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Evolution in animal husbandry –
Fitting animals or fitting systems?

Landbauforschung
Journal of Sustainable and Organic Agricultural Systems

Landbauforschung – *Journal of Sustainable and Organic Agricultural Systems* is a peer-reviewed interdisciplinary journal for scientists concerned with new developments towards sustainable agricultural systems. Of special interest is the further development of agricultural systems to generally fulfil the sustainable development goals of the United Nations' Agenda 2030, and also of organic farming systems.

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Types of papers

Research articles present original new research results. The material should not have been previously published elsewhere. The novelty of results and their possible use in further development of sustainable and organic agricultural systems should be clearly claimed.

Review articles present new overviews generated from existing scientific literature to analyse the current state of knowledge. Conclusions on necessary consequences for further sustainable development of agricultural systems and research needs shall be drawn.

Position Papers present science-based opinions on new, or possibly disruptive, developments in sustainable agricultural systems. Authors should use scientific references to validate and approve arguments for a position. These papers shall allow the reader to understand controversial positions and to find an own position.

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CALL FOR PAPERS FOR THE SPECIAL ISSUE

Evolution in animal husbandry – Fitting animals or fitting systems?

Tail docking, disbudding, beak trimming or castration – all these mutilations aim to fit animals into highly efficient farming systems. Reasons are safety of farm workers, avoiding injuries of livestock, keeping the quality of the final product and eventually achieving profitability. Surgical interventions seem to be particularly cruel and not acceptable to a society that takes animal rights more and more into account. But what about fitting procedures that are not as obvious, like cow calf separation immediately after birth or the use of genetic scissors instead of real ones? For society's trust in future animal husbandry and proud identification of farmers with their livestock systems scientific answers and discussions to derive concepts are needed

With this issue of Landbauforschung we intend to stimulate a controversial discussion of this far reaching topic. We would be very pleased if you could contribute to this issue. We are asking for (1) original research and review papers and (2) science-based position papers from all science disciplines that have a focus on (a) future husbandry practices avoiding mutilations, (b) effects of genetic modifications and breeding on animal welfare, (c) chances and challenges of fitting animals into food production as well as (d) ethical aspects of human driven evolution of animals in husbandry systems. We are looking forward to inspiring contributions.

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Editorial

Evolution in animal husbandry – Fitting animals or fitting systems?

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Hans Marten Paulsen

Kerstin Barth

Solveig March

Dear colleagues, authors, reviewers and readers!

Livestock welfare and moral responsibility in animal husbandry and the consumption of animal products are focus of the first issue of Landbauforschung in 2020. We are glad that our call 'Evolution in animal husbandry – Fitting animals or fitting systems?' has motivated a wide interdisciplinary and international authorship to contribute approaches from philosophical, theological and social sciences as well as results, reviews and views from veterinary and livestock sciences.

Diverse aspects of welfare in dairy, pig and fish production, as well as responsible treatment of male calves and pigs from birth to the slaughterhouse are described and discussed. Options and necessities for improvements are addressed or highlighted as outstanding claims.

Furthermore, ethical views and the options for changing attitudes as well as the steps in political processes that are needed to define socially accepted standards of livestock production systems and to improve the conditions for our animals are presented. Evaluation schemes and other practical approaches for improvement in animal welfare for sustainable and organic agricultural systems are suggested. The diverse contributions on the question of 'Fitting animals or fitting systems?' indicate that this is an issue that must still be solved by society.

We thank all authors who shared their results and positions, and we are very grateful to all reviewers, whose stimulating and critical appraisals improved the quality of many articles.

The complete review process can be followed on our website landbauforschung.net and provide more information on the discussion of some manuscripts. There you may also join the scientific discussion on all articles published in this journal. We are looking forward to your contribution.

