort (and each year of follow-up), the maximal number of GIN larval generation (LG) in the different plots since turnout (LG1, LG2, etc...) as a proxy for the pasture infectivity level (Chauvin and al. 2009). The model takes into account local temperatures, grazing management and immune response of calves against GIN.

Results

Grazing management and parasitic risk modelling

Throughout the study, no disease was observed in the female animals and no anthelmintic treatment was given. Only one calf died due to ruminal tympany.

During the first grazing season, female calves with nurse cows were conducted on rotational grazing approximately from mid-April to November (203 days in 2016, 213 days in 2017 and 228 days in 2018). The calves were weaned at housing. According to Parasit'Sim, the cohorts 1, 2 and 3 were exposed to the 5th, 5th, and 6th larval generation in 2016, 2017, 2018, respectively.

For the second grazing season (weaned females alone), turnout was from late March to mid-April and housing occurred from mid-November to early December for all cohorts. Rotational grazing was conducted for an average of 234 days (232 to 236). According to Parasit'Sim, the three cohorts were exposed to the 6th larval generation and were considered as immunized against GIN at the beginning of the 2nd grazing season (between early April and early May).

Parasitic indicators

Table 1: Mean value (1st row) and standard deviations (2nd row) of parasitic indicators of the 3 cohorts at each sampling point during their 2 years of follow-up at the Mirecourt farm. P1 = Turn-out in April, P2 = June P3 = September, P4 = Housing; nd = not done

	Cohort	Pepsinogen (U Tyr)				Ostertagia ELISA(ODR)				Faecal egg count (epg)			
		P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
1 st grazing season	1	nd	nd	nd	1,29 0,41	nd	nd	nd	nd	nd	nd	nd	nd
	2	1,43 0,71	1,22 0,68	1,79 0,50	1,6 0,54	0,79 0,25	0,33 0,21	1,02 0,20	1,05 0,21	nd	135 97	151 99	43 47
	3	0,98 0,71	1,29 0,72	0,96 0,44	1,1 0,30	0,30 0,28	0,35 0,23	0,66 0,25	0,81 0,30	nd	110 65	82 44	62 35
2 nd grazing season	1	1,89 0,90	2,12 1,18	2,58 1,28	2,81 0,66	0,80 0,15	1,19 0,07	0,98 0,10	0,94 0,15	67 53	20 18	3 7	10 20
	2	1,78 0,54	1,67 0,77	1,61 0,56	1,35 0,30	1,11 0,21	1,15 0,21	1,03 0,20	nd	150 149	11 27	1 4	21 44
	3	1,92 1,07	1,27 0,53	1,48 0,51	1,20 0,53	0,83 0,22	0,66 0,24	1,08 0,21	1,01 0,14	27 32	72 146	14 31	17 26

Average pepsinogen values did not exceed 2.0 Tyr U regardless of cohort and sampling point (Table 1) except for the 2nd grazing season of cohort 1 which had a mean value of 2.81 TyrU at housing.

Regarding the *Ostertagia* ELISA, during the first grazing season, the ODR mean values globally increased. They remained very low for the cohort 3 (0.3-0.8) but were higher for the cohort 2 (0.8 to 1.05). During the second grazing season, the values were rather constant around 1 (Table 1).

Regarding FEC, in the first grazing season the values were highest at P2 and P3 (around 110-151 epg) and then decreased at P4. In the 2nd grazing season the values remained low except at P1 for the cohort 1.

Production indicators

The weight averages of the three cohorts are presented in **Table 2**. Overall, female animals weighed around 200 kg at six months old and reached 375 kg at 15 months old, which corresponded to the insemination age objective for a 1st calving at 24 months old. At 15 months old, 56% of females in the cohort 1, 73% in cohort 2 and 40% in cohort 3 had reached this weight target of 375 kg. The average daily weight gains are shown in **Table 3**. The females had generally high average growth throughout these two years, especially during the grazing months (3 to 9 and 12 to 21 months). At housing (around 9 months old), growths decreased especially for cohorts 2 and 3 (corresponding also to the weaning period).

Table 2: Average and (standard deviation) weights (Kg) of females 0-24 months of age according to the three Mirecourt cohorts

Co-hort	Ages (months)							
	Birth	3	6	9	12	15	18	21
1	41,3	116	187	263	330	374	453	522
	(6,9)	(12)	(18)	(23)	(25)	(23)	(23)	(26)
2	39,9	125	207	285	315	385	444	491
	(4,5)	(15)	(27)	(36)	(35)	(34)	(48)	(35)
3	39,2	114	187	232	277	365	427	482
	(6,5)	(16)	(21)	(31)	(28)	(28)	(31)	(39)

Table 3: Average and (standard deviation) daily weight gains (g/day) of females 0-24 months of age according to the three Mirecourt cohorts

Co-hort	Age ranges (months)						
	0-3	3-6	6-9	9-12	12-15	15-18	18-21
1	776	850	846	702	488	882	766
	(104)	(146)	(107)	(150)	(213)	(210)	(153)
2	884	956	873	310	783	656	522
	(158)	(194)	(128)	(83)	(128)	(365)	(312)
3	771	870	506	474	974	690	613
	(131)	(120)	(134)	(153)	(150)	(107)	(224)

Concerning the reproduction performances, the proportions of female animals that calved at 24 months old were 47% and 57% in cohorts 2 and 3, respectively. There was an average of 1.7 inseminations per female in cohort 2 and 1.4 inseminations per female in cohort 3. There was a strong difference in gestation rates between purebred animals (30%) and crossbred animals (72%). The age of two years at first calving was not an objective for the cohort 1 (first calves involved in this new rearing practice).

Discussion

In our study, the foster cow system implied a long duration of the first grazing season for dairy replacement females (more than 200 days) and this was confirmed by an estimated large number of larval generations on pasture. However, during the first grazing season, the three main indicators related to GIN infection of calves were low compared to figures obtained with

conventional system involving weaned naïve dairy calves (Merlin et al. 2016) and suggested a relatively low contact with infective larvae (ODR values) and a subsequent limited build-up of worm burden (faecal egg counts and pepsinogen values). The persistent low values obtained during the second grazing season indicated that this low contact during the 1st grazing season was strong enough for the development of immunity during the second grazing season. It can therefore be hypothesized that nurse cows might play a protective role for calves against GIN infection in this mixed grazing system. On the one hand, by ingesting a lot of larvae and excreting few eggs, nurse cows should probably reduce the level of infection of the pastures compared to a full group of susceptible first-season calves grazing without nurses. On the other hand, ingestion of milk by calves during the grazing period could have an adverse effect on parasite infection as it has been demonstrated in lambs with *O. circumcincta* (Zeng et al. 2001) and could limit the intake of infective larvae.

The females of these three cohorts globally showed a high growth in the two years of follow-up, weights averaging 375 kg at 15 months while this average was 293 kg from 2005 to 2015 before the implementation of the foster cow-calf rearing system on this farm. The loss of weight at nine months of age was certainly related to weaning which is a stressful period for the animals as it has already been mentioned by Johnsen et al. (2016). This growth enabled earlier calving: in cohort 3, 57 % of the females calved at 24 months whereas all females used to calve at three years of age before the implementation of the foster cow-calf system. This study indicated that being with a nurse cow stimulates better growth during and after the milk feeding period which makes it possible to anticipate the target age at first calving by one year.

The 2018 and 2019 summers were particularly dry with only 185 mm of water in 2018 and 157 mm in 2019 between June and September vs 257 mm in 2016 and 282 mm in 2017 for the same period. This was reflected in reduced growth of females (between 6 and 9 months for the cohort 3). This dryness also altered parasite indicators of the cohort 3 during the 1st grazing season (ODR in particular).

Suggestions for research and support policies to develop further organic animal husbandry

Our study provides arguments in favour of the foster cow-calf rearing system set up in this experimental farm. This study suggested that female calves could benefit from a long 1st grazing season with a protective effect of the nurse cows against gastro-intestinal nematodes while having a strong establishment of immunity in the 2nd grazing season. This innovative management also simulated rapid growth, allowing an early age at first calving, especially for cross-bred females.

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Ammonia emissions from outdoor fattening pigs on concrete pad – a farm case study

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Key words: NH₃, excretion area, toilet area, manure, urine, scraping frequency

Abstract

Keeping organic fattening pigs indoors with access to an outdoor concrete pad is common in EU countries. The main environmental impact is related to a risk of high ammonia emissions from excretions on the concrete pad. The objective was to evaluate the effect of frequency of scraping the pigs' toilet, on ammonia (NH₃) emissions. The experiment was conducted at an organic pig farm in southern Sweden over three consecutive days in August. The experiment included four groups of 68 fattening pigs per group, 24 weeks old. Each group had access to an outdoor concrete area (116,4 m²) divided into two sections with a wall. One section was a toilet (7.2 x 4.1 m) and the other was a concrete run (6.9 x 12.7 m). There was no roof over the outdoor area. The whole outdoor concrete area was scraped before the experiment. Each group received a silage bale on the outdoor concrete run. The experimental set-up was to measure NH₃ emissions each day from not scraped vs. daily scraped sub-areas (N= 2 groups per treatment). In the scraped treatment, only toilet and wet areas with urine and faeces was scraped. Other sub-areas were dry sub-areas with silage and dry concrete areas with/without dry faeces. The pigs had access to the whole outdoor area in between measurements. Wet and dry sub-areas were defined each day before measurements. Measurements of NH₃ emissions were conducted with an equilibrium concentration method, where two chambers and one ambient sampler unit were randomly placed in each defined sub-area. The results indicated that the toilet sub-area could have 84 times higher NH₃ emissions than the dry sub-area. Scraping toilet sub-areas decreased NH₃ emissions, varying from one third lower NH₃ emissions down to 17 times lower. This study was part of the CORE Organic Cofund project POWER.

Introduction

In Europe, ammonia (NH₃) emissions from livestock production, predominantly from animal manure management, are one of the most important factors contributing to eutrophication and acidification of land and water (IED, 2010/75/EU). Keeping organic fattening pigs indoors with access to an outdoor concrete pad is common in EU-countries. The main environmental impact is related to a risk of high NH₃ emissions from excreted urine and faeces on the concrete pad. However, there are few studies of NH₃ emissions from pigs outdoors. Studies in indoor pig houses have shown that fast removal of excreted urine could decrease NH₃ emissions significantly (Kellems et al. 1979). NH₃ emissions also occur from excreted faeces but only after decomposition of organic nitrogen, which takes a longer time. Measuring NH₃ emission from an outdoor concrete pad is complicated due to varied temperature and wind conditions as these influence the risk of NH₃ emissions considerably (Svensson 1994). Further challenges are to consider pigs' excretion behaviour of creating sub-areas preferred and not preferred for excretion, resulting in spatial variation in NH₃ emissions within the concrete pad. In this study we used an equilibrium concentration method which is suitable for measuring NH₃

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emissions from small areas and in situations where turbulent wind conditions could be expected due to nearby buildings (Svensson 1993). The objectives of the study were to: (1) compare effect of scraping vs. not scraping sub-areas preferred for excretion each day on NH₃ emissions and (2) measure the spatial variation in NH₃ emissions from sub-areas preferred and not preferred for excretion within the concrete pad.

Material and methods

The measurements of NH₃ emissions were conducted at a commercial organic pig farm in southern Sweden over three consecutive days in August. The experiment included four groups of 68 fattening pigs per group, 24 weeks old. Each group had access to an outdoor concrete area (116,4 m²) divided into two sections with a wall. The section just outside the entrance to the pig house was the toilet sub-area (7.2 m x 4.1 m) while an entrance in the wall led to the next section which was a concrete run (6.9 m x 12.7 m). There was no roof over the outdoor area. The pigs were fed indoors. The day before the experiment the whole outdoor concrete area was scraped to remove excretions, rainwater and silage residues. Each pig group received a silage bale of 300 kg on the outdoor concrete run, a routine the farmer practiced.

The experimental set-up was to measure ammonia emissions each day from pig groups with not scraped vs. daily scraped concrete sub-areas within each section (N= 2 pig groups per treatment). In the scraped treatment toilet and wet sub-areas, the urine, faeces and possibly rainwater was scraped with a shovel and removed from the sub-areas. Other identified areas on the concrete run were dry sub-areas with silage and dry concrete area with/without dry faeces. During measurements of about six daytime hours the pigs were locked in the pig house and in between measurements the pigs had access to total outdoor area. The toilet sub-area was the same size for all pig groups. Measurements of NH₃ emissions were conducted about one hour after scraping with an equilibrium concentration method, where two chambers and one ambient sampler unit were randomly placed in each defined sub-area within each pig group. The NH₃ concentrations in the ventilated chambers were measured at the start of the sampler exposure with a Kitagawa gas detector tube system to determine the appropriate exposure times (Komyo Rikagaku Kogyo K.K.). The minimum and the maximum exposure time of the samplers were set from the measured concentration value (Svensson and Ferm 1993).

Table 1: Sub-areas within outdoor concrete run for each pig group and day, defined before measurements of NH₃ emissions

Sub areas m ²	Groups day 1				Groups day 2				Groups day 3			
	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4
Toilet	29	29	29	29	29	29	29	29	29	29	29	29
Silage	42	45	42	34	53	57	52	65	50	57	47	60
Wet	21	18	14	20	27	15	25	19	26	12	19	15
Dry	25	25	32	34	8	16	11	4	12	19	22	13

Results

Wet and dry sub-areas on the outdoor run varied between pig groups due to performed pig activities and were therefore defined each day before scraping and measurements, while the toilet sub-area was fixed (Table 1). Overall, toilet sub-areas had highest NH₃ emissions, compared to wet sub-areas on the concrete run (Figure 1). Dry sub-areas had lowest NH₃ emissions, lower than 4 g hr⁻¹. Scraping toilet sub-areas decreased NH₃ emissions compared with

no scraping, from one third lower NH₃ emissions down to 17 times lower. Scraping wet-sub-areas on the concrete run in group 3 and group 4 seemed to result in lower NH₃ emissions day 1 and day 3, compared to wet sub-areas not scraped in group 1 and group 2. Scraping toilet and wet sub-areas daily seemed to keep NH₃ emissions on a more stable lower level than not scraping for three days. However, NH₃ emissions differed between pig groups, especially from group 1 and group 2 without scraping the toilet sub-area day 1, corresponding to 336 g hr⁻¹ and 161 g hr⁻¹, respectively. Group 1 also had the highest NH₃ emissions from the wet sub-area on the concrete run day 1. Average weather conditions during the three consecutive days were quite stable with no rain showers and summer temperatures (Table 2).

Table 2: Weather conditions during measurements of ammonia emissions

Average	Air temperature, °C	Soil surface temperature, °C	Wind, m s ⁻¹
Day 1	18	20	2
Day 2	17	20	4
Day 3	19	19	3

Discussion

Ammonia emissions were each day highest from the toilet sub-area, which confirmed that it was the sub-area preferred for excretions (Salomon et al. 2011). Scraping the toilet sub-area daily had a clear effect and kept NH₃ emissions on a similarly low level over the three experimental days. However, the pig groups seemed to have developed different excretion behaviours which was most obvious in group 1 and group 2 without scraping. Salomon et al. (2005) found that pig groups from the same herd fattened during the same time period and with access to an outdoor run, differed in excreted amounts outdoors. Thus, different pig group excretion behaviours are also a factor that could influence NH₃ emissions. In this study the NH₃ emissions from the not scraped toilet area was highest on the first day and twice as high from group 1 compared to group 2. Scraping wet sub-areas on the concrete run tended to decrease NH₃ emissions but the measure had a less clear effect. The cause could be that the wet sub-area was an area where pigs urinated and defecated but more randomly due to the location in between the toilet sub-area and the dry sub-area with silage (Stolba and Wood-Gush 1981). The dry sub-area on the concrete run had low to hardly detectable NH₃ emissions for all three experimental days, indicating that the pigs avoided excreting on this sub-area. The most likely pig activities on the dry sub-area were eating and resting (Stolba and Wood-Gush 1981).

The differences in NH₃ emissions from the toilet area without scraping could also have been an effect of different turbulent wind conditions around the pig house during the three experimental days, resulting in measuring different micro climatic conditions. This bias is unavoidable as the concrete pad was placed just outside the pig house and highlights the difficulty of measuring NH₃ emissions under realistic conditions.

Suggestions for research and support policies to develop further organic animal husbandry

The toilet sub-area represented a fixed 25 % area of an outdoor concrete run for fattening pigs and had, without scraping off urine and faeces, 84 times higher NH₃ emissions than the dry sub-area on the concrete run during summer weather conditions. The dry sub-area in this case was dry concrete with silage and without/with dry faeces.

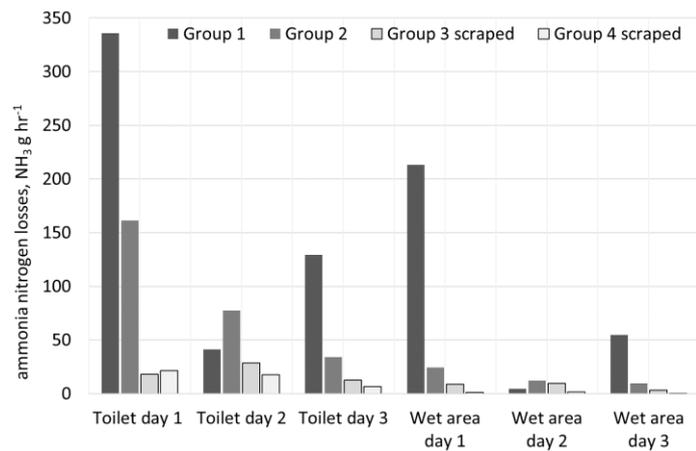


Figure 1. Average ammonia (NH₃) emission losses for each measuring period per day for toilet and wet sub-areas without (Groups 1, 2) and with scraping (Groups 3, 4).

Scraping the toilet sub-area daily to remove urine and faeces had the potential to considerably decrease NH₃ emissions from the outdoor concrete run, compared to no scraping for three days. To be able to introduce daily removal of urine and faeces, the design of the outdoor concrete run should promote pigs' excretion behaviour to choose a toilet sub-area and facilitate development of equipment and work routines for daily removal of urine and faeces. To further decrease NH₃ emissions on the whole pig farm and save valuable nitrogen for crop production, following good manure management principles is crucial. Pig manure should be removed frequently, kept in covered storage and, after spreading on arable land, be incorporated in soil within a few hours.

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Transdisciplinary approach to improve concrete outdoor runs for organic pigs: Identification of innovations

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Key words: finishers, stakeholder-workshops, pen design, animal welfare, environmental impact

Abstract

Across Europe, most organic growing-finishing pigs are kept in systems with outdoor runs. When made from barren concrete, these outdoor runs restrict species-specific behaviour and, together with poor pen hygiene, may lead to high ammonia emissions. While few scientific publications have discussed the effects of such outdoor runs on pig welfare and environment, considerable practical experience exists which could be a valuable source for improvement measures. Therefore, the CORE Organic Cofund project POWER aims for a transdisciplinary approach to identify innovative solutions to improve outdoor runs. Stakeholder workshops with farmers and experts took place in eight European countries resulting in 102 statements regarding innovations and best-practice examples. Researchers of different disciplines evaluated those during a stepwise process based on practical and scientific knowledge. Criteria considered were the potential for welfare improvement and ammonia emission mitigation, innovativeness and feasibility for on-farm experiments. Finally, three innovative elements for outdoor runs were selected: 1) specified rooting areas, 2) improved provision of roughage and 3) strategies for use of showers during summer. Stakeholders from several countries had mentioned these innovations (3, 7 and 6 statements from 3, 5 and 6 countries respectively). While stakeholders and researchers emphasised the potential of these innovations for welfare improvement, they rated the potential for reducing ammonia emissions as less likely, except for showers. Rooting areas were rated lowest for feasibility but highest for innovativeness, while provision of roughage and showers were seen as best-practice. Rating the level of innovativeness varied considerably between countries for various reasons. In conclusion, most of the identified innovations addressed either animal welfare improvement or ammonia emission mitigation. Ensuring feasibility for on-farm experiments caused trade-offs regarding innovativeness. However, combining scientific knowledge and stakeholder involvement is a promising approach to identify practical, relevant and scientifically meaningful research areas, which we now investigate in on-farm experiments.