Hans Marten Paulsen, Kerstin Barth, and Solveig March

POSITION PAPER

Why fitting animals itself is ethically dubious

Daniel Wawrzyniak[1]

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KEYWORDS **animal welfare, animal disenhancement, animal enhancement, genetic modification, genetic engineering, animal husbandry, human-animal relations, selective breeding**

1 Description of the problem

During the last couple of years, two parallel developments have become apparent. On the one hand an increasing public concern for the welfare of animals, especially those used in the food production sector, while on the other hand vast advances have been made in genetic engineering that seemingly enable current animal welfare problems that occur in today's livestock husbandry systems to be dissolved. Those new technologies promise countless new ways of adapting animals to man-made husbandry systems on a level that could not be achieved through selective breeding, e.g. by directly knocking out genes responsible for the development of behavioural urges (Streiffer and Basl, 2011:837). In addition, they promise to avoid causing the suffering usually associated with surgical modifications of already existing animals (e.g. dehorning or tail-docking).

The main ethical question at hand is: should we make use of these new possibilities? Today the promotion of animal welfare is usually accompanied by a credo the German Federal Ministry of Food and Agriculture formulated as follows: "Animal housings and animal husbandry management must be adapted to the animals' needs – not the other way round" (BMEL, 2014). While this may sound like a rejection of fitting animals, in general not all cases seem to be considered as equally morally problematic by welfare scientists and the public (e.g. breeding animals more resistant to diseases). Despite this, I will claim that any kind of fitting animals, no matter how subtle, deserves critical scrutiny and offers no satisfactory solution to current animal welfare problems. This criticism goes beyond the risk of unintentionally harming animals due to our limited understanding of their genetics and the future outcomes of our actions. The fitting of animals fundamentally ignores animals as individuals who deserve appreciation and consideration for their own sakes and reduces the ethical idea about consideration of welfare to a mere bio-medical technicality.

2 Philosophical analysis

The fitting of animals in order to tackle animal welfare problems touches several critical issues. Firstly, it requires a process of test runs of breeding before an animal with the desired biological traits is successfully bred. Therefore, a risk of creating ill-suited animals or even breeding of defects is to be anticipated alongside other suffering during the testing of these "prototype" animals (Ferrari, 2012:71). Secondly, while creating animals that are adapted to man-made husbandry systems may reduce suffering in animals, husbandry systems still include the confinement and premature killing of these animals for economic reasons. While it may be possible, although practically and economically unlikely, to confine and kill animals without causing any suffering, confinement and early death can still limit the range of pleasure an animal can experience during its lifetime (Schmidt, 2015; Bruijnis, 2013). So fitting animals just seems to perpetuate husbandry systems that still involve several other animal welfare problems.

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For the purpose of this paper I will put these issues aside and focus instead on the question of whether the act of fitting animals itself deserves criticism. In my view we can roughly distinguish between three different types of fitting animals genetically. First: genetically removing the ability of an animal to feel certain kinds of pain, stress or develop urges which are difficult to satisfy in current husbandry systems ('animal disenhancement'). Second: shaping an animal's physical appearance to be better suited for current husbandry systems in order to either reduce the risk of injury for the animal in question, other animals, or humans handling them. This could either be achieved through selective breeding (e.g. breeding cows without horns) or by manipulating genes responsible for the growth and development of other specific body parts. (I will call both methods 'animal shaping'). Third: genetically enabling an animal to be more resistant to certain diseases, more tolerant to stress, or to be able to 'perform' better ('animal enhancement').

Even though some of the examples that will be mentioned may be hypothetical or, not as yet, practically realisable, it is worth considering these scenarios since they help illustrate the complexity of the ethical issues involved in this subject matter. I will focus on the ethical question of what we morally 'should' do – not on what we already 'can' do by contemporary bio-medical means. This is important on one hand because we should not wait until new technologies have been implemented before we start contemplating them critically. On the other hand, ethical self-reflection should include asking ourselves what we would be willing to do, independent of what options are currently open to us.