Introduction

Previous studies revealed potential for improvement of concrete outdoor runs for European organic growing-finishing pigs in terms of animal welfare and environmental impact (Rudolph et al. 2018; Leeb et al. 2019). These outdoor runs restrict aspects of pigs' species-specific

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behaviour, especially as they often lack enrichment. Moreover, the relatively large areas soiled with excrements account for higher ammonia emissions in organic pig systems compared to conventional production (Olsson et al. 2014). Practical solutions for improving animal welfare while reducing ammonia emissions in systems with concrete outdoor runs are therefore required. To identify solutions, experience of farmers may be a valuable source of innovative ideas and will increase relevance of research for practical farming. Therefore, within the CORE Organic Cofund project PrOven WElfare and Resilience in organic pig production (POWER), researchers from eight countries conducted stakeholder workshops and interviews and evaluated the results based on their scientific expertise. The final goal was to identify 2-3 innovative measures to improve animal welfare and reduce ammonia emissions, which could then be tested in on-farm experiments across Europe.

Material and methods

Project participants conducted workshops and individual interviews involving organic pig farmers and experts (consultants and other experts from research or companies in the organic pig sector) in eight European countries. The same protocol, consisting of open questions and key words to structure the discussion, was used in all countries for workshops and interviews. Guiding questions were aiming at identifying best-practice examples (*“What is currently, on your farm, working well?”*) and new ideas (*“What would you like to change, which specific measure would you like to test?”*). Stakeholders were then asked to describe benefits and challenges of measures regarding aspects of sustainability, i.e. animal welfare, environmental impact, workload, and economy. Individual statements were sorted according to different elements of concrete outdoor runs (Table 1). Eight researchers from six countries evaluated the statements in a stepwise process based on their expert knowledge following four criteria representative for the project goal: 1) potential for animal welfare improvement, 2) potential for ammonia emissions mitigation, 3) innovativeness and 4) feasibility for on-farm experiments using a five-point scale (1 = positive; 5 = negative). Subsequently, the individual statements were aggregated to specific “innovations”. The following dialogue-based selection process prioritized high potential for animal welfare improvement, followed by potential for ammonia reduction. Stakeholder perspectives regarding aspects of sustainability and relevance for different countries (frequency of mentioning) were considered in the selection process. Finally, researchers decided by consensus for three innovations to be tested in the course of the project.

Results

Seven workshops and 49 individual interviews with a total of 78 farmers and 38 experts revealed 102 individual statements on improvement measures. Most of the statements referred to the provision of enrichment followed by roof or floor design, pen structure, manure removal, and cooling facilities (Table 1).

Table 1: Results of workshops and interviews: number of statements related to different elements of concrete outdoor runs with respective examples

Measures related to	Number of statements	Examples
Provision of enrichment	17	Hayrack with waste tray underneath; sand for rooting.
Roof	16	Larger roof to use bedding material; sun sail.
Pen structure	15	Open partitions in the dunging area.
Manure removal	13	Automatic manure scrapers.
Floor	13	No slatted floor; increased area with drained floor.
Cooling	10	Cooling with garden hoses; wallow or bathtub;
Feeder/drinkers	7	Drinkers outdoors; feeders outdoors.
Additives	3	Effective microorganisms.
Pasture access	2	Additional temporary access to pasture.
Other	6	Brushes; light during night.
Total	102	

Results of the scientist's ratings are presented in Table 2. Regarding potential welfare improvement, they prioritised measures referring to additional pasture, cooling and enrichment. Scores for emission mitigation potential were generally higher (negative) and varied considerably. Most positive scores were relating to manure removal. Ratings for innovativeness were best for pasture and "other measures" (e.g. brushes, light) and varied considerably across scientists representing different countries. Feasibility for on-farm experiments was moderate to negative, with most negative scores for floor design and additional pasture access.

Aggregation of the individual statements (e.g. "access to showers" and "cooling facilities like showers or sprinklers") resulted in 49 specific innovations (e.g. "showers"). Sixteen innovations were rejected mostly due to lack of relevance for concrete outdoor runs.

Table 2: Results of scientists' rating (1 = positive, 5 = negative) across different elements of concrete outdoor runs (average score, [min.-max.])

Measures related to	Potential for welfare improvement	Potential for emission mitigation	Innovativeness	Feasibility for experiments
Enrichment	1.8 [1.0-3.3]	3.0 [2.0-5.0]	2.3 [1.2-3.8]	2.2 [1.5-2.8]
Roof	2.2 [1.7-4.0]	2.4 [1.3-4.0]	3.0 [1.3-4.3]	3.6 [2.0-4.8]
Pen structure	2.4 [1.8-4.3]	3.2 [1.3-5.0]	2.8 [1.0-4.0]	3.0 [2.0-4.5]
Manure removal	3.2 [1.7-4.8]	2.1 [1.0-3.4]	2.9 [1.2-4.2]	3.4 [1.7-4.8]
Floor	3.0 [1.7-4.3]	2.6 [1.3-4.4]	3.4 [2.5-4.6]	4.4 [3.8-4.8]
Cooling	1.7 [1.3-2.2]	2.9 [2.2-3.8]	2.5 [1.8-3.0]	2.5 [1.8-3.8]
Feeder/drinkers	2.4 [1.2-3.2]	2.5 [1.4-3.3]	2.9 [2.3-3.8]	2.8 [2.0-4.0]
Additives	4.0 [3.7-4.3]	3.4 [3.3-3.7]	2.8 [2.2-3.7]	2.4 [1.8-3.3]
Pasture access	1.3 [1.0-1.7]	2.9 [2.4-3.3]	1.4 [1.2-1.7]	3.9 [3.4-4.3]
Other*	2.9 [1.4-4.4]	3.4 [2.0-5.0]	1.9 [1.4-3.0]	3.2 [1.5-4.6]

* E.g. brushes, light, track grids for handling pigs, weight-sorting system.

From the remaining innovations, 11 were pre-selected and the following three were chosen for further examination in on-farm experiments:

- 1) Optimisation of rooting areas, i.e. providing substrate in a defined area (box).
- 2) Improved location and frequency of provision of roughage, which is not only bedding material but also enrichment with nutritional value (e.g. hay, silage, grass).
- 3) Strategies for the use of showers to mitigate heat stress during summer.

Stakeholders perceived these innovations as positive for animal welfare. While rooting areas and showers were also considered suitable to mitigate emissions, this was not necessarily the case for roughage. Depending on the implementation of the measures, farmers mentioned benefits as well as trade-offs regarding labour and economy. Provision of roughage and showers were mentioned most frequently (7 and 6 statements from 5 and 6 countries), while rooting areas seemed to be less relevant (3 statements from 3 countries). Scientists' rating was best (lowest) for the potential for animal welfare improvement (average score 1.2-1.5). In contrast, scores were more negative for emission mitigation potential, with best scores for showers, followed by roughage and rooting areas (average scores 2.5, 3.0 and 3.1). Innovativeness ranged from positive for rooting areas (average score 1.3), to moderate for provision of roughage and showers (average score 2.6 and 2.5). Feasibility was best for the provision of roughage, followed by showers and rooting areas (average scores 1.8, 2.1 and 2.7).

Discussion

The measures identified by stakeholders mostly related to animal welfare improvement, which is due to emphasis of the protocol on this issue. Concerns mentioned by stakeholders mostly related to increased workload and costs, which was acknowledged when choosing the three final innovations.

With regard to animal welfare improvement, stakeholder input as well as scientists' rating emphasised measures related to enrichment and cooling, whereas potential for emission mitigation was mainly related to manure removal. This demonstrates a rather low overlap of animal welfare improvement and emission mitigation, which is in line with findings by Herzog et al. (2018) for dairy cows, stating that welfare improvement measures would not increase emissions if manure management and housing design were appropriate. However, pigs' behaviour, especially elimination, could influence the surface soiled with faeces and therefore the potential for ammonia emissions (Salomon et al. 2012). We therefore argue for measures supporting pigs' natural behaviour to separate functional areas for lying, activity and elimination, e.g. by increasing the attractiveness of the outdoor run. The three selected innovations (rooting area, provision of roughage and showers) have the potential to increase pigs' use of the outdoor run and minimise the area soiled with faeces and urine.

Regarding innovativeness, the evaluation process revealed considerable differences between countries, with some measures not existing in one country (e.g. rooting areas in Austria) but already best practice in another (e.g. rooting areas in Denmark). This shows the high potential of such an approach for knowledge exchange and "learning from each other". A major challenge for the final selection was to ensure feasibility for on-farm experiments while considering innovativeness and relevance for farmers. Some of the innovative and most frequently mentioned measures (e.g. additional access to pasture, manure scrapers or varying degree of roofing) are difficult to test in on-farm experiments with limited resources.

Suggestions for research and support policies to develop further organic animal husbandry

If we, as applied researchers, want to enhance sustainable development in practice, we need to consider farmers' situations and perceptions to provide relevant results. Therefore, it is crucial to involve stakeholders already from an early stage of problem framing. This is especially important for projects collaborating with practitioners e.g. in on-farm experiments, where commitment and motivation is essential for the quality of research results (Schodl et al. 2015). However, including stakeholders in the process of identifying research questions demands additional time and effort and may lead to trade-offs: in our case, limited resources of the project restricted the selection of innovative measures suggested by stakeholders. Therefore, thoughtful project planning considering the challenges and additional effort of transdisciplinary research is crucial. Finally, research collaborations across countries and institutions with different specialisations increase the relevance of results for a broad range of systems and cultural differences and enhances knowledge transfer by learning from each other

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Replacement of anthelmintics, antibiotics, and synthetic vitamins in organic animal husbandry – the contribution of the Horizon 2020 project RELACS

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Key words: gastro-intestinal nematodes, mastitis, vitamins

Introduction

Organic farmers adhere to high standards in producing quality food while protecting the environment and ensuring animal health and welfare. However, organic farming needs to improve continuously to keep meeting its ambitious objectives. The project 'Replacement of Contentious Inputs in Organic Farming Systems' (RELACS) fosters the development and adoption of tools and techniques to further reduce the use of external inputs on organic farms.

RELACS takes far-advanced solutions forward. With regard to animal husbandry, this is brought about by

(i) developing integrated endoparasite control strategies for ruminants by exploiting bioactive forages (heather) and the biocontrol agent *Duddingtonia flagrans*.

(ii) reducing dependency on antibiotic use in dairy cows by transferring Animal Health and Welfare Planning protocols and by refining the use of essential oils.

(iii) exploring the potential for reduction or replacement of synthetic/GMO produced vitamins by validating requirement definitions and by developing GMO-free vitamin B production.

This paper gives an overview of the overall work plan related to livestock and presents selected results obtained during the first 18-month period of RELACS. Outcomes of the RELACS-survey on the use of antibiotics and anthelmintics are presented by Chylinski *et al.* in these proceedings.

Replacement of anthelmintics

Material and methods

RELACS will develop two complementary techniques to reduce application of anthelmintics in livestock production.

First, the efficacy of heather against ovine gastrointestinal nematodes is determined in feeding experiments and will be validated on farm in a multi-actor activity involving organic sheep stakeholders (farmers, farmers' associations, advisors, scientists). Samples of heather (mainly *Calluna vulgaris*) were collected in the UK (Scottish Highland), Switzerland (Alpine), Germany (Lüneburg Heath), Norway (West coast) and Spain (Mediterranean) and anthelmintic activity was tested *in vitro*. Associations between compound profiles in heather extracts with respective anthelmintic efficacy will be investigated.

Second, the efficacy of the nematophagous fungus *Duddingtonia flagrans* to reduce pasture infectivity is investigated with or without additional heather consumption. After a series of combined *in vivo/in vitro* tests using lambs infected with *Haemonchus contortus*, adoption of both

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strategies to different pedo-climatic conditions will be explored on farm, using naturally infected sheep or goat flocks.

Results

In vitro efficacy of *C. vulgaris* is variable across samples originating from different countries. Extracts of heather collected in spring had higher anthelmintic effect compared to those collected in winter. Extracts originating from the UK and Spain were the most efficacious and that from Norway was the least efficacious. In the feeding trial, both heather as well as the feed additive containing fungal spores were readily eaten by sheep. On average, lambs consumed 0.27 kg of heather/day. *D. flagrans* reduced larval development from faecal cultures by about 95%. Effects of and interactions with heather remain to be analysed.

Replacement of antibiotics

Material and methods

RELACS will deliver two strategies to reduce antibiotic use in dairy production.

Together with experienced advisors from France, the UK and Spain, experienced Animal health and welfare planning (AHWP) trainers from FiBL (Switzerland) have developed a protocol for implementing the AHWP approach in dairy farms.

Antibacterial and anti-inflammatory effects of 10 essential oils frequently used on French farms against *E. coli*, *Staphylococcus aureus* and *Streptococcus uberis* have been evaluated through a series of chromatograms and two series of aromagrams. In addition, toxicity tests (tissue cultures) were performed and bibliographic work and feedback from farmers' experiences was taken into consideration for selecting essential oils for on-farm trials.

Essential oils and the new RELACS AHWP protocol (alone and combined) for mastitis control are validated on-farm in three countries (open ended multi-actor activity) in collaboration with two existing French farmer groups (FEVEC and ADAGE35), Soil Association in the UK and organic dairy farmers from the network of ECOVALIA in Spain. Effects of the treatments will be evaluated based on (i) clinical healing as observed by farmers, and (ii) complete healing based on the results of bacteriological analyses and somatic cell counts before and after treatment.

Results

The RELACS AHWP protocol was developed and tested on-farm. Feed-back by farmers and advisors show excellent acceptance of the protocol in all countries. Farm data analysis is ongoing. Based on the comparative analysis of 10 candidates, two essential oils (one with anti-inflammatory and one with antibacterial properties) were selected for on-farm trials. A RELACS essential oil protocol (Fig. 1) was developed and is currently validated on 73 organic dairy farms in three countries.

Replacement of synthetic vitamins

Material and methods

RELACS will provide updated quantitative data on vitamin requirements of organic livestock and develop competitive non-GM high-yield yeast production strains to reduce B and E Vitamin supplementation.



Effects of reducing Vitamin B2 supplementation in diets were evaluated in feeding experiments with layers, broiler breeders and broilers. For each category, health, welfare and production at different levels of supplementation were recorded during the rearing period (broilers and breeders), or during five months of egg production (layers and breeders). To increase the supply of Vitamin B2 from acceptable sources, RELACS explores the potential for the selection of high Vitamin B2-producing non-GM yeast strains by established screening methods.

RELACS reassesses Vitamin E demand and availability in modern diets for ruminants in organic farming systems through targeted analysis of large datasets with a focus on the relationship between basal feed type and quality, stage in animal production cycle, plasma and milk levels of α -tocopherol, and milk excretion of α -tocopherol.

The proposed concepts and revised diet recommendations will be assessed in on-farm trials in commercial farms to rapidly accumulate first-hand information in real-world conditions.

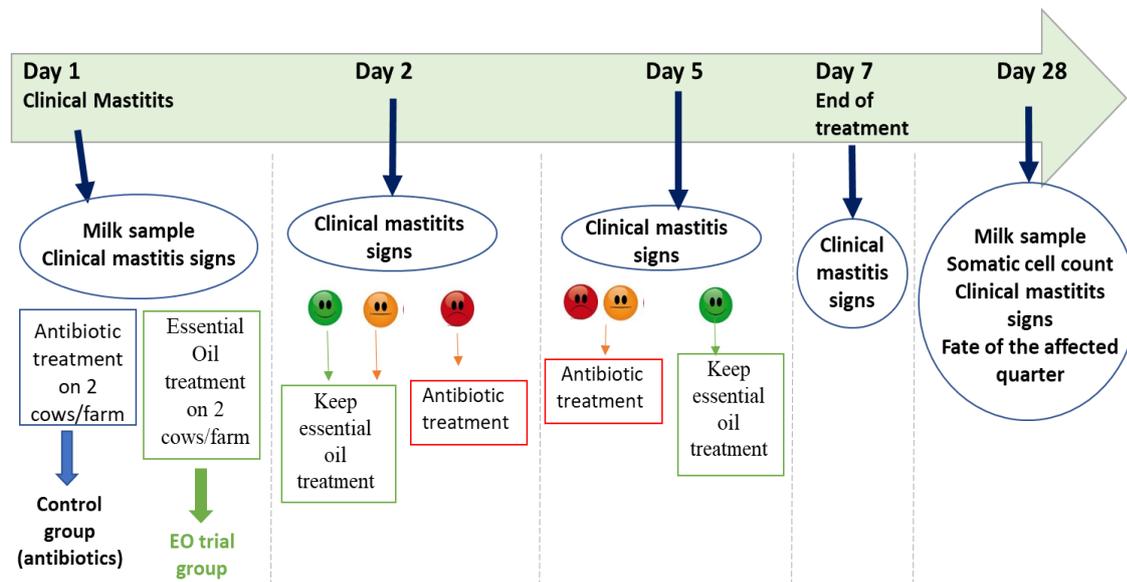


Figure 1. RELACS essential oil application protocol for on-farm validation

Results

The survey on Vitamin E demand and availability and experiments with broiler breeders and broilers are ongoing. The feeding experiment with layers indicates that a supplementation of 3 mg Vitamin B2 per kg feed for laying hens is safe with respect to animal health (e.g. neuronal dysfunctions) and performance, and a supplementation level of 4.5 mg/kg does not provide further advantage.

Wild type strains of yeast were screened for their Vitamin B2 production properties. Two of them were identified as overproducers and are now further evaluated.

Discussion

After the first 18 months of RELACS, many experiments under lab or small-scale experimental conditions are completed and the project team will now focus on multi actor activities and validation. Several positive outcomes are ready to be included in on-farm trials: *D. flagrans* is

a very promising tool to reduce pasture contamination with helminth eggs and it can be combined with other efficient methods, e.g. tannin-rich heather. Dairy farmers and advisors across Europe readily adopted new methods to secure animal health and are willing to test the efficacy of antibacterial and anti-inflammatory essential oils. Vitamin B2 supplementation can be reduced by 30% in layer feed and new sources of this vitamin are being investigated. The potential of these diverse tools to reduce anthelmintics, antibiotics and synthetic/GM-produced Vitamins on organic farms is huge and will now be quantified on-farm under different climatic and socio-economic conditions.

The market for organic dairy products, meat and eggs is exceedingly sensitive to problematic practices with effects on animal welfare (inefficient treatments of mastitis and helminths due to resistant pathogens), the environment and biodiversity (excessive use of anthelmintics), food quality, indirect risks for human health (routine and large scale use of antibiotics in dairy production) and use of vitamins from problematic sources. The solutions brought about by RELACS are therefore essential to enhance organic production, quality and long-term stability of the organic market.

Suggestions for research and support policies to develop further organic animal husbandry

Besides the use of more robust and resilient genotypes, contentious external inputs can be reduced at various levels in the shorter term. The mechanism of self-medication has the potential to reduce antibiotics and anthelmintics and to mitigate metabolic imbalances by allowing feed selection. Treatment with medicinal plants would be particularly promising in young animal's diseases, which are one of the main causes for antibiotic use in livestock. While several European projects addressed gastro-intestinal nematodes in ruminants, alternative control measures for many other internal and external parasites of livestock are largely missing.

The introduction of natural inputs with the potential to replace synthetic or GM-produced inputs encounters several regulatory obstacles, which are often not passed by promising new developments. The RELACS policy brief (<https://relacs-project.eu/resources/policy-documents/>) describes five steps towards more appropriate regulation for natural substances in animal health and welfare.

Acknowledgement

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References

A comprehensive list of references can be found in the scientific papers resulting from the project. Please check for updates under <https://relacs-project.eu>

Can extract from Norwegian spruce bark control coccidiosis in suckling lambs?