2.1 Fitting through 'animal disenhancement'

Scenarios of 'animal disenhancement' in particular have been met with shock and rejection by many animal welfare scientists and the public at large (Thompson, 2008; Thompson, 2010). Admittedly, creating pigs with only enough brain mass to allow biological growth yet not support consciousness, to pick one example, definitely solves welfare problems connected to animal suffering. As they lack any consciousness, these animals simply cannot subjectively feel any suffering nor do they possess any subjective welfare that could be taken into account (Streiffer and Basl, 2011; Palmer, 2011). Although it is quite tricky to philosophically criticise 'animal disenhancement' (Thompson, 2008; Palmer, 2011), the wide emotional rejection of such cases among consumers and agricultural producers already seems to disqualify this kind of fitting animals as a promising future perspective for our dealing with animals (Thompson, 2010).

A key element in the rejection of such strategies to tackle animal welfare problems has been the emphasis on 'positive welfare'. An animal should not only be spared suffering but also offered a certain level of joy during its lifetime (Webster, 2011:7) which an apathetically vegetating animal cannot experience. But then again, an animal without any consciousness is incapable of noticing the lack of any positive welfare in its life, so it cannot be bad for the animal itself to live such a life. The emotional unease regarding such cases rather implies that many of us believe deliberately creating animals that no longer experience any kind of welfare (negative or positive) conflicts with our demand to treat animals respectfully. This underlying point will become clearer as we consider the other two ways of fitting animals.

Firstly, however, I should stress that there are also less drastic cases in which not the complete ability to suffer, but only some selective perceptive properties are eliminated or diminished, e.g. the ability to feel certain pain or sight (Sandøe et al., 2014; Thompson, 2008). In such cases we can assume that the range of positive experience of these animals will be limited, so their welfare will be diminished in certain aspects.

Additionally, their limitations can have harmful side effects as the incapability to feel certain pain increases the risk of injury in animals (Schmidt, 2008:350), just as the limitation of their perception negatively affects social behaviour and stress (Sandøe et al., 2014). I will claim that beside these obvious welfare constraints, the very act of disenhancing animals already betrays the sincerity of our concerns about animal welfare, simply by being an act of adapting the animal rather than adapting our consumptive habits or other ways of life.

2.2 Fitting through 'animal shaping'

By contrast, 'animal shaping' (and also 'enhancement') seems to be compatible with the consideration of positive welfare. Breeding cows with no horns is definitely less stressful and painful than surgically dehorning them and further reduces the risk of injury for other cows in the same shed and for the humans handling them. The absence of horns does not seem to limit a cow's opportunities for physical satisfaction. In a similar way, tail-docking in pigs could be substituted by creating tailless pigs thus eliminating the risk of tail-biting without causing any stress or limiting the pigs' ability to enjoy positive welfare. Admittedly, though, the absence of certain body parts can still negatively affect the social needs of animals, e.g. concerning socially important playing behaviour with conspecifics (Sambraus, 1978). This would suggest that the only things that should prevent us from adopting 'animal shaping' are our incomplete understanding of their behavioural needs and the high complexity of genetics.

But from a philosophical point of view, the problem behind this kind of fitting animals lies deeper. Let us assume for the sake of the argument that we had a perfect understanding of the ways animals and their needs work and access to perfect methods to sensitively alter the shape of their bodies. In other words, let us put aside the obvious problems of unpredicted sufferings or diminished positive welfare as side effects of 'animal shaping' through genetic engineering.

Even then, these cases of fitting animals could be criticised as unjustified meddling with the physical appearance of animals: as a violation of 'animal integrity'. This concept faces philosophical problems of its own (Bovenkerk et al., 2002; Schmidt, 2008:176) just as the idea of "naturalness" (a biological condition of animals untouched by humans) does (Thompson, 2010). However, such concepts give voice to a more general ethical claim: we cannot just interfere with the genetics of animals as we please. It is this intuitive rejection of genetic alteration of animals which deserves our attention beside our wish to reduce suffering in animals.