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Key words: sheep, coccidia, bark extract, condensed tannins

Abstract

Coccidiosis is a serious disease caused by Eimeria spp. in young lambs in Norway. Resistance against anticoccidial chemicals has been demonstrated in conventional sheep farming. In organic farming we are looking for natural plant sources to increase animal health and welfare. Condensed tannins (CT) have showed effect against coccidia in several trials. Extract from Norwegian spruce bark (Picea abies), a waste product from the wood industry, was shown to contain CT in a Norwegian study. In our trial we tested the effect of bark extract from Norwegian spruce against Eimeria spp in young lambs. The extract was prepared by hot water extraction followed by evaporation and freeze drying. 24 naïve lambs were randomly grouped, 16 of them were inoculated with 100 000 Eimeria oocysts each for three days at 3 weeks of age, and eight of the 16 were treated with bark extract for 12 successive days post infection. The CTg per lamb per day correspond to 0.05% BMW. A control group of eight lambs was not infected or treated. Individually faeces samples were collected and analysed for faecal score and oocysts. Clinically observations and weight gain were measured.

In this trial the bark extract was found to have a significant effect on the development of Eimeria spp. oocysts in the lambs ($p < 0,001$). The extract was given by a stomach tube, and had a negative effect on the lambs appetite as long as it was administered.

Introduction

Coccidiosis is a severe disease in young lambs in Norway and other countries. The disease leads to decreased animal welfare and has a significant economic impact on the farming industry. Eleven different *Eimeria spp.* have been detected in sheep of which two are considered major pathogens, *E. crandallis* and *E. ovinoidalis*. *Eimeria spp.* are environmentally robust and may survive for several months in humid surroundings. The common preventive measures in Norway are pasture rotation or treatment with toltrazuril at 7-10 days after the lambs are left on pasture. Reduced efficacy against *Eimeria spp.* of toltrazuril has been demonstrated in Norwegian sheep farms (Odden et al. 2018) Organic farming aims to avoid the use of chemicals. The overall aim is to promote healthy and robust animals that do not succumb to clinical disease despite the presence of pathogens in the environment. Some natural plant sources have bioactive components that can strengthen the immune system, or they can have a direct effect against parasites and thereby increasing health and welfare of the animals (Saratsis et al. 2016). Condensed tannins (CT) from different plants have been shown to be effective against parasites in several trials (Odden et al. 2018, Jackson et al. 2014, Holm et al. 2014). Norway has a strong sawmill industry, processing large quantities of Norwegian spruce (*Picea abies*) and pine (*Pinus sylvestris*), and bark is a co-product. Bark is a rich source of CT, and bark from species grown in Scandinavia has relatively high concentrations of CT (Kemppainen et al. 2014, Moilanen et al. 2013, Steinshamn et al. 2014). The CT content can differ between

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season and debarking method. The objective of the current study was to test if an extract from Norwegian spruce can reduce the burden of coccidia in young lambs.

Material and methods

Bark of Norwegian spruce (*Picea abies*) was collected in winter (March 2019). The stems were debarked using a drum debarking process. Subsequently, the bark was partly dried to approximately 40 % DM by air drying and milled to pieces of 1-3 cm. Extraction of CTs from the partly dried bark (~240 kg) was carried out using tap water in a stirred tank at 80°C. The bark was extracted twice for 1-1.5 h, 1000 L water in step 1 and 850 L in step 2. After each extraction step, stirring was turned off to let the bark sediment. The extract was collected from the top of the tank by pumping and transferred to a holding tank. The combined extract (approximately 1300 L) was evaporated in a mechanical vapour recompression evaporator with forced recirculation (Epcos, Epcovap MVR 4) to a final concentrated volume of 82 L. Then, the concentrate was freeze-dried, and approximately 6 kg dried extract (92-93 % dm) was obtained. The CT-content was 50 mg/g extract, determined by the "Butanol-HCl" assay (Engström et al. 2014), i.e. 300 g CT in total.

The animal trial was approved by the Norwegian Food Safety Authority. Naïve lambs (n=24), aged between 18 and 21 days, were randomly distributed by gender and weight into three experimental groups; group EIN with eight lambs were inoculated with *Eimeria* oocysts without any treatment, group EIT with eight lambs were inoculated with *Eimeria* oocysts and treated orally with bark extract for 12 days, and group C with eight lambs were not inoculated with parasites or given CT containing bark extract. The inoculation with *Eimeria* (EIN and EIT) was initiated when the lambs were three weeks old and each lamb received 100 000 *Eimeria* oocysts daily for three successive days. In each treatment group, the lambs were randomly allocated to pens with two or three lambs per pen in an indoor "infection -free zone". The amount of CT administered per lamb and day corresponded to 0.05% of BW.

Clinical observations were made twice daily and the body weight was measured at birth and at days 14, 21, 30 and 42. Individual faecal samples were collected before infection and at days 9-22 after infection. The faeces consistency was scored on a scale from 1 (normal) to 5 (watery and bloody diarrhoea) and the oocyst excretion was quantified by a modified McMaster technique (Gregory et al. 1989).

The lambs were taken from the dam immediately after lambing and washed in Optima, then they were all given 150 ml colostrum within 1 hour, followed by five meals of 150 ml the next day. Then they were fed 400 – 500 ml milk from dried milk powder twice daily. The lambs were fed hay and concentrate ad lib from birth. Prior to use, the colostrum was frozen at -80 °C for two weeks and the hay at -25 °C for eight weeks to prevent potential contamination with *Eimeria* oocysts. The oocysts used in this trial were collected from a faeces field isolate obtained from a sheep flock held at the Norwegian University of Life Sciences (NMBU) in Sandnes, Norway. The flock was infected with a mixed strain of *Eimeria* spp. with no history of anticoccidial resistance. To isolate oocysts, faeces and water were mixed at a 10% w/v concentration in a blender, passed through a 250 µm sieve and centrifuged once (1550 x g, 5 min). The oocysts were recovered from the sediment by adding flotation fluid (400 g NaCl, 500 g sucrose in 1000 µL water; specific gravity: 1.28) and standing for 30 minutes. The supernatant was washed three times (1550 x g, 5 min), the last wash with phosphate buffered saline (PBS). The oocysts were kept in a 1L borosilicate 3.3 bottle (ISO 4796) with constant aeration for 10 days at 21°C to sporulate and then stored for one day at 2-5°C before infecting the animals. By adding 25 µL suspension and 75 µL flotation fluid to a counting chamber and examining 10 x 100 oocysts at 400x magnification, the degree of sporulation was calculated to be 60%. Counting the total number of oocysts in five counting chambers gave the number of oocysts per mL. By adding PBS, the oocyst suspension was adjusted to a concentration of 20,000 oocysts/mL

The bark extract was given by a stomach tube as voluntary oral intake was not feasible. A liquid suspension of bark extract in tap water (250 mL) was given twice daily, at 8 AM and 8 PM, containing on average 1.7 g CT (dm) per treatment, which means that each lamb got 0.05 % CT of BMW per day. The lambs in the EIN-group and the control group were given the same volume of water by stomach tube. Initial excretion of *Eimeria* oocysts has been shown to follow an exponential pattern in lambs (6). We assumed the faecal oocyst excretion per g of faeces (OPG) could be described by the following equation $Y = C e^{k(1/t)}$, where C is the constant, k is the growth rate and t is the time in day. We transformed the exponential expression into a linear equation: $Y_1 = a + b \cdot t_1$, where Y_1 is $\log(Y+1)$, $a = \log(C)$, b is k and t_1 is $1/t$. After transformation, we analysed the data with a repeated-measure analysis treatment (without and with bark extract), time ($t_1=1$ stday in experiment), and the interaction treatment by time as fixed effects, and the effects of pen and animal were treated as random effects. We used the LS Means procedure to estimate mean values with 95% confidence intervals at the measurement time points.

Results

The bark extract had a significant effect on the development of *Eimeria* spp. in the lambs, measured by faecal excretion of oocysts per gram of faeces ($p < 0,001$) on days 12, 14, 17 and 19 after infection. This is shown graphically in Figure 1. Except one sample, the control group had zero oocysts.

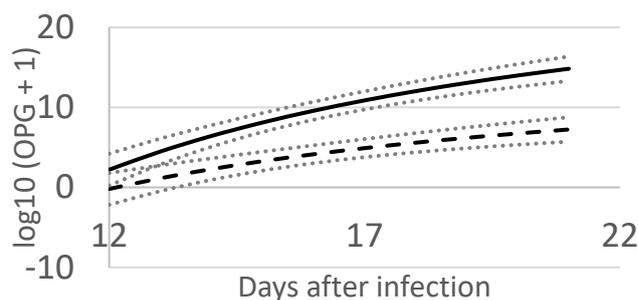


Figure 1. Faecal excretion of *Eimeria* oocysts per g faeces ($\log_{10}(\text{OPG}+1)$) in lambs without (solid black lines) and with (stipled black line) oral bark extract treatment. The dotted lines indicate the 95% confidence interval.

Analysis of the faecal samples revealed a significantly lower faecal score in the untreated group on day 8 after infection, but 14 days and 19 days post treatment the treated group had significantly lower faecal score ($p < 0.001$) than the untreated group. The untreated group had FS = 3 and diarrhea, while there was no difference between the treated group and the control group, both with a FS score < 2 and no diarrhea on day 19.

The weight gain was significantly lower for the group (EIT) that was infected and treated with bark extract than for the group that was infected but not treated (EIN) and the control group (C), measured from birth until the end of the experiment (average weight EIT 322 g/day, EIN 373 g/day and C 390 g/day, $p < 0.01$, paired t-test). The weight gains in the control group (C) and the untreated group (EIN) were not significantly different. From birth until start of the experiment there was no significant difference in weight gain between the three groups. Also, when we looked at the weight gain from termination of the treatment (day 30) to the end of the experiment (day 42) the control group and the treated group were significantly different ($p < 0.02$), but the treated group tended to gain more weight than during the period of treatment. The EIT group lost their appetite during the treatment and were less active. Otherwise no clinical symptoms were seen before day 41, where one lamb in the treated group was observed with arthritis.

Discussion

The period of *Eimeria* infection in lambs in Norway is the first weeks on grazing area in the spring. The lambs are then suckling their mother, they are very often digging soil and they start grazing. This is the period they need protection. As we found no publications on CT given to very young lambs, i.e. lambs before they have developed their rumen function, we had some challenges in designing the experiment. The first challenge was to decide the CT-content to be given. We decided to start to give 0.1 % CT (dm) of BMW to each lamb, based on references from experiments on lambs and kids (Saratsis et al. 2013). The next challenge was to decide when to dose the extract, either from the start of infection or from the day when the lambs began to excrete oocysts in the faeces. We do not have enough knowledge on the detailed effects of tannins and other bioactive components on the lifecycle of *Eimeria spp.*, so we decided to dose the extract from the day of infection and for the following 12 days, which corresponds to the prepatent period for *E. ovinoidalis* and before the gut became damaged.

We found that the extract of *Picea abies* apparently inhibited the development of coccidia in the intestines of these young lambs. There were significantly less coccidia oocysts in the faeces of the treated lambs compared to the untreated at the end of the trial, which indicates inhibition of parasite development. However, the experiment should have been prolonged to cover the whole prepatent period for both *Eimeria spp.* and even some weeks longer, to see if such treatment was enough to keep the coccidia number low enough to prevent disease for the whole grazing period.

In this experiment, we have not analysed the extract for presence of any bioactive substances other than condensed tannins, so it is possible that the observed anticoccidial effect was not due to CT's alone.

Because the extract had a low CT concentration we needed to dose the lambs with a large volume, which is not practical in farming systems. Obviously, the extract also had a negative effect on the appetite of the lambs indicated by the reduced weight gain and lower intake of milk, hay and concentrate in the period of treatment. Once the treatment stopped, the appetite became normal again. It has been previously proven that tannins can affect appetite and growth in ruminants (Mueller-Harvey et al. 2006), and now we also observe this in suckling lambs.

Suggestions for further research

Bark extract of *Picea abies* may potentially be useful against *Eimeria spp.* in young lambs. However, additional research is needed to establish the mode of action and if the observed antiprotozoal effect is caused by CT alone or in combination with other biological components in the bark. Long-term effects of the bark extract on the performance of the lambs need further investigations. If use of bark extracts for antiprotozoal purposes should be transferred into practical solutions for the farmers, we need to find a simple and secure method for prolonged intake of the extract, as well as a practical, technical and economically viable method for industrial extract production.

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Evaluation of optimum dilution rate and liquid storage period for marshal rooster semen extended with tris egg yolk orange juice extender

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Key words: extender, semen, dilution, liquid storage, egg-yolk, rooster

Abstract

Liquid storage of cock semen remains the only easy and efficient close substitute to cryopreservation for in-situ conservation and accelerated genetic improvement in poultry breeding. The experiment was conducted to evaluate the optimum dilution rate and liquid storage period of marshal rooster semen diluted with Tris Egg-yolk Orange Juice (TEY-O), a natural-based extender. The TEY-O extender was prepared and maintained at 37°C. Twenty marshal roosters of 30-40 weeks of age were sourced from Obasanjo farms limited. Pooled ejaculates of 10 roosters were collected into glass funnel per trial. Pooled semen with motility > 80% was processed for extension and stored at 4°C. Pooled semen was divided into four treatments and preserved with TEY-O extender at different dilutions; undiluted semen and diluted (1:2, 1:3 and 1:4). The samples were assessed at 0hr, 4hrs, 24hrs, and 48hrs respectively. The diluted and undiluted semen samples were evaluated at the designated intervals for motility, viability membrane and acrosome integrity. Freshly diluted and neat semen samples showed no significant difference ($P < 0.05$) in all parameters except viability. At 4-24hrs of storage, preserved neat semen was significantly ($P > 0.05$) lower in motility (58.33%-1.67%), viability 53.33%-18.33% and membrane (33.5%-10.60% acrosome integrity (70.00%-53.67%) compared to the extended semen. It is concluded that rooster semen when diluted up to four-fold with TEY-O extender can be stored or preserved for 24hrs without significant adverse effects on semen quality which predicts likely fertilization success.

Introduction

Following the increasingly important quest for organic animal products in most countries in Nigeria, the emphasis is placed mostly on poultry products because they are accepted by all regions, peoples and communities. However, organic poultry products appear to be scantily distributed, probably because organic poultry farming is still only practiced by peasant farmers and not on a large scale. It is therefore deemed that extending assisted reproductive biotechnology tools like artificial insemination simultaneously with semen dilution and preservation techniques to organic poultry farmers may be a holistic approach leading to a wider distribution of organic poultry germplasm/products for general consumption. However, both the sperm quality and the fertilizing ability of undiluted neat fowl semen stored *in vitro* have been observed to decrease within 30mins of collection.

ASB design, analyse, and wrote the rough and final draft of the manuscript. JAO, AIS, KJO and OO assisted in the laboratory analysis and management of the experimental animals.

Therefore, to preserve poultry semen, the composition of the diluents, dilution rate and storage temperature are very important to avoid significant reduction in sperm quality.

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The technologies available for preservation of semen are essentially: 1) hypothermic-liquid storage (refrigeration), which enables the storage of semen for up to 24 or 48h at chilling temperatures of around 5°C (Wishart 2009); and 2) cryopreservation, whereby semen can be stored long-term at -196°C (liquid nitrogen temperature). However, liquid storage of poultry semen seems to be the only viable and more reliable method of preservation and transfer of germplasm than cryopreservation (Balogun *et al.* 2017b). Liquid semen storage has been used to reduce the metabolism of the sperm cell and to maintain sperm viability over an extended period of time (Karunakaran *et al.* 2007) even beyond 48hrs (Balogun *et al.* 2019; 2017b). Notably, unlike other farm animal species, poultry semen is more tolerant to the cold and rarely reacts to immediate cold shock except when exposed to extremely low temperatures.

Approaches have been introduced to enhance poultry semen quality and the anti-oxidative capacity of seminal plasma, with the use of fresh and dried garlic (Balogun *et al.*, 2016b) and dried tomato pomace (Saemi *et al.*, 2012).

Interestingly, the addition of 20-25% quail egg-yolk to the extender has been reported to give good motility and livability results when used in Tris buffer with poultry semen (Balogun, 2019) and 20-50% in bovine. Thus, identifying the appropriate optimum dilution rate and preservation periods for rooster semen extended with a Tris egg-yolk orange juice extender may be an important step towards achieving the best viable sperm to be distributed through artificial insemination in poultry breeding flocks as well as wider distribution of organic poultry germplasm/products. This experiment evaluated the optimum storage period and dilution rate of rooster semen extended with a Tris egg-yolk orange juice diluent.

Materials and Methods

To prepare the Tris egg yolk orange juice (TEY-O) extender. Tris buffer was prepared by adding 3.785g of tris to distilled water, and the pH was adjusted to 7.2. Fresh domestic fowl eggs were collected from the farm and disinfected, the shell was broken and the yolk was separated from the albumen. 20% egg-yolk was vigorously mixed with Tris buffer in a beaker and then supplemented with 10% orange juice and mixed very well. The TEY-O extender was kept in the freezer for further use. Ten Marshal roosters were source from Obasanjo Farm Nigeria limited. Any blood stained and contaminated semen was discarded remaining, and samples were examined for individual progressive motility. The ejaculated pooled semen with motility > 80% was processed for dilution. The extender and semen were kept at 37°C 5-10 mins before dilution. The pooled semen was divided into four equal parts constituting four treatments, and diluted at different ratio with TEY-O extender; undiluted semen and diluted Marshal rooster semen (1:2, 1:3 and 1:4). The samples were kept for 48hrs and were assessed for motility, viability, membrane and acrosome integrity at 0hr, 4hrs, 24hrs and 48hrs. A total of three trials were conducted. All data collected were subjected to analysis of variance and means were separated with Duncan multiple range test.

Results

The microscopic semen evaluation of freshly diluted rooster semen with TEYO extender is presented in Table 1. Percentage motility, membrane and acrosome integrity of freshly diluted rooster semen showed no significant difference ($P > 0.05$) amongst the different dilution rates including the neat semen. The values recorded for these parameters ranged from 90 - 93.3% (motility), 92.67 - 95.67% (acrosome integrity) and 93% (membrane integrity).

Microscopic semen evaluation of preserved diluted rooster semen with TEYO extender from 4-48hrs is presented in **Table 2**. The results showed that treatment1 (neat semen) had significant ($P > 0.05$) lower values and decreased drastically in all microscopic semen parameters

evaluated compared to others as the storage periods progressed from 4hrs to 48hrs of storage viz motility (58.33 to 1.67%), viability (53.33 to 18.33%), membrane integrity (33.5 to 10.60%) and acrosome integrity (70.00 to 53.67%). However, treatments 2 and 3 were not significantly different ($P < 0.05$) from each other throughout the storage periods.

Table 1.: Immediate effects of different dilution rates on freshly extended marshal rooster semen with Tris Egg-Yolk Orange Juice Extender

Parameters	T1 (neat semen)	T2 (1:2)	T3(1:3)	T4(1:4)	SEM
Motility (%)	90.00	91.67	93.33	90.00	0.89
Viability (%live sperm)	89.67 ^b	92.67 ^{ab}	96.33 ^a	96.00 ^a	1.08
Membrane Integrity (%)	93.00	93.00	93.00	93.00	0.67
Acrosome Integrity (%)	95.67	95.33	95.67	92.67	0.70

Superscripts indicate significant difference at 5 % level with in the columns (a,b)

Table 2.: Effects of different dilution rates and liquid storage on extended marshal Rooster semen with Tris Egg-Yolk Orange Juice Extender from 4-48hrs

Peri-ods	Parameters	T1(neat semen)	T2(1:2)	T3(1:3)	T4(1:4)	SEM
4hrs	Motility (%)	58.33 ^b	81.67 ^a	78.33 ^a	75.00 ^a	2.97
	Viability (%live sperm)	53.33 ^b	86.67 ^a	86.33 ^a	91.67 ^a	4.65
	Membrane Integrity (%)	33.5 ^b	87.33 ^a	78.33 ^a	71.70 ^a	6.91
	Acrosome Integrity (%)	70.00 ^b	90.67 ^a	89.00 ^a	88.33 ^a	2.70
24hrs	Motility (%)	16.67 ^b	53.33 ^a	46.67 ^a	46.67 ^a	4.80
	Viability (%live sperm)	24.33 ^b	75.33 ^a	74.33 ^a	72.67 ^a	6.82
	Membrane Integrity (%)	9.00 ^c	57.07 ^a	55.4 ^a	47.47 ^b	5.91
	Acrosome Integrity (%)	64.00 ^c	87.33 ^a	81.33 ^a	72.00 ^b	2.83
48hrs	Motility (%)	1.67 ^d	46.67 ^a	35.00 ^b	21.67 ^c	5.20
	Viability (%live sperm)	18.33 ^b	72.33 ^a	74.33 ^a	66.00 ^a	7.06
	Membrane Integrity (%)	10.60 ^c	47.77 ^a	46.10 ^a	30.57 ^b	0.47
	Acrosome Integrity (%)	53.67 ^b	78.00 ^a	73.67 ^a	67.67 ^a	3.15

Superscripts indicate significant difference at 5 % level with in the columns (a-c)

Discussion

These result indicate that immediate dilution of fresh semen with TEYO extender at different dilution rate does not significantly affect semen quality before insemination and also corroborated the findings of Balogun (2019). Iaffaldano et al. (2010) also reported superior spermatozoa motility with Bestville poultry semen extender (BPSE) and IMV technology diluents at lower dilution (1:2 and 1:3), in which we also recorded highest values in our present experiment. Conversely, Keerthy *et al.* (2016) reported that irrespective of the diluents and dilution rates, the spermatozoa motility in guinea fowl showed a declining trend as storage time progresses from 0-6 hours.

Semen quality of both diluted and undiluted rooster semen decreases with an increase in storage period irrespective of dilution rate. Preserving the rooster semen with TEY-O extender for 48hrs had a significant influence on viability regardless of dilution rate. The results reported confirm those reported in Balogun. (2019), that there was no significant difference in motility, viability and membrane integrity ($P \leq 0.5$) in freshly extended semen for 4 and 24 hrs of storage at 4°C with different concentrations of quail egg yolk with tris buffer.

The 1:2 and 1:3 (semen:extender) dilution rate with TEY-O had the highest values recorded for semen quality parameters throughout the storage period. After 24hrs of storage, quality decreased. It is recommended that 1:2 and 1:3 dilution rates are appropriate for rooster semen dilution with TEY-O extender and 24hrs is the optimum storage period for better *in-vitro* semen quality which predicts the fertilizing ability of the liquid stored semen. Although, 48hrs extended semen had better quality than neat semen, it was not deemed good for artificial insemination since motility and membrane integrity values were below 50%.

We suggest that rapid genetic improvement and the multiplication of organic farm animals are paramount to prevent genetic erosion which could be caused by sudden outbreaks disease.

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Pathways of sustainability in organic mixed livestock farms are based on local embeddedness: case studies in France and Belgium

Marc Moraine¹, Manon Fuselier¹, Marie Moerman²

Key words: mixed livestock systems, territory, diversification, sustainability

Abstract

Mixed livestock farms, through the diversity of productions and potential synergies among animals, are possibly robust and resilient models of livestock farming. Sustainability of livestock systems highly depend on the degree of self-sufficiency, and the type and intensity of ecosystem services and disservices delivered to the territory. Achieving such sustainability goals in livestock systems is a challenge, for which mixed livestock systems (MLS) can be good candidates.

This article presents an analysis of territorial embeddedness of MLS through the lens of the diverse resources that MLS mobilize: natural spaces, feed sources, genetics (local breed), local knowledge, specific commercialization channels (direct sales, farmers' shops), support from local stakeholders (environmental managers, public authorities, citizens) and local agricultural networks. Based on farm surveys in 12 farms in South of France and 16 in Belgium, we identified the strategies and practices of local embeddedness of MLS. We assessed qualitatively the environmental, economic and social performances of the surveyed systems and elaborated models of MLS and their role in their territory.

We discuss the benefits of MLS for their territory, their complementarity and condition of co-existence with other types of farms, their potential development in other contexts and the possible pathways of improvement.

We conclude that developing MLS can be a promising way to produce livestock in a sustainable way, but under several conditions. Notably, farmers in MLS should be supported for work management, financial capacity of farms and skill acquisition.

Introduction

Diversification in organic cropping systems is well-documented and stated as a principle of agroecology (Soussana et al. 2015). In livestock systems, agroecological principles rely on the diversity of feed sources, the adaptation of animals and practices to the local ecosystems and the recycling of by-products in a rationale of circular economy (Thomas et al. 2014). Mixing animal species in Mixed Livestock Systems (MLS) can be a promising option for organising complementarities at farm level. This article presents a characterisation of MLS types according to their embeddedness in the local territory. It is obtained from farm surveys in organic farms in the South of France and in Belgium, conducted within the CORE Organic MIX-ENABLE project. We present the strategies developed by mixed livestock farmers to adapt to the resources available in their territory, resulting in different MLS types. Then we present and discuss the resulting performances and we raise questions about the sustainability of such farming systems.

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Material and methods

Surveys were conducted in organic livestock farms in the Languedoc area, the South of France and Wallonia, South of Belgium, on a total of 11 and 16 farms, respectively. The Languedoc area is characterized by a strong wine industry mainly located in lowlands and by specialised livestock farms in mountainous regions. The main sustainability issues are: the decreasing number of farms in agropastoralism and extensive livestock farming; degradation of biodiversity and grazing resources by encroachment; and adaptation to climate change. In Wallonia, the UAA represents 40% of the Walloon area. Between 1990 and 2015, the number of farms declined by 55.8%. Northern Wallonia specialises in the production of cereals and industrial crops. In the south, grasslands (mostly permanent) dominate. Diverse livestock systems exist depending on the regions.

Surveys covered: (i) the farm structure, history and determinants of mixity; (ii) the practices and average performances regarding efficiency of use and conservation of natural resources, animals' health and welfare, farm productivity and profitability, work organization and farmer satisfaction; and (iii) the degree of integration in local territory, based on the explanation of farmers' relationships with the territory. The farm typology is built qualitatively upon these three items. We characterize MLS in their relation with the territory, using Therond et al. (2017) conceptual framework of agricultural models.

Results

Farm structures and strategies

The combinations of animal species are well distributed (Fig. 1), with a high share of combinations of ruminants with monogastrics: 11/16 in Wallonia, 8/11 in Languedoc, even more if taking into account the often smaller enterprises on farms. Dairy or meat orientations do not seem to influence the type of combinations.

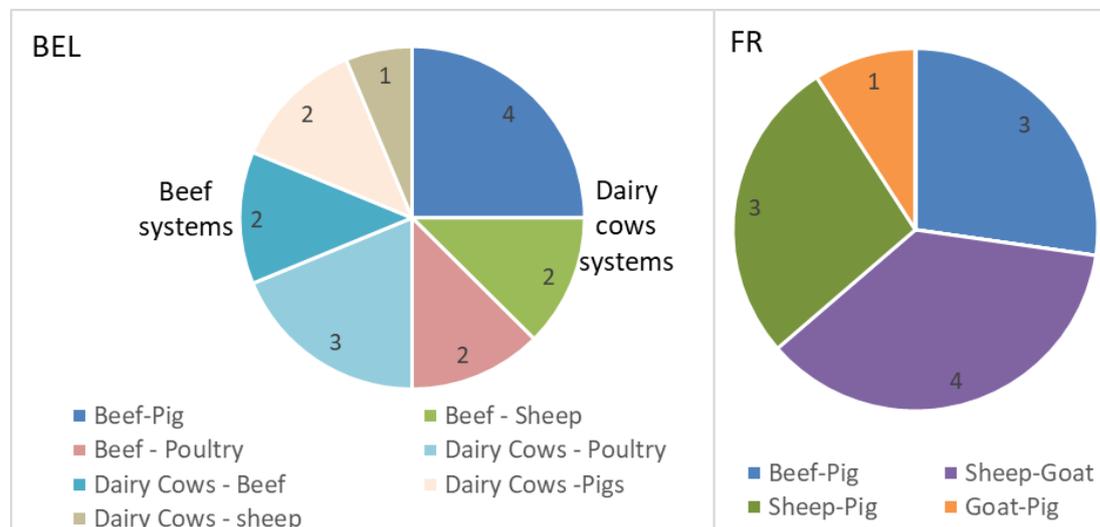


Figure 1: Main species combinations in mixed livestock farms in Wallonia (left) and Languedoc (right). Other species might be present on the farms but only the two main ones are presented here.

Reasons underlying mixity are: 1) organisation of work: introduction of a new animal production to bring additional income for a new farmer or be able to hire workers; 2) technical complementarities: using lactoserum from milk production to feed pigs, grazing complementarities between species (e.g. cows, ewes and horses), production of manure to fertilize lands, or

protection against predators (e.g. pigs and ewes); 3) combination of “production-oriented” (e.g. dairy cows) and “service-oriented” (e.g. rustic sheep) species to manage land of high ecological value; and 4) commercial complementarities to sell diverse products on farm or on open air markets: cheese from dairy ewes or goats, pig meat or sausages, sometimes mixed products.

Farm types, territorial embeddedness and mobilisation of biodiversity

Mixed farms in Languedoc and Wallonia present three profiles, determined by the opportunities and constraints of their territory (access to land, local resources), the strategies and motivations of farmers resulting in different levels of mobilization of biodiversity and territorial embeddedness (Fig. 2).

Type 1 gathers mixed crop-livestock farms producing part of their feedstuffs and cereals for human consumption. They correspond to the most “intensive” one, with conventional animal breeds, a higher stocking rate than the other types, and low level of self-sufficiency in fodder and integration between animal productions. Farmers in this type look to increase their production. Some combine organic and conventional productions on different enterprises (e.g. organic goats and conventional pigs). They combine direct sales and long supply chains, especially for cereals but sometimes also for animals, e.g. lean lambs sold to resellers. Diversification and organic conversion are answers to some economic difficulties, what Lamine et al. (2014) describes as “maintaining of the structure in a sector crisis context”.

Type 2 gathers mainly dairy producers, with semi-extensive practices based on traditional and rustic animal breeds, often including: diversification (multiple animal species such as goat, ewes, pigs and poultry), with medium stocking rate; a share of arable land in which they grow productive temporary grasslands and feed crops such as cereal-legumes associations; and co-grazing of animal species. The milk is processed into cheese and sold directly. Consequently, these farms require lot of human work, so hire workers and host students. Most of the farmers in this type raise ethical and activism motivation behind their practices. This type is similar to “rationalisation after a hyper diversification” (Lamine et al., 2014). The rationalisation of the production corresponds to the optimisation of the practices (e.g. irrigation of grasslands, animal selection to increase their productivity) to ensure the economic performances and the remuneration of workers.

Type 3 gathers the most extensive farms, based mainly on rangelands and natural areas. Stocking rates are very low and it can be explained by the wide quarried surface (up to 1000 hectares). They mostly produce meat, though two farms produce meat and milk. Farms are located in a rough, mountainous environment experiencing long winters and low productivity of land with very little arable land. Farmers strategies to adapt are to have a limited level of species diversification (often only two species); and develop high quality products, sold in short supply chains. Farmers are often rewarded contracts with local organisations for land management and nature conservation. Mobilisation of biodiversity is high because of an adapted use of natural resources and very few exogenous inputs. Local breeds are important, some breeders received public subsidies and support of researchers to maintain the rare breed. Some developed a labelled wool supply chain, and some host tourists or nature-based activities.

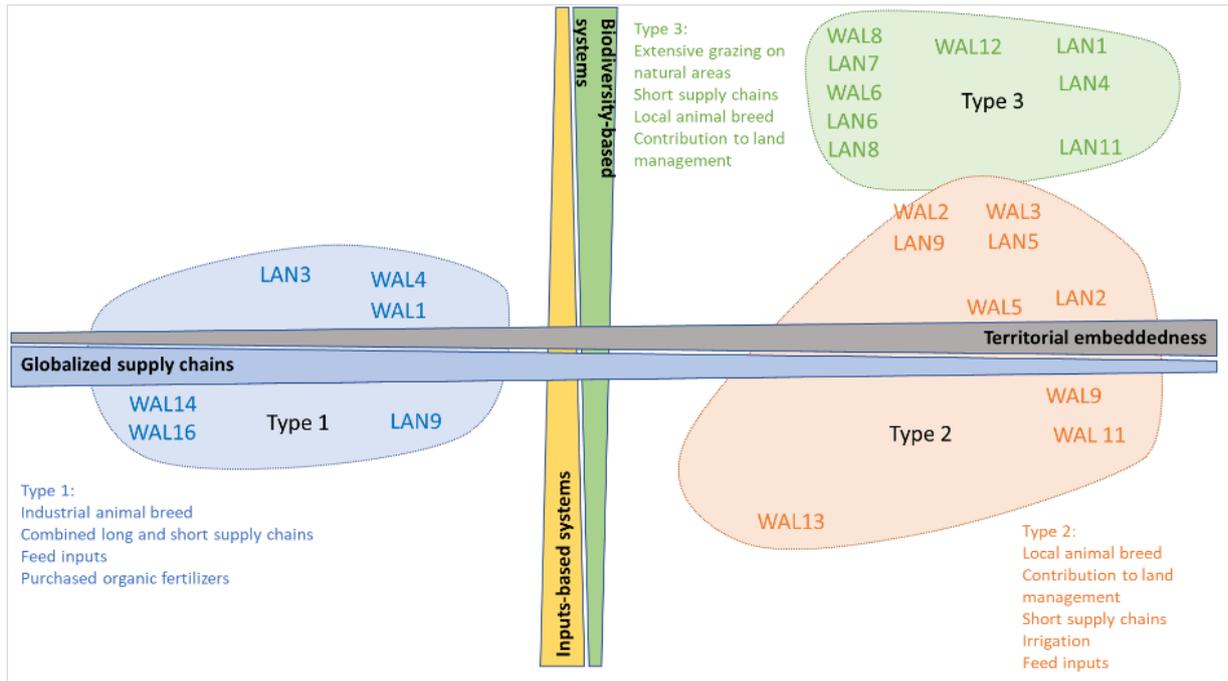


Figure 2: Embeddedness of farm types in territory and mobilisation of biodiversity in the production process. Adapted from Therond et al. 2017. WAL: Wallonia; LAN: Languedoc.

Farm performances and sustainability

The observed performances are summarised in Figure 3. The performances are quite contrasting, with a trade-off appearing between productivity (high in type 1) and natural resources conservation (high in type 3). In Belgian type 2 for example, natural resource conservation is a slightly higher priority than in type 1 (where it remains an important challenge), but the productivity is lower so the overall efficiency is the same. Health and animal welfare appear good in almost every system, illustrating the interest of MLS farmers for this aspect and often their good skills for this. Farm productivity is low in French type 3 due to their very harsh, low potential productive areas, and good in types 1 located mostly in plains on productive lands. Profitability is high for French types 2 and 3 benefitting from niche markets and often high subsidies linked to Less Favoured Areas and for management of Natura 2000 areas. It is medium for all Belgian types, either because of the added value of processing products (type 3), the optimised use of by-products and self-sufficiency (type 2), or the high productivity (type 1). There is a sharp contrast between work organization and farmers' satisfaction. Types 1 and French type 2 have too heavy workload whereas types 3 and Belgian type 2 manage to organize work satisfactorily.

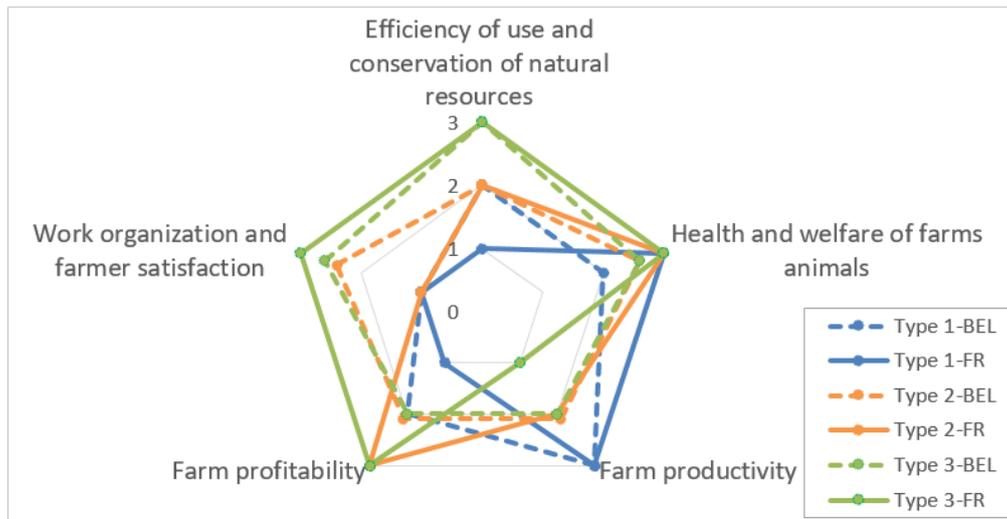


Figure 3: Performances of farm types for the selected sustainability indicators. Ratings are qualitative and represent the average of each type: 1: Low; 2: Medium; 3: High.

Discussion and perspectives

The three types of MLS show a coexistence in the farms' strategies to adapt to their environment, constraints and dynamics. The mixity appears to be a strong lever for managing such adaptations and provides various sets of performances. However, we notice the difficulties experienced by many farmers: economic issues and workload mainly. The most performant MLS appear to be those who are not the most productive in quantity but rely on innovative agroecological practices and often niche markets and a complementary income such as public subsidies or tourism activities. We can thus consider MLS as "sociotechnical niches" (Geels et al. 2004), which can be promising examples of agroecological transitions, including a criticism of the standardised and specialised dominant livestock systems and examples of alternatives. At the same time, those models seem difficult to generalise considering their specificities and the work hardness. To some extent, we can consider that MLS contribute to the agroecological transition by adopting innovative practices along the chain, by contributing to the territory dynamic and by developing adaptation capacities linked with their environment. This research proposes a qualitative analysis of MLS types. It is a first step in the understanding of these promising systems and a possible pathway for the redesign of livestock systems towards sustainability and new challenges such as climate change.

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Animal welfare on organic mixed livestock farms across seven European countries

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Key words: animal welfare, mixed, livestock, Europe

Abstract

Over the last decades, farms have become more specialised. This creates challenges on different levels - for example, nutrient deficiencies in the soil or financial instability due to market price fluctuations. As the call for more sustainable farming has become louder alternatives have been explored, such as more diversified farming by keeping several livestock species and thereby for example increasing financial stability. Keeping several livestock species on one farm may impact the welfare of the animals, which is one dimension of sustainable farming - for example, in terms of animal health or social acceptance of animal products for sale.

To gain a more thorough understanding of the benefits, challenges and management practises on organic mixed livestock farms we conducted interviews with 119 farmers in seven European countries. Various topics were broached to characterise each farm, by asking qualitative and quantitative questions, thereby producing answers to a total of more than 100 items per farm. Our animal welfare data includes housing conditions, pasture management, veterinary treatments and costs, mortality rate, time that farmers spend with their animals and farmers' perception of their animals' welfare. For this contribution, we make a comparison between countries and focus on farms with two combinations of animals, i.e. beef cattle with meat sheep (in France and Sweden) and beef cattle with poultry (in France and Germany). Preliminary descriptive analysis revealed some differences between countries in both combinations for various parameters of animal welfare. However, variation may mostly be explained by climatic differences and farming types (e.g. intensive vs. extensive grazing strategies) and therefore it is not possible to form firm conclusions regarding the animals' welfare in mixed livestock farms.

Introduction

Intensive livestock farming has raised issues about environmental and social impacts over the last 20 years. Consequently, there is a strong social demand for livestock systems that are environmentally friendly, economically viable and socially acceptable, notably with regard to animal welfare. Diversified farming with several livestock species can be an option to meet these challenges (Martin et al. 2020). In the frame of animal welfare, existing literature indicates that co-grazing and mixed livestock farming in general may provide some benefits in regard to for example pasture usage, weight gain, predation reduction and parasite management (D'Alexis et al. 2014; Kremen et al. 2012; Anderson et al. 2011).