It is worth noting that the logic behind fitting animals follows prominent animal welfare accounts advocated, e.g. by Wiepkema. According to him, animal welfare simply consists of matching what an animal wants or needs on one hand and on the other hand which of these desires or needs it can satisfy within its current life situation – no matter how matches are brought about (Wiepkema, 1987). "Coping approaches", too, suggest that as long as an animal is able to successfully cope with its surroundings (no matter how this is achieved), its current welfare is satisfying (Webster, 2011:7). Webster, however, also emphasises that animal welfare is about more than just the state of an animal itself. It is about acknowledging that we are dealing with an individual that we can reasonably care about, that we can harm and that therefore should be treated respectfully (Webster, 2011:6). By simply focussing on mismatches between an animal's needs and its life situation we are treating the animal as a repository of a state of welfare which becomes the focus of your attention while the individual itself gets ignored and only gains indirect derivative concern.

If we are more willing to alter animals instead of husbandry systems – or our consumption patterns – we are not displaying concern for an individual but rather some fixation on a desired result regarding that individual's state of welfare. At the same time, we put our own interests before that of the animals and even decide that our interests not only define how we can treat animals, but also which kinds of animals should exist, or be created. Thompson thus argues that the strategy of solving animal welfare problems through genetic means is an expression "of arrogance, of coldness and of calculating venality" (Thompson, 2008:314).

Webster's point is that animals should be acknowledged as individuals with a well-being of their own and that they should be respected for their own sakes. If we accept this, 'animal shaping', no matter how innovatively done, cannot offer us a clear conscience while continuing to use these animals. Shaping animals does not aim at improving their life situation as such. Rather, is an attempt to reduce welfare problems that were caused by humans in the first place, while at the same time giving up as few of our consumptive habits and production methods as possible. This, however, is incompatible with the demand to treat animals respectfully for their own sakes. Considering animal welfare is not just a technical question about how to achieve a desired outcome. It is also an ethical question about how we want to define our internal moral compass. This implies that the path we choose to reach our goals must also be considered.

Animal welfare, as Haynes stresses, is a complex concept consisting of measurable states of welfare and an underlying normative conviction that animals deserve our consideration. Without this there would be no motivation for us to trouble our minds about their life situation (Haynes, 2011). That is, unless we believe that welfare problems should be reduced because negative and positive welfare states are valuable in themselves, as utilitarianism implies. But this view is firstly ethically dubious (Raz, 2004) and secondly at odds with the idea of considering an animal for its own sake.

2.3 Fitting through 'animal enhancement'

If this is true for 'animal shaping', it also concerns 'animal enhancement'. If we only focus on animal welfare as an animal's state of physical fitness and mental contentment, there would seem to be nothing wrong with putting all our efforts into creating animals that are more resistant to diseases, more persistent, and more "productive", which again is defined by what humans desire of those animals, such as a high egg-laying rate, growth of muscular tissue, high fertility, etc.

However, as argued above, animal welfare is a concept with an appellative character that also covers our attitudes towards animals and which includes seeing them as individuals that matter for their own sakes. Animal suffering is not an undesirable state in itself. It is problematic, because it affects individuals that we care – or should care – about. This aspect is ignored when we try to reduce welfare problems by creating animals that are less susceptible to common welfare problems instead of treating existing animals with more consideration.

And if genetically enhancing animals is to be scrutinised with a critical eye, the same applies to selective breeding for more resistant or "productive" animals (Fernyhough et al., 2020). The only significant difference between those two methods is the level of precision in modifying animal genetics. Both follow the same logic: if the pursuit of our human interests conflicts with animal welfare, let us create animals that better match our interests. This, however, contradicts the claim that it is the animals themselves we care about. Advances in genetic engineering therefore also shed some critical light on selective breeding as a traditional and widely accepted way of fitting animals.

This point also helps to back up the emotional unease concerning 'animal disenhancement'. Creating animals that cannot experience any kind of welfare at all means acknowledging that the animals we use for our purposes usually do possess a well-being of their own which must be considered – and then choosing to remove that source of obligation instead of being more respectful and caring in our actions towards animals. Such an attitude seems highly questionable. I do not claim that advocates of the fitting of animals necessarily have bad intentions.

My point is, though, that as long as altering animals so that humans do not have to alter their habits persists, there are no just reasons to fit animals since there is no urgent necessity to maintain our current habits. Even if these people honestly only had the animals' best interests at heart, they would fail to address the fact that humans can change their living habits.