For this paper, we have surveyed organic mixed livestock farms in Europe. Using an array of quantitative and qualitative questions, we compared aspects of animal welfare between countries and livestock combinations.

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Material and methods

We conducted interviews with 119 farmers in seven European countries, namely Austria (16), Belgium (16), France (31), Italy (7), Germany (21), Sweden (15) and Switzerland (13). All participating farms were organic farms with two or three livestock species or enterprises, each contributing at least 10 % to the farm income. Any combination of species (cattle, goats, horses, pigs, poultry and sheep) and enterprise type (e.g. dairy, meat, laying hens, broilers) provided eligibility to participate in the interview. Using quantitative and qualitative questions, farmers produced answers to more than 100 items per farm. Out of these items, seven are linked with animal welfare (housing situation, pasture management, veterinary treatments and costs, mortality rate, time that farmers spend with their animals and farmers' perception of their animals' welfare), while others provide insights into the farmer's perceptions (i.e. of their animals' welfare).

For this contribution, we are focusing on two combinations of livestock species with at least four surveyed farms in two countries. One combination we explored was beef cattle and meat sheep in France (9) and Sweden (11). The other combination was beef cattle and poultry in France (6) and Germany (4). For poultry any type of poultry was included in this analysis, i.e. laying hens, broilers or turkeys. A characterisation of both samples can be found in Table 1.

Table 1: Characterisation of the sample of beef cattle and meat sheep farms and beef cattle and poultry farms

	beef cattle + meat sheep			beef cattle + poultry		
	mean	min.	max.	mean	min.	max.
UAA ³⁰ (ha)	96	17	267	99	11	300
pasture (ha)	81	10	257	63	7	166
arable land (ha)	67	0	190	49	0	150
beef cattle (n)	62	5	127	84	19	180
meat sheep (n)	190	24	500	-	-	-
poultry (n)	-	-	-	7730	60	30000

Mortality, vaccination and treatment rate were calculated as percentages of all, adult and young animals, respectively. The farmers scored the perceived status of animal welfare on their farms using a four-point categorical scale: highly satisfied; satisfied; poorly satisfied; not satisfied. Only descriptive statistical analysis was performed.

Results

Beef cattle and meat sheep

Across all 20 farms, beef cattle were housed similarly in straw bedded pens, with one exception in France, where the cattle were housed in straw-bedded cubicles and one farm in Sweden, which used straw bedding and a scraped alley. All farms used straw-bedded pens for their meat sheep. In France, both beef cattle (mean \pm SD: 201 \pm 98) and meat sheep (216 \pm 73) spent more days on pasture than beef cattle (151 \pm 18) and meat sheep (156 \pm 14) in Sweden and had access to more pasture (in ha) per livestock unit (France: 2.3 \pm 1.5, Sweden: 2.2 \pm 2.5).

Vaccination rates (in %) for both beef cattle and meat sheep were zero for most farms, with one exception for beef cattle (20 %) in France and one for meat sheep (36 %) in Sweden.

³⁰ utilised agricultural area

Treatment rates (in %) were generally low, with some outlier farms (beef cattle: France: 5 ± 10 , Sweden: 12 ± 25 ; meat sheep: France: 1 ± 2 , Sweden: 13 ± 25). **Veterinary costs** per animal (in EUR) were higher in France than in Sweden for beef cattle and low for meat sheep in both countries (Figure 1, A and D). The **mortality rate** of beef cattle was lower in Sweden when compared to France, especially in young animals (Figure 1, B and C). For meat sheep, mortality rate was lower in Sweden for adult animals when compared to France, but similar when it came to young animals (Figure 1, E and F). There was a high variety in time spent with animals per day (in h) in both countries and both species (beef cattle: France: 2 ± 1.3 ; Sweden: 2 ± 1.3), with a slightly higher amount of time spent with meat sheep in France (2.3 ± 1) compared to Sweden (1 ± 0.8).

The overall **welfare** perception of the farmers was generally high; only the two top categories (out of four) were used in both countries. More farmers in Sweden were highly satisfied ($n = 9$) with their animals' welfare than in France ($n = 2$), where most farmers were satisfied (France: $n = 6$; Sweden: $n = 2$).

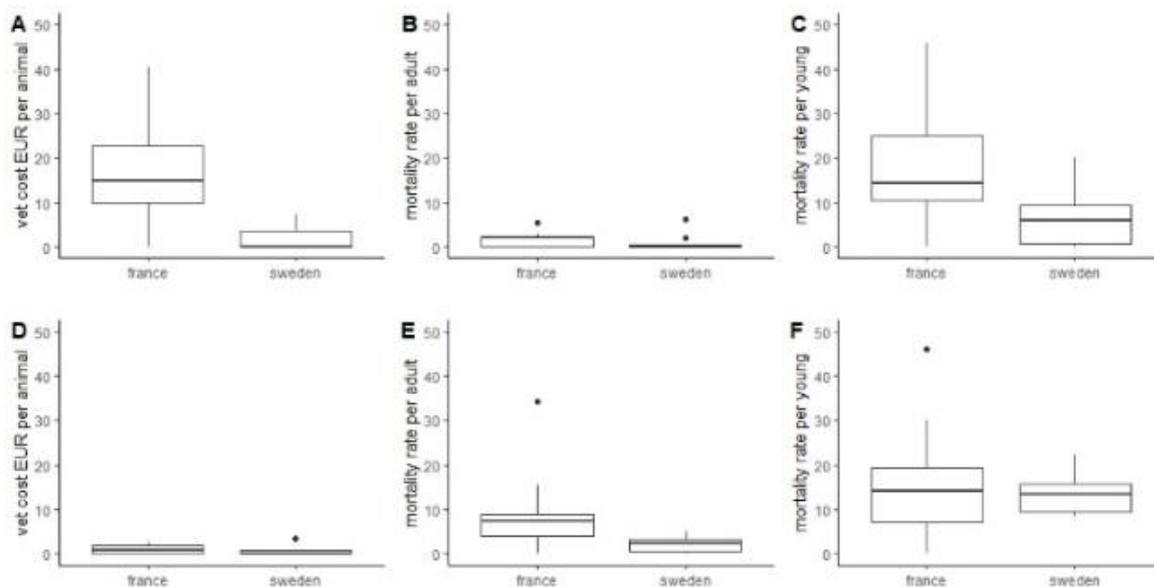


Figure 1. Veterinary costs per animal (A, D), mortality rate per adult (B, E) and mortality rate per young (C, F) for beef cattle (A-C) and meat sheep (D-F)

Beef cattle and poultry

Beef cattle in France (6) were mostly housed in straw-bedded pens and, on one farm, on straw bedding with a scraped alley; whereas in Germany (4), housing conditions were more diverse (straw-bedded cubicles, straw-bedded pen, straw bedding and scraped alley, straw bedding and slatted floors). Poultry was housed in floor barns on all farms. In France, beef cattle spent slightly more days on pasture (256 ± 58) compared to Germany (211 ± 8), whereas no data was available for the days that poultry spent on pasture in either country (but access mandatory when conditions allow for it). The pasture area (in ha) used per livestock unit was higher in France (1.1 ± 0.5) than in Germany (0.3 ± 0.3) for beef cattle and the opposite for poultry (France: 0.02 ± 0.04 , Germany: 0.1 ± 0.1).

No vaccination was done on either beef cattle or poultry. Additionally, no treatment was performed on poultry in both countries. For beef cattle, the treatment rate (in %) in France (0.4 ± 0.6) and Germany (6 ± 10) was low. Veterinary costs per animal were higher in France than in Germany for beef cattle and close to zero for poultry in both countries (Figure 2, A and D). The mortality rate for beef cattle was very low for adult animals in both countries, but higher in France for young animals when compared to Germany (Figure 2, B and C). Similarly, the

mortality rate for poultry was lower in Germany than in France (Figure 2, E). The time spent with both beef cattle and poultry was mostly similar for both countries.

The overall welfare perception was high as for the other combination; only the top two categories (out of four) were used. In France, most farmers were highly satisfied (n = 3) with their animals' welfare (satisfied: n = 2), compared to Germany where most farmers were satisfied (n = 3) and only one highly satisfied.

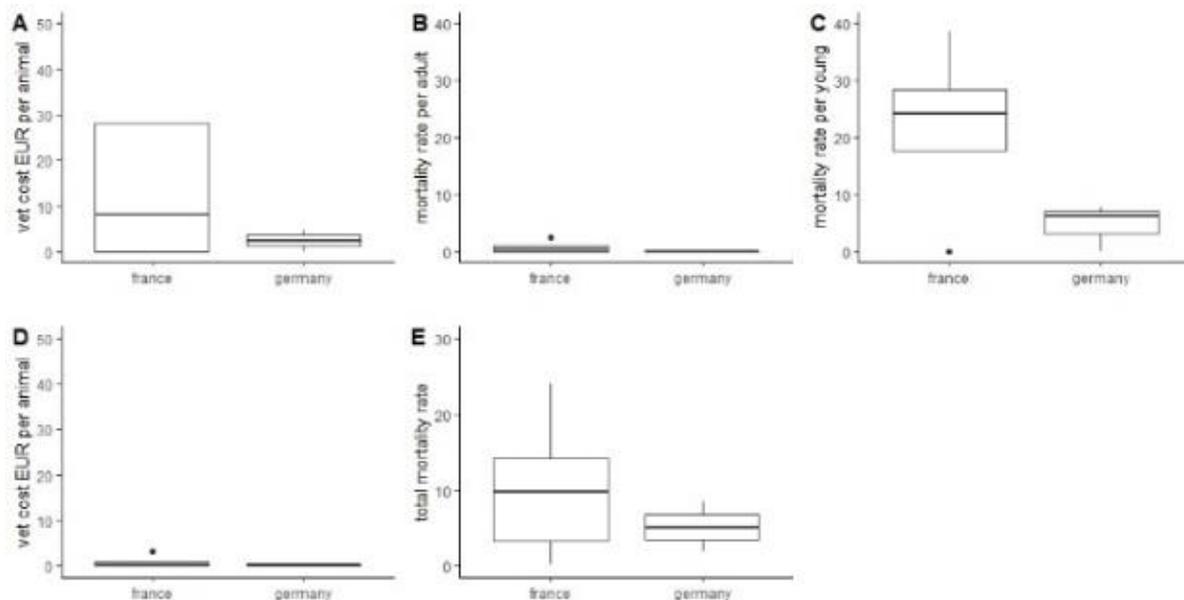


Figure 2. Veterinary costs per animal (A, D), mortality rate per adult (B), mortality rate per young (C) and total mortality rate (E) for beef cattle (A-C) and poultry (D-E)

Discussion

Our preliminary analysis revealed some differences in the assessed parameters between countries for animal combinations of beef cattle with meat sheep (FR, SWE) and beef cattle with poultry (FR, GER). However, it does not allow for firm conclusions on the welfare state in those mixed livestock farms. For example, the comparison of veterinary cost between countries is difficult, as it is unclear whether similar procedures are priced similarly. The low vaccination and treatment rates may indicate rare health problems in the countries and livestock combinations studied. This is in line with the farmers' self-reported perception of their animals' welfare, which was at least high across all farms. In conclusion, differences between countries might have largely been driven by variation in climatic conditions or farming type. It would be interesting to deepen the analysis to study the effect of other factors (e.g. farmer's welfare and satisfaction) on animal health and welfare, thus accounting for the One Welfare concept.

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Are there any benefits in keeping young cattle and broilers on the same pasture?

Severin Hübner¹, Kerstin Barth¹

Key words: mixed animal husbandry, pasture, organic farming, animal health

Abstract

Mixing two different species on pasture has several potential benefits through resource use efficiency and the interaction of the species. We investigate the potential benefits and challenges of mixing young cattle and broilers on pasture. The following questions lead our study: Do large ruminants work for broilers as a form of protection against predators? Does mixing cattle with broilers have an effect on the parasitic load in cattle? In our experiment we compare two systems with the following set-up: the first system has a group of 55 broilers with access to the same pasture as 10 young cattle. The second system has a group of 55 broilers with access to a pasture which was grazed by 10 young cattle two weeks before. Both groups are embedded in a rotational grazing system with six paddocks per group. Each paddock is used for one week and one experimental round ends after six weeks with the slaughter of the broilers. From 2018 – 2020 two rounds per year have been conducted. We focus on the following variables: 1) losses of broilers due to predatory birds; 2) percentage of broilers using the pasture and maximum range distance to the henhouse; 3) lesions in broilers; and 4) fecal egg count in cattle. Preliminary results indicate a kind of protection when broilers and cattle share one pasture: broiler losses due to predators were considerably lower than in the other group. Broilers without cattle also ranged the pasture closer to the henhouse. Broilers seemed not to interact with cattle feces as scratches on the surface could not be recorded. Final results are expected in September 2020.

Introduction

Several potential benefits are associated with mixing two or more species of animals on pasture. The most prevalent ones are: one species developing a guarding function to the other (Smith et al., 2000); increased resource use efficiency as different species might cover different niches on the same pasture (Cuchillo-Hilario et al., 2018); and interference with pathogenic cycles (Marley et al., 2006). Despite these advantages, even organic farms tend to either specialise in one animal, or at least keep their species separated. In this trial we mixed young cattle and broilers on pasture. The reasoning was that with a combination of ruminants and poultry, the parasitic cycle is unlikely to overlap and both species will occupy different food niches. The aim of this study was to answer the following questions: (1) Does the presence of cattle on the same pasture protect broilers from attacks by predators? (2) Do broilers scratch in dung of cattle and do they use it as feed source? And, as a consequence, (3) does scratching reduce the parasite load on pasture and therefore have an impact on cattle health?

The experiment was conducted in the years 2018 – 2020. In this abstract only the results of the first two years are presented.

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Material and methods

The experiment was conducted at the Thuenen-Institute of Organic Farming in northern Germany and compares two treatments. Both experimental groups were kept in a relative distance of 600m to one another:

Mixed System: a group of 55 broilers had access to the same pasture as 10 young dairy cattle.

Mono System: a group of 55 broilers had access to a pasture which had been grazed by 10 young cattle two weeks before.

Both systems were embedded in a rotational grazing system with six paddocks per group. Each paddock was used for one week, so one round lasted six weeks. Each experimental round ended with the slaughter of the broilers. Between 2018 and 2020, two rounds (I & II) per year will have been conducted to total six rounds. Each year, the same groups of young cattle were used, but the system to which they were assigned rotated in such a way that each group of cattle was subjected to both systems.

Broilers belonged to the breed Hubbard (formerly: ISA) JA 575, officially recognised as a slow-growing breed by the German government and applicable for organic poultry production. Broiler chicks were raised indoors with access to an outside area until the age of four weeks and then moved to the experimental site. Broilers had unlimited access to grain feed. The young cattle consisted of female German Holstein raised indoors and slowly adjusted to pasture feed one week prior to the trials. Before each round, cattle were housed indoors and, if necessary, received an anthelmintic treatment to guarantee a parasite-free condition at the beginning of each round.

The maximum distance broilers moved away from the henhouse was estimated during direct observations. To assess the general willingness to stay outside, the percentage of the respective broiler group outside was calculated. Direct observations were conducted on two days each week, for periods of two hours after sunrise and two hours before sunset. Every 6 min the plots were scanned and the location and number of broilers outside the henhouse was noted down. Broiler losses were registered daily and cause of death was confirmed via the video recordings.

The intactness of cow pats was controlled before and after broilers had access to a new area. Any cow pats that were damaged by something other than a cow were counted, examined more closely and their distribution on pasture determined.

Faecal samples of the cattle were collected biweekly during weighing, resulting in four samples per animal in each round. Samples are analysed according to the McMaster-floating-technique and results extrapolated to eggs per gram of faeces (Epg). As the findings were extrapolated to eggs per gram, levels of infestation can only be a multiple of 33.33. Results were tested with the Mann-Whitney-U-Test. The respective weeks of the treatments were compared by using the values corresponding to the same number of weeks spent on pasture.

Results

In the first round of 2018, the gates of the henhouse were 45cm wide. This turned out to be too narrow as individual broilers kept blocking the opening. The gates were replaced by ones measuring 80cm from 2018-II onwards.

Broiler losses

Broilers were found to be attacked only by predatory birds, notably by northern goshawk (*Accipiter gentilis*). Broiler losses due to predators accounted for a maximum of 8.9% losses for the respective groups (Table 1). Further losses due to causes other than predators mostly

accounted to one per group in 2018-II and 2019-II. In 2018-I, only losses due to predators were registered and in 2019-I, only the mono-group suffered a nonviolent loss.

Table 1: Broiler losses due to predatory birds in the treatment groups (Mono: only broilers on paddock, Mix: broilers and cattle on the same paddock) during the two experimental rounds of years 2018 and 2019

	Year & Group							
	2018 Mono		2018 Mix		2019 Mono		2019 Mix	
Round	I	II	I	II	I	II	I	II
n	55	56	55	55	55	58	55	55
n losses	3	5	0	2	3	5	0	1
Total losses	8		2		7		1	

Ranging behaviour

Individual broilers of the mixed group were found to explore the pasture up to 80m and 70m in 2018 (2019: 50m and 60m in round I and II, respectively). Whereas the most daring broilers in the mono-group explored up to 50m in round II 2018 (2019: 20m and 40m in round I and II, respectively). Generally, most explorative behaviour was found in weeks 2- 4 on pasture. In the first and the last week of the experimental rounds, the values of maximum area explored per week were found to be the same in both groups.

Parasitic load

In 2018, a total of 80 samples in the first round and 40 in the second round were analysed. Due to dry weather conditions, the number of cattle per paddock had to be decreased to five animals. With the exception of the mono-group in the second round, less than 15% of the samples showed nematode eggs per group. A maximum of 66.66 Epg were counted in one sample.

In 2019, infestation rates ranged from 50% to 82.5% of the total number of samples per group (Table 2).

Table 2: Infestation rates in cattle faeces in the treatment groups (Mono: only cattle on paddock, Mix: broilers and cattle on the same paddock) during the two experimental rounds of years 2018 and 2019

	Year & Group							
	2018 Mono		2018 Mix		2019 Mono		2019 Mix	
Round	I	II	I	II	I	II	I	II
Total n	37	18	37	19	40	40	40	40
Total n positive samples	4	9	5	2	21	33	20	32
Samples ≥ 166.65 Ep G	0	0	0	0	3	13	3	6
Samples ≥ 299.97 Ep G	0	0	0	0	0	4	0	0

The first round showed no differences between groups in terms of the infestation rate of animals but with a tendency of the mono-group to have higher values if infestation was present in the second round (Table 2). A Mann-Whitney-U-Test showed that in each period of time spent on pasture (2, 4, 6 weeks), the presence of chicken did not significantly affect the excretion of parasitic eggs in cattle faeces.

Intactness of cattle faeces

The cowpats showed no signs of broilers pecking in them.

Discussion

As goshawks cover territories of at least 5km² in northern Germany (Ziesemer), we assume that predatory birds were aware of both groups. As the attacks were aimed more frequently at the mono group throughout the experiment, we assume that the presence of young cattle did influence the preferential hunting ground. The literature on losses of free-ranging broilers to predators is scarce, but Stahl et al. (2002) described an average loss of about 4% (± 1) per flock in the first seven weeks on pasture, registering losses due to both avian and mammalian predators. These values would be lower than in the unprotected mono-group in this study (7.1%), but much higher than in the mix-group (1.4%).

There were no differences between the treatments in terms of total number of broilers outside which indicates that moving large ruminants alone are not enough to bring the broilers outside. Some broilers of the mixed group were observed further away from their henhouse, compared to the mono group. This has occurred during every round so far. It indicates that the young cattle in fact might have been recognised as a structural element by the broilers.

The broilers' lack of interest in the cowpats could have various reasons. Deposited faeces were accepted by insects which could be seen by egg holes, bugs and flies. The deposited insect larvae in up to three-week-old cowpats can be expected to have a size that is right in the scope of chicken requirements (Lachmann, 1991). Therefore, availability of palatable larvae can be assumed. Likely, broilers did not range the outdoor area in search for feed, as they had *ad libitum* access to grain feed indoors or did not recognise cowpats as a food source due to lack of experience – they were slaughtered at an early age compared to laying hens. We regularly observed broilers chasing flying insects which could be seen as an expression of their natural behaviour independent of their need to feed.