3 Conclusion and future perspectives

Using fitted animals will admittedly in some cases reduce or possibly even eliminate a range of animal welfare problems. This effect could potentially be magnified by simultaneously changing husbandry systems and our consumptive habits as well. Changing the genetics of animals to suit human ends still remains a problematic element. What does it say about us if we are more willing to create animals that need less consideration in order to maintain our habits than to be more considerate in our actions towards animals? This is an ethical issue worthy of our attention in addition to concerns about the harmful effects of our meddling with the genetics of animals. Concern for animal welfare does not only allude to the causation or avoidance of harm in animals, but also to our moral character in dealing with them.

The demand to adapt husbandry systems to the animals' needs and not the other way around should be taken more seriously than it has been so far. Not all cases of fitting animals are met with the same degree of public rejection, but they all touch an important ethical point, which might be less alarming in some instances but still deserves the same critical eye. If we truly understand animal welfare not as an exclusively bio-medical or economic factor, but as an ethical and socio-political issue, no form of fitting animals can provide us with a satisfying solution for animal welfare concerns – it can merely gradually reduce some currently striking welfare problems. Instead we should put more innovative energy into the development of animal-free agricultural systems and steps that allow farmers and other producers to shift to new forms of businesses.

In the meantime, more responsible forms of husbandry and the use of animals able to cope with their man-made environment can be seen as minor steps toward better animal welfare standards, but not as sufficient solutions. Animal welfare is not just about empirically measurable welfare standards. It is also about what kind of people we want to be. Attempting to be more considerate towards animals by trying our hardest to create animals we can consider less is a contradiction in itself.

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POSITION PAPER

Animal Welfare: Thoughts about how to achieve the most (for the animals!) Consensus-driven dialogues vs. scandalisation, gradual improvements vs. maximisation

Thomas Blaha[1]

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Thomas Blaha

KEYWORDS **human-animal-relationship, 'wicked' problems, discourse ethics, benchmarking systems, continuous improvement processes**

1 Animal welfare improvements lag far behind societal expectations and realistic opportunities

The human-animal-relationship has drastically changed in the last two decades: animals are no longer regarded as just objects that an owner can treat how he or she wants, but they are regarded more and more as subjects, i.e. as sentient creatures, who have an intrinsic value and should deserve the guarantee of a decent life provided by the people that own or care for animals (Kunzmann, 2013). There are several animal welfare frameworks that define the wellbeing of animals in different ways. Fraser (2008) describes the welfare criteria "health, "natural living" and "affective state"; the EU research Welfare Quality® project (FOOD-CT-2004-506508) defines the four animal welfare domains: good feeding, good housing, good health, appropriate behaviour (Temple et al., 2011), to which Mellor (2017) added a fifth domain, the mental state of the animals. On a global scale, the animal welfare definition of the OIE (World Organisation for Animal Health) in 2008, given in the Terrestrial Animal Health Code (OIE, 2011), is widely accepted. All in all, a good description of a decent life of animals in human care is still the concept of the "Five Freedoms", which was already developed in the 1960s in the UK (Brambell, 1965), and describes quite well the European understanding of good animal welfare:

- Freedom from hunger and thirst, by ready access to fresh water and a diet to maintain full health and vigour.
- Freedom from discomfort, by providing an appropriate environment including shelter and a comfortable resting area.
- Freedom from pain, injury, and disease, by prevention or rapid diagnosis and treatment.
- Freedom to express normal behaviour, by providing sufficient space, proper facilities and company of the animal's own kind.
- Freedom from fear and distress, by ensuring conditions and treatment that avoid mental suffering.

Of course, keeping and using animals for human purposes is mostly connected with imposing some sort of stress on the animals, curtailing normal behaviours and even causing them some unavoidable pain and suffering. Therefore, in the light of the growing understanding of the responsibility that humans have for the animals in their custody and/or use, there is the moral imperative that, while providing the animals with the

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"five freedoms", only minor infringements should be allowed and there must be a strong justification for causing any avoidable pain or stress to animals.