Parasites' eggs were found in the faeces of the cattle throughout the experiment. Among them were *Nematodirus spp.*, *Strongyloides papillosus* and a group of further nematodes including *Cooperia spp.* The Whitney-Mann-U-Test did not confirm any differences between the groups. Generally, the rather low values in 2018 can be accredited to the very dry weather conditions in that year. The differentiation between the class of *Nematodirus spp.* and further nematodes brought no clear picture, but the four highest infestation rates of *Nematodirus spp.* were found in the mixed group. On the other side, the four samples with at least 298 Epg solely occurred in the mono group and in four different animals. When deciding if anthelmintic treatment is necessary or not, 300 Epg is considered a threshold (Jäger, 2003).

Suggestions for research and support policies to develop further organic animal husbandry

For one, mixing broilers and young cattle showed no negative impacts on either of the species. Large ruminants seem to encourage broilers to roam larger distances and to provide them protection. As the current policies move to stricter standards regarding the layout and structure

of range areas for chickens, keeping large ruminants should be recognised as such required structural elements.

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Ayurvedic understanding of herbal formulation for Mastitis

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Key words: veterinary ayurveda, medicinal plants, animal health, natural products, antibiotics.

Abstract

Nature has an answer for the health and ill health of all species in biodiversity. Animals play a major role in this ecosystem not just for food but also for nutrition; similarly, plants play a major role in our biodiversity, with a function in air, food and medicine. There are hundreds of references available in Vedas and Upanishads regarding the utility of plant sources for animal health. Classical textbooks of Ayurveda and similar subjects provide detailed accounts of medicinal plants and their formulations for domestic and wild animals. These herbal formulations have been based on theories and principles. Due to the emergence of many infectious diseases and microorganisms, antibiotics have been developed to protect species from deadly organisms. Abuse and overuse of these antibiotics has led to serious issues such as antimicrobial resistance and drug residues in animal products. Thus, there is an urgent need to review our traditional knowledge of systems for animal health. There are more than 100 medicinal plants which are potent enough to address the issues of infectious and non-infectious diseases in animals. By reintroducing the traditional knowledge of Ayurveda for the primary health care of animals, we can produce safe animal products and protect the health and wealth of biodiversity. As mastitis is one of the most important economically devastating diseases in dairy animals, our traditional formulation is a promising remedy and observational studies have found it to have an efficacy of around 92% in 25,000 cases of mastitis (Data source from NDDDB, KMF and ABOTT Nutrition). The results of this study suggest that the group treated with ethnoveterinary preparations had similar results to that of the group treated with antibiotics and better results than that of the control group.

Introduction

Ethnoveterinary medicine, the scientific term for traditional animal health care, encompasses the knowledge, skills, methods, practices and beliefs about animal health care found among the members of a community.¹

Ayurveda and Veterinary Ayurveda

Ayurveda, the eternal science, dates back to its utility for mankind. It is a perfect material science which helps to achieve total health including social, mental, physical and spiritual aspects. *Ayurveda* is a traditional science, with a history of over 4,000 years. It is not only a medical science, it is also science of life which includes animals and other living creatures on the earth. The science of animals is called *Mrugayurveda*³ (Ayurveda for animals) or *veterinary Ayurveda*. The science of plants is called *Vrukshayurveda* (Ayurveda for plants) and the science of birds is called *Pakshi Ayurveda* (Ayurveda for birds). The principles and practice for human health hold good for animals too. So, the basic principles of *Mruagayurveda* will also include *Tridosha* theory (three humours theory), *Sapthadhatu* theory (seven tissue elements

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theory), *Trimala* theory (three waste materials theory) and *Panchamahabootha* theory (five basic elements theory).

Materials and Methods

Sample design

The simple random technique was used to allocate the animals for each group. The selection of animals was based on exclusion and inclusion criteria. Informed consent was given by the owner of the animals. The study consists of 45 days, five days after parturition.

Inclusion criteria

- Breed: cross breed
- Age: after 3 years
- Calving status: second calving onwards

Exclusion criteria

- Native breeds
- Before 3 years
- First calving and after fifth calving

Parameters for Assessment

1. Milk

- Color
- Consistency
- pH
- Somatic cell count

2. Nature of udder

- Swelling/ hard mass
- Tenderness

Table 1: Study grouping

Group	Drug Intervention	No. of Animals	Dose
I	Ethnoveterinary Formulation	20	250 g of <i>Aloe vera</i> 50 g of <i>Curcuma longa</i> 10 g of <i>calcium hydroxide</i>
II	Dry cow therapy Ampiclox – oil base	20	SD
III	Control	20	NA

Method application and drug preparation

The study group was administered with an ethnoveterinary formulation consisting of 205g *Aloe vera*, 50g *Curcuma longa* and 10g *Calcium hydroxide*, twice a day during the dry period.

Method of milk sample collection

Collection of milk samples on the following days:

- Day 0 (partial drying)
- Day 15 (complete drying)
- Day of calving
- 5th day after calving.

Results

pH and Somatic cell count

Table 2: Comparison of pH and SCC in three groups studied

	EVP group	Antibiotic group	Control group	P value	EVP vs. Antibiotic
pH	5.69±0.80	6.18±0.77	5.43±0.72	<0.001**	<0.001**
SCC	1.48±0.74	1.60±0.61	2.08±1.06	<0.001**	0.628

Table 5. Comparison of pH and SCC in different time periods in Group I (EVP)

	Group I - Ethnoveterinary				P value
	Partial drying	Complete drying	Day calving	5 th day of	
pH	6.16±0.67	5.66±0.83	5.51±0.76	5.45±0.79	0.017*
SCC	2.00±1.17	1.48±0.55	1.25±0.34	1.18±0.24	0.001**

Table 6. Comparison of pH and SCC in different time periods in Group II (Antibiotic)

	Group II - Antibiotic				P value
	Day of partial drying	Complete drying	Day of calving	5 th day	
pH	6.83±0.30	6.69±0.63	5.67±0.60	5.53±0.45	<0.001**
SCC	1.33±0.57	1.50±0.69	1.90±0.60	1.65±0.46	0.021*

Table 7. Comparison of pH and SCC in different time periods in Group III (Control)

	Group III - Control				P value
	Partial drying	Complete drying	Day calving	5 th day of calving	
pH	5.48±0.79	5.56±0.71	5.31±0.63	5.36±0.76	0.705
SCC	1.68±0.85	2.13±1.37	2.15±0.95	2.35±0.95	0.225

Conclusion

In this article, we have tried to establish the link between *Ayurveda* and veterinary *Ayurveda*. This traditional system from India called *Mrugayurveda* (*Ayurveda* for animals) or veterinary *Ayurveda* is robust and time tested. It is an age-old practice. The results of this study suggest that the group treated with an ethnoveterinary preparation (EVP) had similar results to that of the group treated with antibiotics and better results than that of the control group. Therefore, this study shows that the EVP preparation can be adopted by our dairy farmers during the dry period to prevent mastitis after parturition. These practices not only prevent the incidence of the disease, but are also very cost effective for the poorer farmers with two or three dairy animals as their livelihood. They also help in reducing the use of antibiotics and other veterinary drugs in animal management. This robust system of medicine can address the current challenges of mainstream medicine such as affordability, accessibility and acceptability.

These ethnoveterinary and veterinary Ayurveda practices are a promising traditional system of medicine for the reduction of indiscriminate usage of antibiotics and other chemical veterinary drugs providing a solution to antimicrobial resistance in animal and human health.

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Rongoa pastures, native species for health, conservation and culture

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Key words: Rongoa, pasture, livestock, zoopharmacognosy, Aotearoa New Zealand

Abstract

The concept of using Rongoa (Maori traditional medicine) to improve animal health on farm has met with approval but concern has been expressed as to the amount of land that might be taken out of grazing if medicinal shrubs and trees are planted on a large scale. The focus of this paper is on the inclusion of low growing Rongoa and native grass species in pasture mixes. Livestock benefit from a broader dietary intake. Many Rongoa species, in addition to specific medicinal actions have a tonic activity, improving the resilience of animals and the quality of their meat and milk. By providing a mixture of plants in the pasture animals can select and balance their diets and self-medicate.

The use of diverse pastures is regaining popularity but most farmers are unaware that in the mid 19th through to early 20th centuries mixtures of 15-21 species were considered necessary for animal health.

When livestock were first introduced to Aotearoa New Zealand they thrived on native pastures and shrubs. Early records indicate that stock relished over 50 species of native grasses and forbs many of which have medicinal properties. These species could be usefully included in organic pastures and grazed carefully would contribute to animal health and to conservation. Without the specific plants it is difficult to support the practice of Rongoa. If healers cannot pass the skills onto the next generation, much knowledge may be lost, and cultural practices diminished.

Livestock are an important part of the farmscape and carefully managed Rongoa pastures can contribute to biodiversity, culture and health.

Introduction

Industrial farming methods have increased the carrying capacity of farms but at a cost. Many farmers have observed a decline in soil health, biodiversity and animal health. With forecast changes in climate, reduction in the availability of fossil fuels and increasing health concerns arising from the application of pesticides, herbicides and antibiotics in farming systems, adopting an organic, locally focussed approach to farm management is both logical and necessary. In Aotearoa New Zealand there is a rich heritage of traditional medicine (Rongoa) in which plant medicine plays an important part. The loss of biodiversity in the country is reflected in a scarcity of some Rongoa species and thus an inability to transmit a medicinal heritage to another generation. A return to diverse grazings which include species that promote a holistic health - soil, plant, animal and human will safeguard the existence of species and knowledge and increase the resilience of many farms.

Maori land trustees and farmers welcomed the concept of applying the principles of Rongoa to farm management (Johnson 2012) but caution was expressed as to the amount of land that might be taken out of grazing if medicinal forbs, shrubs and trees were incorporated into large scale plantings. The suggestion was adopted to increase the diversity of pastures, improving nutrition and including a therapeutic component. Rongoa pastures would complement shrubs

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and trees, improve animal and soil health and help conserve many native and introduced species that are disappearing from the landscape.

Pastures

Mixed pastures should provide a range of forages (grasses, legumes, herbs) that are nutritious at different times of the year, providing a succession of dietary choice. A diversity of rooting depths, chemistry and growth forms encourages resilience in pastures, soils and grazing animals.

Foster (1988) when reviewing pasture research in Britain from 1850 through to 1984 listed 6 herbs, 11 legumes and 15 grass species that were considered vital components of any mix. It was assumed that this mix would be supplemented by naturally occurring herbs such as rib-grass (*Plantago lanceolata*), dandelion (*Taraxacum* spp.) and self heal (*Prunella vulgaris*). Analysis of typical seed mixtures available in the early 20th century shows that they usually contained between 15 and 20 species of legume, grass and herb.

Forage herbs often have higher concentrations of most minerals than grasses and legumes (Pirhofer-Wasl et al 2011) and thus complement grasses and legumes. Animals can sense an imbalance (Hart 2005; Villalba and Provenza 2007) often before a stockman notices that they are not well. Diverse pastures allow an animal to choose different foods from amongst the nutritional components of its diet to balance its internal state (Villalba and Landau 2012). Stock which can choose from the pastures on offer will inevitably choose the best parts of the plant and the best mixtures for them (Cosgrove and Hodgson 2002), and studies at the Louis Bolk institute have shown that the more diverse the pasture, including a range of herbs, the lower the amount of antibiotics given to cattle. Parasitism is a problem facing livestock producers across the world. There is an extensive and growing literature on the anthelmintic properties of a range of forbs, shrubs and trees. Animals in well managed environments with access to bioactive species have lower parasite burdens. The ingested allelochemicals may act directly on the parasite, may alter the gut environment, or decrease the amount of nutrient available to the parasite. Additionally, by consuming a range of bioactive forages the nutritional status of an animal will improve enabling a greater resistance to parasite challenge and an alteration in immune response (Houdijk et al 2012). The needs and preferences of an animal change annually, seasonally, daily and when it requires a prophylactic or therapeutic dose of a particular allelochemical. Plants vary in their nutritional value and express different arrays of allelochemicals depending upon the growth stage, season and experience. Knowledgeable stock will vary their diets to meet their physiological requirements and to balance the ingestion of allelochemicals. Although high doses of secondary compounds can be toxic to livestock they are also toxic to pathogens so an unwell animal will balance their intake to match their requirements and to regain health. Different species will make different dietary choices but all are influenced by early life experience and learned behaviours. Managing grazing so that animals cannot “eat the best and leave the rest” will encourage a broad diet and ensure that the pasture also remains healthy.

Livestock and pastures in Aotearoa New Zealand

When livestock were first introduced to Aotearoa New Zealand sustenance was provided by the native grasses, forbs and shrubs. Animals arrived after long sea voyages on which their nutritional needs are unlikely to have been fully met, they were then marched across the country and spread with no form of controlled grazing, eating whatever appealed.

Early settlers had mixed views on the value of native grasses, of the 21 species he identified on Tutira Station in the North island Guthrie- Smith (1907) valued only 6 species for feed. *Trisetum antarcticum* was regarded as superlative by graziers and by the early twentieth century only occurred where sheep could not reach it. Blue tussock (*Poa colensoi*) and Blue wheat grasses (*Anthosachne solandri* and *A. aprica*) were also considered good sheep feed, and in many areas because of uncontrolled grazing were eaten out. The plume grasses *Dichelachne crinita* and *D. intermedia* were regarded as useful, as were the fescue tussocks (*Festuca* spp.) and snow grasses (*Chionachloa* spp.), the seed heads of which were a favoured choice of horses. Sheep ate meadow rice grass (*Microlaena stipoides*) early in the season and cattle browsed bush rice grass (*M.avenacea*) all year. Much land was cleared by burning and sheep relished the regrowth of silver tussock (*Festuca novae-zelandiae*) but cattle grazed silver tussock at all stages and consequently in many areas it disappeared. *Danthonia semiannularis* was prized but the other *Danthonia* species (now *Rytidosperma*) were regarded by some as useful, not so by others. Danthonias major virtue in the eyes of many was that it was the first grass to produce new shoots after fire.

Some records exist of the forbs that were favoured by stock when they arrived in Aotearoa New Zealand. Scurvy grass (*Lepidium oleraceum*) and Maori anise (*Gingida montana*) were nearly browsed to extinction with only small protected populations now remaining. In all 32 species are recorded as being palatable and actively sought by livestock. Animals also browsed many tree species including Makomako (*Aristolelia serrata*), Broad leaf (*Griselinia littoralis*), Mahoe (*Meliccytus ramiflorus*) and Karaka (*Corynocarpus leavigatus*).

Te Rongoa - Maori traditional medicine

Rongoa is a holistic vision of health with the emphasis on nurturing good health, rather than waiting for disease to manifest. The practice of Rongoa is multifaceted, incorporating a range of modalities but always addressing physical and mental health, character, family relationships and relationships to the land (Pere 1997). Many healers believe that unless the land is healthy we cannot be healthy. Much emphasis is placed upon Te taha wairua our spiritual link with the land, which acknowledges the connections between all species, the environment, land and water. Wilson (2003) writes of therapeutic landscapes, and the link between the health of the land and the people culturally associated with it.

Maori wisdom acknowledges that “the trees and birds and all living creatures are tuakana (senior) to us” and thus deserve our respect. “Land is a symbol of continuity with those who have passed onto the spiritual world and respect for the land augments ones spiritual strength” (Durie 1985). The principles of Rongoa Maori apply as equally to healing the land as they do to those who walk upon it.

Healing practices vary across Aotearoa New Zealand, it is a basic tenet that plants are part of their landscape and their medicinal properties relate to the environment in which they are growing. Thus, much knowledge of Rongoa rakau (healing with plants) is retained by healers and centres around their practices and their locality. Maori practitioners were cognisant of the variation between plants and between seasons and many Rongoa protocols relate to the availability of allelochemicals as well as sustainable practices.

Zoopharmacognosy

The concept of zoopharmacognosy has had a renaissance driven initially by researchers in Africa, (e.g. Huffman (2001) and America e.g. Villalba and Provenza (2007). The literature describing the effectiveness of traditional plant remedies and the ability of farmed animals to treat themselves is also growing. Today it is largely accepted that animals can and will select a diet to reflect and rebalance their inner state.

Rongoa pastures

Utilising Rongoa on farm will require conscientious management. Rongoa practitioners adhere to cultural practices that uphold the integrity of harvesting. Likewise land managers must strive to keep the land, water, flora and fauna in good heart and balance the needs of livestock with the capacity of the farm to provide them.

If Rongoa species are routinely planted on farms the land and stock will benefit, but so will communities. If there are no plants available it is difficult to train the next generation of practitioners in the arts of harvesting, preparing and administering Rongoa rakau.

Although the focus of this paper is on the lower growing species that contribute to a pasture, livestock should be presented with a range of species from grasses through forbs to shrubs and trees, all of which form the space from which an animal can select its diet. All the grasses discussed above could be included in a Rongoa pasture mix as could the Rongoa herbs in Table 1.

Table 1. Species of herbs used in Rongoa that could be included in a Rongoa pasture

Latin name	Common names	Activity
<i>Althaea officinalis</i>	Marshmallow	Demulcent
<i>Anaphalioides spp</i>	Puatea, cudweed	Tonic, wounds, scour
<i>Apium prostratum</i>	Tutae koau, wild celery	Tonic
<i>Brassica rapa var.oleifera</i>	Nani, Maori turnip	Tonic, laxative
<i>Brassica oleracea var oleracea</i>	Kapeti, Maori cabbage	Stomachic, colic
<i>Celmisia spectabilis</i>	Tikumu, cotton plant	Chest complaints Wound dressing
<i>Chenopodium album</i>	Huainanga lambs quarters	Tonic, ulcers, alterative
<i>Epilobium spp</i>	willowherb	Anthelmintic
<i>Geranium spp</i>		Antiseptic, wounds
<i>Geum urbanum</i>	Kopata, Herb Bennet	Anthelmintic, astringent, tonic
<i>Gingidia montana</i>	Kohepiro, Maori anise	Diuretic
<i>Mentha cunninghamii</i>	Hioi, Maori mint	Tonic, stimulant
<i>Plantago spp</i>	Kopakopa, plantain	Tonic, healing
<i>Rumex flexuosus</i>	Runa	Anthelmintic, alterative
<i>Rumex obtusifolius</i>	Pauwhenua	Bloat
<i>Sonchus spp</i>	Puha, sow thistle	Tonic
<i>Taraxacum magellanicum</i>	Tohetaka, native dandelion	Alterative, calcium

A truly diverse and healthy/health promoting pasture should also include a mixture of legumes and introduced herbs and grasses. Some species will be mineral rich, others high in allelochemicals, others contain allelochemicals to balance the ones previously ingested, some species will be high in protein or vitamins or carbohydrate. Animals that have the opportunity to browse widely and adapt to a regime of choice are healthier and more productive. Turner (1955) reminds us that mental health is important in stock rearing and animals with the leisure to choose are likely to be healthier. Furthermore, if a farm commits to planting culturally important species the knowledge of generations can be successfully passed on to new recipients.

Research and support policies to develop further organic animal husbandry

Organic animal husbandry depends for its success upon healthy animals. As a holistic system we should be supporting our farmers to plant a variety of species adapted to their localities and then to graze them with local breeds of livestock. Research needs to support farmers in different countries to investigate how they might combine species to benefit soils, stock and their culture. Further research should be directed at specific animal health needs such as holistic management of parasitism, mastitis and other problematic diseases.

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OK-Net EcoFeed: working towards 100% organic and regional feed for monogastrics in Europe

Lindsay Whistance¹, Bram Moeskops²

Keywords: pigs, poultry, regional, organic feed, protein, amino acids

Abstract

For pigs and poultry, achieving fully organic diets from regionally grown feedstuffs is problematic. The major difficulty is sourcing protein that satisfies specific amino acid requirements. Overfeeding of protein to correct amino acid levels leads to environmental pollution and underfeeding of amino acids can cause welfare problems such as cannibalism as well as poor growth and egg production. To test potential solutions, the OK-Net EcoFeed project is working with farmers and industry partners in 12 Innovation Groups in eight European countries. The Innovation Groups (IGs) first identified current gaps and barriers which include gaps in knowledge of protein quality and amino acid content in all feedstuffs and a lack of knowledge about the specific nutritional requirements of animals managed in organic systems. Adequate and optimal storage of feedstuffs as well as a lack of land for growing crops were issues and poor collaboration with regional arable growers and feed companies were also seen as barriers. Organic regulations state that feed should be produced in the same region in which animals are kept, but the word 'region' has several meanings. IGs were therefore asked for their understanding of what was 'regional'. Farmers considered it to mean closer to the farm than advisors or feed companies who both accepted 'region' to be up to EU level for difficult-to-source feed components. IGs have all identified potential solutions to be tested including like-for-like replacements for soya such as camelina, canola and sunflower; sprouting seeds to optimise protein and palatability; 'green protein' from grass/clover leys; on-farm processing of regionally-grown soya; silage from brewer's yeast and straw; management methods for feeding silage; and the development of an annual ration plan using in-season forage and fodder. All IGs will produce videos and factsheets to be placed on the Organic Farm Knowledge platform: <https://organic-farmknowledge.org>.

Introduction

For organic animals, the goal is to offer balanced diets that are fully organic and from regionally sourced feedstuffs. For monogastrics, a major problem is sourcing quality protein that satisfies amino acid (AA) needs - particularly methionine, lysine and cysteine. To correct AA levels, overfeeding protein leads to nitrogen pollution and underfeeding AAs risks welfare problems and poor production. Several protein sources are also part of human diets and can be imported from other continents, such as soya from China, increasing both feed competition and pollution associated with food miles. Currently, five percent non-organic feed is permitted in organic regulations until EU legislation changes in 2021. To investigate potential solutions, the OK-Net EcoFeed project is working with farmers and industry partners in 12 Innovation Groups (IGs),

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in eight European countries, by sharing and adapting existing knowledge and translating selected texts. Knowledge is also being created with the development of a ration planning tool and with IGs conducting trials to test potential regional solutions.

Results and discussion

Innovation groups

There are up to three IGs in each country (UK, Sweden, Spain, Italy, Germany, France, Denmark and Austria who is working with farmers in Serbia). IGs are facilitated by a project member and consist of farmers, organic advisors and organic feed companies. They represent the many different organic monogastric systems including low-input and extensive and both small- and large-scale, single species and mixed species farms.

Gaps and barriers

Identifying current gaps and barriers was an important step towards considering potential solutions. IGs identified a lack of knowledge of protein quality and AA levels in all current and potential feedstuffs, not just traditional sources. A further gap was understanding the specific nutritional requirements of animals managed in organic systems. For on-farm production, barriers included a shortage of land, organic seed and field equipment and, for some, unfavourable weather, steep terrain, poor soils and a lack of appropriate soil inputs. For on-farm feed management, there is a lack of appropriate processing and storage equipment as well as a gap in knowledge about optimal storage techniques. Poor or absent relationships with local arable farmers and feed companies or mills where home-grown feed can be processed and returned were also identified. Finally, organic monogastric farming is heavily influenced by the conventional industry which, by its sheer comparative scale, exerts a control over breeds and feedstuffs available to organic farmers.

Regional solutions

IG members were also invited to consider potential solutions and their responses highlighted just how important is the focus on regional conditions. For example, Serbia enjoys good growing conditions for soya whereas in Denmark, silage and protein cake from grass/clover leys are considered to offer more promising solutions. In the Dehesa system in Spain, where limited land is available for growing crops, one solution is to use by-products from the human food processing industry. Taking the long view, IG members suggested a threefold approach that could help farmers reach a sustainable and regional solution to rearing pigs and poultry on 100% organic feed. This approach would be based on the careful selection of breeds suitable to each region and system, an in-depth knowledge of their nutritional requirements at each stage of life and production and a greater knowledge of the nutritional value of all feedstuffs available to them including that which is present in the range.

What is regional?

Organic regulations state that feed should be produced in the same region in which the animals are kept but there is no accompanying definition of what is a region. To confuse matters, the word 'region' is legitimately used to mean several things relating to, e.g., climate, geography and administrative districts. IG members were therefore asked to consider what they thought constitutes regional production of feed. Responses differed depending on the identity of respondent, with farmers generally considering it to mean closer to the farm (up to 50 km) compared to advisors (up to 250 km) and feed companies (up to 300 km), who both accepted a wider definition. Responses also differed depending on the value of feedstuffs, depending on

how difficult it was to source, so that several advisors and feed companies accepted Europe as regional for protein and one farmer also thought it '*OK to consider EU as a region*' if there was a lack of available protein in a given year. For farmers who were part of a local cooperative, the definition of region was most restricted, for example, to the '*maximal distance for a farmer to deliver to another by tractor*'.

Creating a map of existing knowledge

In order not to reinvent the wheel and to value what has already been learned in each country, project partners gathered existing knowledge (called tools for the purposes of the project), in the form of reports, research papers, on-farm trials and extension material to put into a mapping library. In addition to the collection of these tools, more than 30 of them have been selected, and shorter user-friendly 'Tools' are currently being created in English and placed on the Organic Farm Knowledge platform.

Translating existing knowledge for use in different countries

From the mapping library, the IGs have been given the opportunity to identify tools that are of particular interest to their farming systems and to translate this work into their own language. All eight countries have taken the opportunity to do so for various topics under the two main themes of 1) feeding and ration planning and 2) processing and handling of harvested feed (Table 1).

Table 1: Tools selected for translation by the Innovation Groups in OK-Net EcoFeed

Topic	Translation from	Translation to	Tool type	Pages
Improving range use and foraging behaviour in poultry	Danish	French/English	Booklet	24
Substituting soya with oil seed rape and sunflower seeds	English	Danish	Report	14
Dehulled legumes for broiler chicks	English	Italian	Report	14
Protein sources and feeding strategies for organic broilers	French	Danish	Technical Note	9
Homegrown fibre and forage for organic pigs	French	Spanish	Technical Note	4
Feeding organic pigs, an overview	French	Spanish	Manual	40
Report on feeding regimes, protein sources and rations	French	Swedish	Booklet	40
Feed values of and how to grow faba beans	French	Swedish	Technical Note	12
Improving the health and welfare of pigs	English	Serbian	Manual	94
Soya bean processing	German	French	Handbook	29
Organic concentrates for pigs	English	French	Technical Note	4
Organic roughage and forage for pigs	English	French	Technical Note	4

Testing potential solutions

Each IG is testing a potential solution in a practical trial. Some of the trials are entirely novel for the systems in which they are being tested, whilst others build on knowledge gained from previous trials (Table 2). For example, previous research looking at individual sources of feed and forage in France will be integrated into a year-round ration plan for pigs. Most trials are farmer centred with a few being driven by other industry partners although, in all cases, farmers are part of the trial process.

An example of the latter is the trial in Serbia where a non-profit organisation from Austria is supporting farmers to learn more about on-farm soya processing using a small-scale toaster. In Spain, the trial will focus on the use of brewer's yeast for growing pigs in the Dehesa system. Brewer's yeast is difficult to conserve and feed on-farm and, with a small local organic brewery, availability is sporadic. The Spanish IG will therefore experiment with making a silage of brewer's yeast, straw and other potential by-products. These trials are expected to be completed by October 2020.

Table 3: Practical tests to be carried out by Innovation Groups in each country.

Country	Innovation Themes	Group	Test
Denmark	Broilers		'Green-protein' from grass/clover leys
France	Broilers		Replacing soya with camelina, canola and sun-flower
UK	Broilers		Nutritional value of tailings and weed seeds from grain
Denmark	Layers		Fermented silage and lactic acid on intestinal health
France	Layers		Replacing 5% non-organic with available organic feedstuffs
Germany	Layers		Nettle cultivation
Germany	Layers		Nettle feeding
Germany	Layers		Choice feeding clover and alfalfa varieties
Italy	Layers		Growing and using camelina to replace soya in feed
UK	Layers		Sprouting seeds to optimise protein and palatability
France	Pigs		Ration planning using in-season forage and fodder
Spain	Pigs		Brewer's yeast and straw as silage
Austria	Pigs		Nutritional analysis of soya grown in European countries
Sweden	Pigs		Forage turnips for non-lactating sows and growing pigs
Sweden	Pigs		Methods of feeding silage to growing pigs
UK	Pigs		Small-scale toasting of Field beans

Videos and practice abstracts for the Organic Farm Knowledge platform.

For every trial, the IGs will produce a short video illustrating the process capturing results and key moments along the way. They will also produce at least one practice abstract for each trial and these, along with the videos, will be added to the Organic Farm Knowledge platform. This platform is designed to be a long-term hub for different projects and news items that help to enhance organic farming through knowledge exchange (<https://organic-farmknowledge.org>). For further details of the Innovation Groups, a report entitled “Synthesis report on Innovation Group Framework” is available at: https://ok-net-ecofeed.eu/wp-content/uploads/2019/03/OK-Net-EcoFeed_Description_of_Innovation_Groups.pdf

The knowledge synthesis report produced from the mapping library is available at: <http://orgprints.org/34560/>

Improving organic animal husbandry

Gaps, barriers, tools and solutions identified in the project can be used to encourage the industry to adopt best practice that ultimately enables farmers to access appropriate breeds and feed for organic systems along with improved knowledge of the nutritional content of regionally available foodstuffs and the needs of animals at different life and production stages in organic systems.

LIFE POLYFARMING project: Demonstration of a new agro-silvo-pastoral land use to improve farm profitability in mountain areas *

Marc Gràcia¹, Maria José Broncano¹, Javier Retana²

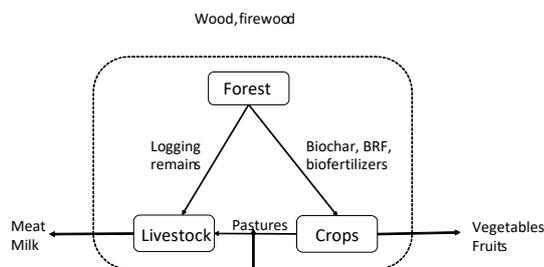
Key words: multi-functional management, pilot farm, livestock

Abstract

The objective of the LIFE POLYFARMING project is to demonstrate the interest of a new integrated multi-functional agro-silvo-pastoral management system as a cost-effective management alternative to combat the problem of abandonment of agriculture in Mediterranean mountain areas and the environmental consequences (degradation of the soil, vulnerability to climate change, loss of biodiversity) and socio-economic (territorial imbalances, loss of productive capacity of the territory) that this abandonment is producing. Livestock becomes an important tool for project management: the movement of cows, chickens, and rabbits in pasture areas helps maintain pastures and improves soil structure and fertility, and therefore productivity. But it also helps in the management of other activities on the farm: cleaning the undergrowth, managing fruit trees with pastures, improving the fertility of the garden, among others.

Introduction

The LIFE POLYFARMING project aims to demonstrate that a new multi-functional agro-silvo-pastoral management system can be applied, integrating the different uses at the farm level as a profitable management alternative to the problem of abandonment of agricultural and livestock activities in Mediterranean mountain areas. The project is carried out in a pilot farm where the proposed agro-silvo-pastoral system, which we call polyfarming, is implemented and valued on a real scale. The real-scale implementation of polyfarming is essential to be able to reach the groups of farmers and owners who must guarantee its replicability in the territory. This system is based on the following scheme:



- **The forest is a source of resources**, so that the by-products of forest exploitation (such as cuttings, clearings and understory cleaning) are used for the rest of the farm's activities in the form of biochar, BRF or biofertilizers.

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* The project POLYFARMING have been co-funded by the LIFE program of the European Commission.

- **Livestock becomes an important tool for the management of other activities:** understory cleaning, management of fruit trees with pastures, improvement of the fertility of the orchard, among others.
- **Crops (orchard and fruit trees) can be done more sustainably** and profitably on small areas by using forest resources (again Biochar, BRF, biofertilizers) and developing pastures to meet the needs of livestock.

Results

The performance of the farm is improved when an integrated agro-silvo-pastoral management is carried out. In this management, livestock is the main management tool for the other uses. On the Planeses farm, where the POLYFARMING project is taking place, **there are cows, chickens and rabbits**. With each of these animals we participate in a different way in managing the other uses appropriately (Table 1).

Table 1. Use of livestock as a management tool in other components of the system.

Component of polyfarming	Livestock as management tool
Forest	<ul style="list-style-type: none"> • The presence of cows in the forest facilitates the decomposition and incorporation of the felling remains into the soil, improving the fertility of the soil. • Cows consume cutting remains and help maintain the understory, reducing vulnerability to fires.
Pastures	<ul style="list-style-type: none"> • Movement of cows, chickens, and rabbits in pasture areas helps maintaining pastures and improves soil structure and fertility and, therefore, productivity.
Fruit trees	<ul style="list-style-type: none"> • Cows are a tool for managing the environment of fruit trees, which avoids treatments to eliminate weeds. • At the same time, the droppings released by cows help improve soil fertility, which fruit trees also benefit from.
Orchard	<ul style="list-style-type: none"> • In the periods when the orchard is not cultivated or when the crops are at a height that is not affected by animals, the presence of chickens helps to eliminate harmful insects and pests and reduces the presence of weeds.

Discussion

The different uses each improve their performance thanks to this integrated management of all of them.

Forest: Forest clearing can be compatible with other uses (it is carried out in times of less work) and is an important complement to multifunctional systems. In the Mediterranean areas it allows an integrated use of different product qualities (wood, firewood, charcoal). Its importance as a source of resources for other uses should always be valued.

Livestock: Holistic livestock management improves productivity per hectare up to 4 times and reduces management costs. It can offer interesting returns on its own, but in multi-functional management this performance can be improved and risks can be reduced by having more varied production. Also, managed together, livestock can enhance other resources (as indicated in Table 1).

Fruit trees: they offer an important landscape and a productive complement. Joint management of livestock with pastures is important for profit until the trees reach significant production and reduce management costs by eliminating weeds.

Orchard: It requires a lot of labour and has a lower labour yield than other uses, although it has a more continuous yield, faster to obtain and requires less initial investment to start. Although it is a production that can be greatly improved with the proposed techniques and the integration of different uses, the production of the garden alone in the mountainous area of the Mediterranean offers little profitability.

Suggestions for research and support policies to develop further organic animal husbandry

Livestock becomes an important tool for managing a multifunctional system: it helps to maintain pastures, prevent fires, improve soil structure and fertility, and therefore the overall productivity of the system.

Securing organic animal and plant breeding through a common cross-sector financing strategy

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Key words: breeding, financing, value-chain, partnership, cross-sector collaboration

Abstract

Organic breeding is the basis for a self-determined, independent organic sector. Despite the benefits provided to the organic sector, the number of dedicated breeding initiatives in Europe is very limited. Currently, the financing of organic breeding is insufficient and fragmented. Therefore, there is a need to place financing of organic breeding on a solid and sustainable basis with shared responsibilities along the value chain. We propose for discussion with the organic livestock sector, a financing concept of joint pre-commercial investment of the organic value chain (0.1 -0.2% organic market turnover at point of sale) into organic animal and plant breeding.

Introduction

Conventional and organic livestock systems differ in terms of breeding goals and reproduction techniques. In organic breeding, health, fertility and longevity of the animals have highest priority, together with product quality. Organic breeding is aimed at producing robust animals that remain healthy and efficient producers under free-range conditions and farm-based feed. Additionally, in some instances, conventional breeding strategies rely on techniques that diverge from the principles of organic farming. From this arises the need for tailored breeding responding to organic sector needs. Organic breeding provides gains to the organic sector by ensuring the integrity of organic products and by strengthening consumers' trust. However, the business case of organic breeding is still challenging and organic breeding initiatives are chronically underfunded. As organic breeding has an overall positive impact on the sector, we propose the development of a cross-sector financing strategy based on a value-chain partnership.

Results - A cross-sector pool funding strategy for boosting organic breeding

The existing organic breeding initiatives are characterised by chronic underfunding. The diversification and dispersion of the sector makes it difficult to achieve massive demand, hence making it quite difficult to develop many profitable business cases. In addition, the possibility of using conventional breeding stock affects this development. Therefore, an improvement in the financial basis is urgently needed. An initial cross-sector pool funding concept was developed (Figure 1) during a multi-step stakeholder dialogue activated within the organic seed and breeding sector with the objective to boost value chain collaborations. It is proposed as a starting point for discussing a common financing concept for organic plant and animal breeding.

From this dialogue emerged the need to propose an integrated concept for animal and plant breeding (Figure 1). Licences at farm level or at different product level of the value chain lead to distortions of competition or disproportionate price increases. Therefore, a flat rate of 1 to 2

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per mille of total organic market turnover at the point of sale is proposed for promoting the participation of the entire organic industry. Clear criteria and methods for the transparent allocation of funds must be developed together with independent monitoring protocols of the breeding programs financed. Increasing these investments will leverage the whole sector, providing efficient gains to all organic value chain actors. Awareness raising and communication of the importance of breeding for ensuring the independence of the organic sector and the integrity of organic products are an integral part of the concept.

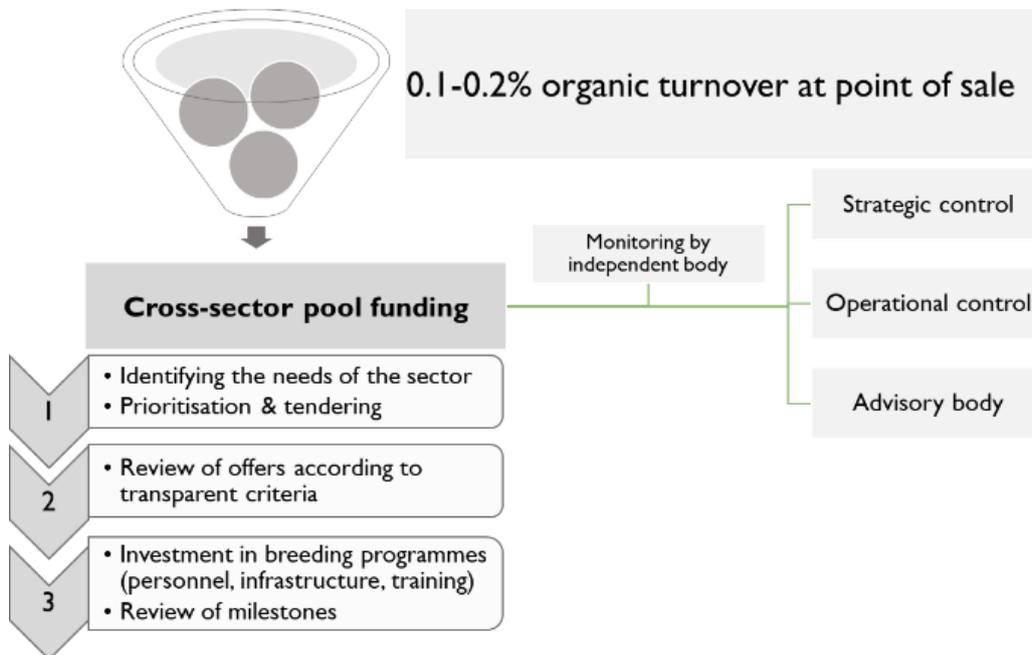


Figure 1. Schematic representation of cross-sector pool funding strategy

Discussion

- *ENGAGEMENT.BIOBREEDING EUROPE initiative*

It is evident that the need to increase organic breeding exists equally in animal and plant production at European level. Therefore, integrating organic animal and plant breeding right from the start in the pool funding strategy would prevent a competition between the concepts and the actors of the organic breeding initiatives. However, the needs are very different between the plant and animal sector. A dedicated dialogue within the organic livestock sector is necessary for developing adequate framework conditions and priority selection procedures suitable for the organic animal breeding context.

Network and collaboration - your suggestions for research and support policies to develop further organic animal husbandry

To increase the availability of organic cultivars and animal breeds in order to achieve the vision in the new Organic Regulation 2018/848, a strong independent organic breeding sector is needed. The whole sector should be engaged in obtaining this objective by direct contribution and by advocating for additional public funds and resources.