However, despite the rapidly growing consensus in society over the last 20 years that animals deserve a decent life, there has been little change in the quality of life of our food animals: most animals are kept in confinement without sufficient enrichment; lack of choice of climatic zones; no access to open areas; few opportunities to express their behavioural repertoires; chicken beaks are still trimmed; pig tails are still docked; and not all herds and flocks are healthy and receive sufficient competent care from the humans that have the responsibility for them.

2 Reasons for this discrepancy

2.1 The high complexity of animal welfare

To understand the reasons for the suboptimal housing and management of our food animals, it is necessary to explain that improving animal welfare is, like acting against climate change, not a "tame" (one-dimensional and solvable), but one of the "wicked" problems (multi-dimensional, complex and not solvable). The phenomenon of "wicked" problems was defined in the late 1960s by the German Wilhelm Horst Jakob Rittel, who was a design and sociology professor in Ulm, Germany, and in Berkeley, USA (Rittel and Webber, 1973). According to him, wicked problems are highly complex and involve many different stakeholders with very different expectations. Due to their social complexity, wicked problems have no stopping point. The consequence is that the aim of action against wicked problems needs to be shifted from "solution" to "continuous intervention". And it means that changes in the right direction of not solving but tackling wicked problems more successfully require a great number of people to change their mindsets, habits and behaviours. They are also characterised by very complex interdependencies, which means that the effort to solve one aspect of a wicked problem reveals or creates other problems, which is especially complicated if genuine conflicts of societal goals are involved. In the case of animal welfare, conflicting societal goals include examples such as "affordable food for all", "food security and food safety" and "a decent income for farmers", and "international competitiveness". Maximising one of the societal goals will automatically lead to reducing the other interdependent goals (see the parable of the principle of communicating vessels in *Figure 1* and *Figure 2*).

The consequence of maximising, e.g. the focus on animal welfare, is that those who are affected by the decrease of the appreciation and support for "their" values will oppose any animal welfare improvement efforts.

2.2 Public discourses as good governance

As seen above, the growing complexity of society and its increasing diversification lead to the fact that more and more norms are no longer generally accepted, but controversial and hotly disputed. Discourses about moral behaviours, attitudes and judgements have become part of our daily life. In the 1970s and 1980s, the German philosophers/sociologists K.O. Apel and J. Habermas developed the theoretical basis of the "discourse ethics" that are the precondition if public discourses are to become engines of societal change to the better. They pointed out that for discourse ethics to be successful there must be an effective level of civility between people or persons involved. According to Habermas (1991), the following (idealistic) presuppositions are necessary to make public discourses successful:

- that participants in communicative exchange use the same linguistic expressions in the same way,
- that no relevant argument is suppressed or excluded by the participants,
- that no force except that of the better argument is exerted,
- that all the participants are motivated only by a concern for the better argument
- that everyone would agree to the universal validity of the claim thematised,
- that everyone capable of speech and action is entitled to participate, everyone is equally entitled to introduce

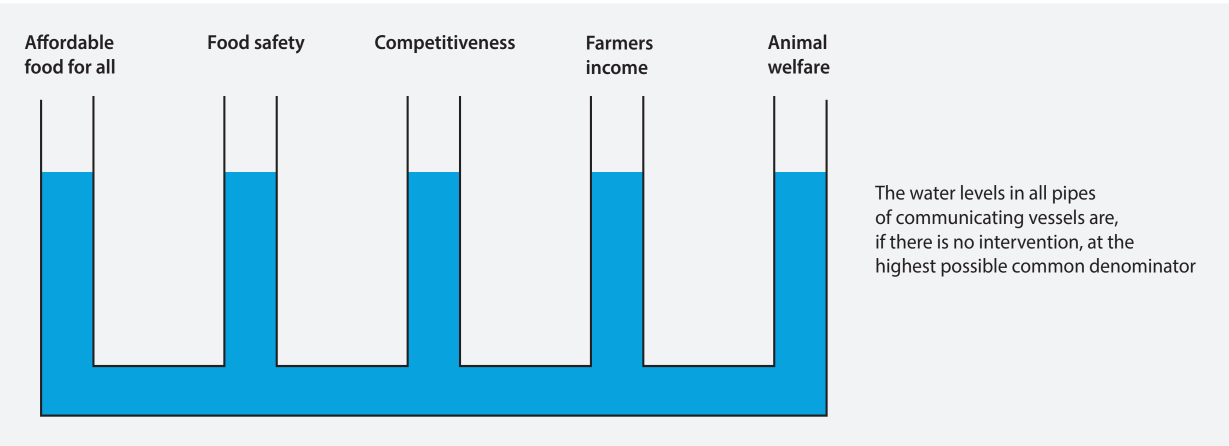

FIGURE 1
With no one-dimensional intervention, the five interdependent societal values are treated with equal public appreciation and governmental support

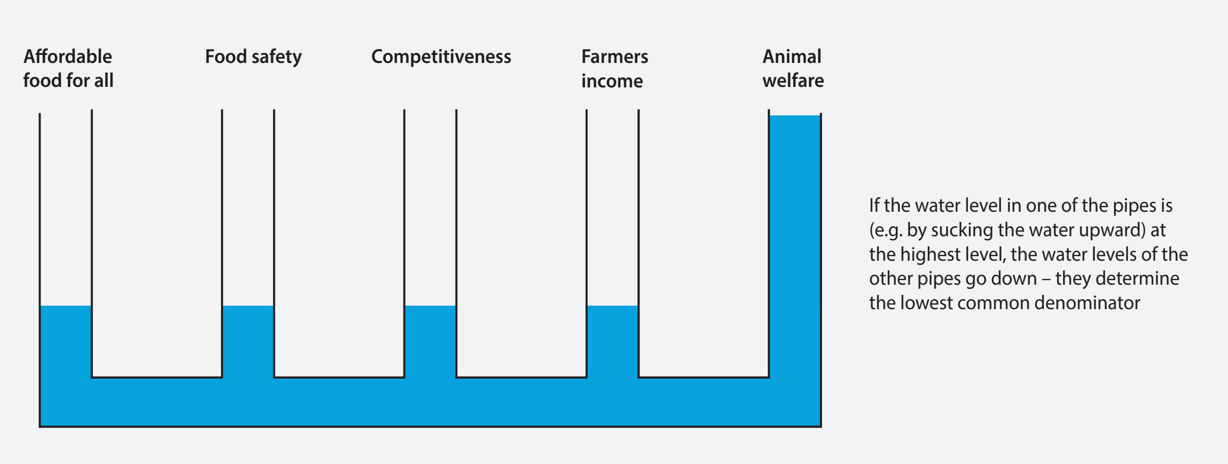

FIGURE 2
With one of the societal values maximised, the other interdependent values lose governmental support

new topics or express attitudes, needs or desires, and the concerns of those that are affected, but not included in the discourse, are taken into consideration, and

- that no validity claim is exempt in principle from critical evaluation in argumentation.

This long list of presuppositions explains why public discourses do not "automatically" lead either to change at all or to changes that are accepted and become a valid norm. The less the rules of a civil and constructive discourse are complied with, the less can and will be achieved.

As for the animal welfare debate, the stigmatisation of farmers as "animal tormentors" and radical demands such as "abolishing intensive animal husbandry completely" or "keeping all animals only on pastures" obstruct reasonable and achievable animal welfare improvements. The affected farmers – who often are not included in the discourse – develop a siege mentality and are not ready to consider or implement practical changes. They feel stigmatised, disrespected and unfairly treated and are therefore not ready for any constructive dialogue. Feeling abused is no basis for listening, for understanding reasonable concerns, and not at all for acting in order to fulfil any of the demands. Thus, outraged animal welfare activists with maximum demands who do not attempt to understand the needs, the fears and the anxieties of those who they expect to change their ways of production and of generating their income, contribute to the stagnation that these critics complain about.