Does p-phenol rich feed ingredients or seaweed reduce diarrhea in organic piglets?

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Key words: diarrhea, organic piglets, alternative to zinc

Abstract

From mid-2022 EU regulations will ban the addition of a high level of zinc (2,500 mg) to the feed of weaned piglets up until two weeks after weaning. This affects both conventional and organic pigs. Thus, there is a need to identify new solutions so that healthy production without high levels of zinc - and without antibiotics – can be practiced. The characteristics of organic production, such as later weaning, outdoor access and more space, are generally considered to be positive for animal health. However, the fact is that diarrhea in organic piglets still occurs very often.

This work is based on the EU-project “Organic-PLUS”. In addition to this, two other projects will be mentioned that also deal with the problem of diarrhea in piglets. The three studies conducted with each project are:

Study 1. Mapping the infection pressure in the farrowing outdoor pen (Mapping infection pressure in organic pig production)

Study 2. Test of p-phenol as a substitute for zinc to avoid diarrhea (Organic-PLUS)

Study 3. Test of seaweed as a substitute for zinc to avoid diarrhea (Seaweed now)

- *The results showed that there are a wide range of bacteria, viruses, coccidia and intestinal worms in the environment. This means that the piglets must deal with a lot more than E Coli.*
- *In an “on farm test” the p-phenol was tested as a substitute for zinc. Six to seven days after weaning we were forced to administer zinc again. The mortality in the test groups reached 10 % compared to 0 % in the control group.*
- *Results did not show a consistent effect on gut health. The results are preliminary (May 2020) and calculations are ongoing - so the results may be slightly altered.*

It is concluded that no substitute for zinc was found in these studies.

Introduction

E Coli (F4 and F18) are often assumed responsible for diarrhea, but the work carried out in study 1 showed a wide range of sources of infection: other types of E Coli, Clostridium Perfringens, different lung infections, coccidia and intestinal worms. This shows how complex the problem is. Even if the individual source of infection is not directly related to diarrhea, it can cause poor health and, in this way, be partly responsible for diarrhea.

In the “on farm test” the five groups all developed serious diarrhea on day 6 to 7 after weaning and required the administration of zinc again. Groups 1 to 4 had 0.2 % p-phenol in the feed and group 5 had twice as much (0.4 % p-phenol). Lactating sows and suckling piglets also had p-phenol to lower the excretion of infective matter to the environment.

The test of seaweed was carried out by Aarhus University on five groups of 18 piglets – two control groups and three groups fed with different types of seaweed. Results did not show a

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consistent effect on gut health. Calculations on short chain fatty acids in intestinal digestion are ongoing.

Results

Study 1: Mapping the infection pressure in the farrowing outdoor pen

During testing, it became obvious that it is very difficult to set a diagnosis under outdoor conditions due to the disappearance of diarrhea faeces. Dry weather conditions with sunshine and even frost contribute to destroying E. Coli bacteria, as confirmed by the faeces analysis. However, a wide range of other sources of infection were also found such as E. Coli types other than F4 or F18, Clostridium perfringens, different lung infections, coccidia and intestinal worms.

Study 2. Test of p-phenol as a substitute for zinc to avoid diarrhea

In regard to diarrhea, all five groups developed serious diarrhea on day 6 to 7 after weaning and we were forced to administer zinc again. Group 5 was given a double dose of p-phenol (0.4% in the feed) but this had no effect. For the pigs in the test group the mortality rate reached 10 % compared to 0 % in the control group.

Study 3. Test of seaweed as a substitute for zinc to avoid diarrhea

Results did not show a consistent effect on gut health after feeding seaweed meals. Upcoming results on short chain fatty acids in intestinal digesta may show changes in the fermentation profile from feeding with seaweed.

Discussion

In the Organic-PLUS test (study 2) p-phenol did not show a strong enough effect as to avoid diarrhea. Likewise, seaweed in study 3 showed only a tendency to decrease post weaning diarrhea. As demonstrated in study 1, infection pressure is high and varies considerably in the farrowing outdoor pen. Even if the infection is not directly related to diarrhea (e.g. in the case of lung infection), it can cause poor health, which in fact may be partly responsible for the diarrhea.

A 7-week-old piglet must have a generally high level of health in order to manage the weaning period. In the “on farm test” the piglets were very fit before weaning, but often it was the strongest who got diarrhea first.

So far, no substitute for zinc has been found. However, it can be considered if the dose of natural additives is set at the optimal level, does the processing effect the results or can other types of seaweed with better effects be found?

There is a need for further studies on how to produce strong and healthy pigs. This can be done by focusing on management and combining it with healthy feed.

Acknowledgements

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This work was also carried out as part of the project “Kortlægning af smittepres i økologisk svineproduktion” (Mapping of the infection pressure in organic pig production), that has received funding by ”Fonden for Økologisk Landbrug” (The Fond for Organic Farming). The project has financed the P-phenol for the on-farm test, retrieving, coordination and publishing of results from the project on mapping of the infection pressure in the farrowing outdoor pen in organic pig production.

For further information, please contact the communication responsible of the studies: tos@seges.dk or the Livestock responsible for Organic-PLUS project at massimo.de-marchi@unipd.it.

Effect of dilution rates and preservation period on microscopic semen quality of liquid stored marshal rooster semen with plant based extender

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Key words: extender, semen, dilution, liquid storage, coconut-water orange juice

Abstract

Affordable and effective transfer of germplasm is key to cross breeding and rapid genetic improvement of both livestock and poultry breeding. An experiment was conducted to evaluate the effects of dilution and preservation period on rooster semen diluted with Tris coconut-water orange-juice (TCWO) extender at three different dilution ratios; 1:2, 1:3 and 1:4 (Semen: extender). The extender and semen were warmed to 37°C before dilution. Semen with motility > 80% was processed for extension. Semen was divided into four equal parts consisting of four treatments; undiluted semen and diluted (1:2, 1:3 and 1:4) with TCW-O extender. The samples were kept for 48hrs at 4°C and were assessed at 0h, 4h, 24h, and 48h for motility, viability, membrane and acrosome integrity. Throughout the storage period (0-48hrs), the lowest values were observed in all measured parameters for liquid stored neat semen, the values were significantly lower ($P>0.05$) compared to diluted semen. The (1:3) dilutions had the highest scores amongst the treatments in most parameters except for acrosome integrity at 0 and 4hrs and motility at 48hrs of storage. Evidently, liquid stored semen quality of 1:3 dilution is of better quality than neat or semen diluted at ratios of 1:2 or 1:4 over a period of 48hrs. Irrespective of dilution ratio, storage durations and temperature, the use of extender is paramount for semen preservation for better post thawed sperm quality.

Introduction

A notable reason for the poor distribution of organic poultry germplasm/products is the low number of breeders. This factor serves as a major constraint to the rapid multiplication and genetic improvement of organic poultry germplasm. Artificial insemination in poultry, as in other farm animals, can play an important role in genetic improvement. The sensitivity of rooster sperm to both warm and cold storage temperatures, limits the storage of semen for more than 24 hours and thus the transfer and distribution of organic poultry germplasm. Dilution and preservation of organic poultry germplasm with a plant based natural extender almost free of chemicals may be a significant step towards achieving the wider distribution of organic poultry germplasm/meat products.

ASB design, analyse, and wrote the final draft of the manuscript. AIS, AAA, MMF and SBO assisted in the laboratory analysis and management of the experimental animals.

Semen preparation and conditioning after ejaculation plays an important role in sperm survival. Semen preservation at a low temperature for extended periods of time could be a suitable strategy for the management of reproduction in poultry (Neuman et al., 2002a), and has an

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application in organic poultry farming. Spermatozoa are not able to synthesize new PUFAs (Surai, 2002) or repair damages especially during storage. Therefore, a measure to increase the life of roosters semen exogenously/*in-vitro* is highly desirable.

The maintenance of the fertilizing capacity of poultry sperm for up to 24 and 48 h requires the provision of oxygen, an extender that supplies fructose or glucose as a substrate for the production of ATP, sufficient buffering capacity to maintain pH, and an ambient temperature of 4-7°C (Wishart, 1982). Coconut water has five electrolytes that are required by the sperm cells for both *in-vivo* and *in-vitro* storage. The electrolyte present in coconut water reflects the major components of most chemical based poultry semen diluents. Balogun, (2019) emphasized the importance of formulating a plant-based extender similar in composition to seminal plasma and fortified with natural antioxidant sources for successful preservation of poultry semen thereby improving fertilizing ability of stored roosters semen. Not only must the right component for developing a poultry semen extender be found but an optimum dilution rate and preservation technique must be identified. This experiment aimed to identify the optimum dilution and storage period appropriate for rooster semen when diluted with Tris Coconut-water orange juice (TCW-O) extender.

Materials and Methods

This study was conducted at Oyo State College of Agriculture and Technology, in collaboration with Obasanjo farm Nigeria limited (OFN) at Igboora. The study was a complete randomized block design, consisting of four treatments with three trials. Tris buffer was prepared by adding 3.785g of tris to distilled water, and the pH was adjusted to 7.2. Coconut fruits were purchased from the market. The shell was then pierced and water was drained from it into a beaker before being decanted and filtered. Coconut-water was kept at -20°C for further use. The coconut water was thawed and added to tris buffer at a concentration of 50% (v/v). Subsequently 10% orange juice was added and mixed vigorously. The TCW-O extender was kept in the freezer until required. Ten 40-week old Marshal roosters were sourced from Obasanjo Farm Nigeria limited. Each rooster ejaculate was collected, pooled and checked. Semen with motility >80% were processed for dilution. The pooled semen was divided into four equal parts providing four treatments and diluted at different ratios with TCW-O extender; undiluted semen, diluted (1:2, 1:3 and 1:4). The samples were kept for 48h and were assessed at 0h, 4h, 24h, and 48h for motility, viability, membrane and acrosome integrity. All data collected were subjected to analysis of variance and means were separated with a Duncan multiple range test.

Table 1.0: Immediate effects of different dilution rates on freshly extended Marshal rooster semen with Tris Coconut-water Orange Juice Extender

Parameters	T1 (neat semen)	T2 (1:2)	T3(1:3)	T4(1:4)	SEM
Motility (%)	91.67	91.67	91.67	91.67	0.71
Viability (%live sperm)	93.33	91.67	94.00	92.33	0.77
Membrane Integrity (%)	93.00	93.00	93.00	93.00	0.67
Acrosome Integrity (%)	95.00 ^a	95.00 ^a	92.33 ^b	91.00 ^b	0.62

Superscripts indicate significant difference at 5 % level with in the columns (a,b)

The effects of dilution rate on rooster semen preserved from 4h to 48h with TCW-O extender is presented in Table 2.

Table 2.0: Effects of different dilution rate and liquid storage on extended Marshal rooster semen with Tris Coconut-water Orange Juice Extender from 4-48hrs

1st periods	Pe	2nd Parameters	3rd eat semen)	T1(n	4th 1:2)	T2(5th 1:3)	T3(6th 1:4)	T4(SEM
8th rs	4h	9th Motility (%)	10th 7 ^b	61.6	11th 3 ^a	88.3	12th 7 ^a	86.6	13th 7 ^a	86.6	3.53
		14th Vi-ability (%live sperm)	15th 3 ^b	53.3	16th 7 ^a	86.6	17th 3 ^a	86.3	18th 7 ^a	91.6	4.65
		19th Me mbrane Integrity (%)	20th ^b	33.5	21st 3 ^a	87.3	22nd 6 ^a	87.6	23rd 3 ^a	78.3	6.91
		24th Ac rososome Integrity (%)	70.00 ^b		86.00 ^a		84.33 ^a		82.67 ^a		25th 2.12
26th hrs	24	27th Motility (%)	20.00 ^c		81.67 ^a		86.67 ^a		45.00 ^b		28th 8.31
		29th Vi-ability (%live sperm)	39.67 ^b		73.33 ^a		79.33 ^a		71.00 ^a		30th 4.84
		31st Me mbrane Integrity (%)	39.33 ^c		71.33 ^{ab}		80.00 ^a		68.00 ^b		32nd 4.82
		33rd Ac rososome Integrity (%)	64.33 ^b		83.00 ^a		85.33 ^a		81.33 ^a		2.60
34th hrs	48	35th Motility (%)	3.33 ^c		46.67 ^a		45.00 ^{ab}		35.00 ^b		36th 5.42
		37th Vi-ability (%live sperm)	9.33 ^c		69.33 ^{ab}		73.00 ^a		64.67 ^b		38th 4.84
		39th Me mbrane Integrity (%)	1.33 ^d		65.67 ^b		71.67 ^a		61.00 ^c		40th 8.55
		41st Ac rososome Integrity (%)	31.33 ^b		75.67 ^a		83.00 ^a		80.67 ^a		42nd 6.64

Superscripts indicate significant difference at 5 % level with in the columns (a-d)

The immediate effects of dilution rate on rooster semen extended with Tris coconut-water Orange juice (TCW-O) are presented in Table 1. The results showed no significant difference ($P>0.05$) in motility, viability and membrane integrity among the different dilution rates (1:2, 1:3 and 1:4) or neat semen. Neat semen and 1:2 dilution rate had higher acrosome integrity (95.00) compared to 1:3 and 1:4 dilution rate.

The viability, motility, membrane and acrosome integrity of neat semen over the preservation period, was significantly lower ($P< 0.05$) compared to different dilution rates (1:2, 1:3 and 1:4). However, the 1:2 and 1:3 dilution rates were significantly higher ($P<0.05$) than the 1:4 dilution rate with respect to motility and membrane integrity at 24h and 48h of preservation. Generally, irrespective of dilution rate, semen quality declined with increasing storage durations from 4 to 48hours.

Discussion

Optimizing semen dilution rate of ejaculated semen usually within an average range of 0.25mL is an important approach to accelerate the genetic improvement of organic poultry and economic poultry species. Ejaculate from an outstanding sire when treated and stored can effectively be used for a larger number of hen inseminations. In agreement with our studies, Parker and McDaniel (2002) revealed a significant correlation between the semen quality index and live sperm concentration when broiler semen was diluted 10-fold prior to analysis. They also noted improvement in fertility and hatchability.

The decrease in guinea fowl spermatozoa motility with an increase in the dilution ratio and storage period has been reported with Bestville poultry semen extender (BPSE) and IMV diluents in the ratio 1:2 and 1:3 stored for up to six hours (Hudson, 2015), highlighting the different responses between species. In all cases, the reduction in sperm quality of stored semen may be attributed to metabolic activities and the reactive oxygen species (ROS) generated by the stored sperm.

All extended semen was significantly higher in all quality parameters than neat semen. This may be credited to the complimentary effects of both coconut-water and orange juice, being plant-based antioxidants that supply the necessary nutrients to the sperm during storage. Balogun (2019) reported that the number of spermatozoa with partially damaged acrosomes was increased with an increase in preservation time at 4°C but remained comparatively low in the presence of orange juice compared to tomato juice, throughout the storage period. The level of ascorbic acid is higher in orange juice than in tomato juice and ascorbic acid provides better resistance against ROS damage during liquid storage with respect to sperm motility, live sperm, morphological defects and fertility (Jabbar *et al* 2015).

It is convincing from these results that irrespective of dilution ratio, storage durations and temperature, the use of extender is paramount for semen preservation for better post-thawed sperm quality. Evidently, liquid stored semen quality of 1:3 dilution is better than neat or dilutions of 1:2 and 1:4 across the storage periods examined.

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Behavioural observations of sows and piglets in an organic free farrowing pen with a focus on the piglet nest

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Key words: organic pig production, free farrowing, piglet behaviour, piglet losses, piglet nest, video observation

Abstract

Piglet losses in the early suckling period, in particular due to crushing by the sow, must be kept as low as possible. A prolonged stay in the piglet nest can improve the probability of piglet survival because there is a reduced risk of hypothermia and crushing or kicking by the sow. Different piglet nest designs and management strategies will be compared to find the conditions under which piglets are most likely to be in the nest: electric lid heating vs. underfloor heating, with vs. without LED-light, and with vs. without confinement in the piglet nest during the first feeding times of the sow after farrowing, resulting in eight combinations of treatments. To evaluate the whereabouts and behaviour of the animals, video cameras in the piglet nest, the pen and the outdoor run will record the first 72 hours after farrowing. The videos of about 160 farrowings will be evaluated using a scan sampling method with an interval of ten minutes. In addition, animal performance, medical treatments and animal losses, the temperature in the piglet nest, the stable and outdoors, as well as economic indicators like energy consumption of the heating systems and labour input for confinement of the piglets will be collected. The experiments are currently ongoing and will help to find possible differences in behaviour, growth or losses of piglets due to the different measures and to increase the use of the piglet nest.

Introduction

Animal welfare remains a major challenge in piglet production. Although organic sow management allows the animals to move freely and to live out species-specific behaviour, considerable suckling piglet losses can occur here as well (Prunier et al. 2014). Due to ethical and economic reasons, the aim should be to reduce these as far as possible. Most piglet losses occur in the first days after birth and free farrowing can be associated with an increased risk of piglets being kicked or crushed by the sow (Lohmeier et al. 2020). Therefore, we hypothesize that an early and frequent use of the piglet nest should be aimed at in order to increase the survival probability of the piglets. The present study compares different measures concerning piglet nest design and management to identify the conditions under which piglets are most likely to accept the nest. To this end, possible effects of heating, lighting and confinement of the piglets in the nest are considered using video analysis.

Material and methods

The experiment started in May 2018 and is being conducted at the experimental station of Thünen Institute of Organic Farming in Trenthorst, Germany. Animal husbandry follows the rules of European Commission Regulation 889/2008. The piglets are born of crossbred sows

(German Landrace x Large White), inseminated with Piétrain. To date, data has been collected from about 120 of the planned 160 litters, so the trial is still ongoing.

From about one week *ante partum* until two weeks *post partum*, the sows are kept in one of the eight individual straw-bedded experimental farrowing pens of 7.7 m² indoor area and 6.0 m² outdoor area. A water and feeding trough for the sow and a heated creep area for piglets are installed in each pen. The piglet nests are equipped with either electric floor heating or electric lid heating; a red LED light inside the nest is switched on or off and the piglets of the litter are either locked in the piglet nest during the sow's first four feeding times after farrowing or not. These six different measures can be combined into eight variants. Each variant can be carried out in any farrowing pen. The sows, the variants and the pens were initially distributed randomly, but in the course of the experiment repetitions should be avoided.

Each farrowing pen has been equipped with three cameras to take video recordings in the piglet nest, in the pen and in the outdoor run during the first 72 hours after farrowing.

The videos are evaluated with the scan sampling method, with a time interval of ten minutes, using the Behavioural Observation Research Interactive Software (BORIS). Every ten minutes the animals are counted and different whereabouts and behaviour patterns are distinguished: the sow is either in the pen or in the outdoor run; being active (standing, walking, eating, drinking), sitting, lying ventral or lateral; or suckling her piglets. The piglets are either in the pen, in the outdoor run or in the piglet nest, being active, lying in a pile or scattered in prone or lateral position or suckling.

General performance parameters of each animal are collected. The number of alive and dead-born piglets as well as weaned piglets per litter is noted. Piglets are weighed individually once a week until weaning, and daily weight gain is calculated from individual body weight. All medical treatments and mortality are documented on an individual animal basis during the experimental period including date and body weight. The body weight, the Body Condition Score and the back fat of each sow are recorded *post partum* and after weaning.

In addition, material and operating costs (in €) of heat and light sources as well as labour effort to confine the piglets (in minutes) are recorded to compare the different measure combinations.

Results and discussion

As data collection is still ongoing, no results are available at this stage. These are to be published next year. Since no results are available yet, no conclusions can be drawn.

Our suggestions for research and support policies:

As pig farming as a whole has come under criticism and meat consumption is the subject of current discussions, it is particularly important to keep animal welfare in focus, to develop it further and not to be satisfied with existing conditions. Organic animal husbandry, with its pioneering role, also needs to continue to improve this complex area.

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