3 Ways to a socially agreed continuous improvement of the quality of life of animals

As shown above, consensus-driven dialogues about continuous gradual animal welfare improvements are the most suitable way to increase the quality of life of food animals over time as suggested in the Expert Opinion on "Directions to a societally accepted food animal system in Germany" by the Scientific Advisory Board of the Federal Ministry of Agriculture in 2015. However, this way of orchestrating change is only convincing and acceptable for both the affected farmers and the concerned critics, if there are concepts that are affordable for the farmers and that make real differences in overcoming animal welfare shortcomings, which the critics can recognise and appreciate.

In the following, three evidence-based examples of initiatives to improve animal welfare are explained: national or regional animal health databases for benchmarking purposes, animal care ratios for large animal herds and flocks and the use of animal-oriented sensor techniques. These three concepts have been suggested for years by scientific working groups, they are "ready to use", and need minimal time to be implemented, i.e. almost no transition time in contrast to rebuilding and reorganising the entire conventional husbandry system.

3.1 Animal health databases for benchmarking purposes

It is well known and documented that the majority of the dramatic animal welfare violations that are broadcast by the media has little to do with the husbandry system or the herd or flock size, but more with marked deficiencies in the quality of the animal care. The pictures of sick, injured, neglected and suffering animals that the media present are clear proof of the fact that the veterinary authorities responsible for monitoring the animal owners' compliance with the Animal Welfare Act and the Directives for the Animal Protection of Food Animals have no early warning system which is able to identify herds or flocks with suboptimal care for the animals much earlier. Before farm animals present such a poor status of health, the ratios of dead animals and sick animals that reach the slaughter plant will have been increasing for quite a long time. The European regulations on inspections of food producing operations, including farmers, as "risk-oriented" controls are reasonable and represent considerable progress towards efficient state interventions compared with the traditional, mandatory randomly selected farm visits by official veterinarians, which e.g. in Ireland are implemented by the Irish Animal Identification and Movement (AIMS) database to identify at risk farms (Kelly et al., 2011; Kelly et al., 2013). However, this progress is, at least in Germany, only theoretical as there is no monitoring of health and animal welfare indicators at farm level which is comparable to quality assurance systems of successful food companies (More et al., 2017). The EU regulations on registering food animal operations and on the traceability of animal movements are mainly aimed at preventing emerging and re-emerging animal diseases at national level. Since these data are neither standardised nor centralised at national level, they do not provide the databases that could be used for continuous monitoring for identifying individual food animal farms with a very poor or suboptimal animal health and animal welfare status.

If there was a national database, or regional databases, that continuously recorded the mortality rates, the slaughter inspection data and other health and welfare indicators (both from the live animals at unloading and in the lairage, and from the carcasses at the slaughter line) cumulated for each herd and flock (Elbers, 1991; Blaha, 2005), early interventions by consultants ("yellow herds") and/or by veterinary authorities ("red" herds) would be possible. The latter would be given a simple and doable tool to perform the necessary "risk-oriented" state controls (see *Figure 3*).

The databases could be anonymised for the public so that only the individual farmer would know where his or her herd or flock rates on the scale from a low to a high frequency of findings that indicate serious health and animal care shortcomings. Most farmers would use the data bank for their own corrective measures, since the majority of the farmers do not know their herd's or flock's health status compared with other farmers. If they know their shortcomings, most of them will consult a competent advisor to help solve the problems. Only those farmers who do not respond to this early warning system, would be subjected to an inspection by the responsible veterinary authority. Using this benchmarking tool continuously, a reliable instrument for an ongoing animal welfare improvement process could be implemented, which would prevent animals in poor husbandry and poor animal care situations not being recognised early enough and suffering much longer than is necessary (Dickhaus et al., 2009; Alt et al., 2010; Blaha and Richter, 2011; Grandin, 2017).

3.2 Animal care ratios for large animal herds and flocks

The structural changes in agriculture to larger farms and larger food animal herds and flocks (in the East during the communist period due to central planning, in the West due to increasing competitive forces) has led to the fact that the larger a herd or flock becomes, the more animals have to be observed and cared for by one person. This has been regarded for several decades as a mostly welcomed economic effect: apart from feed, labour accounts for the highest costs in food animal production. Thus, the decrease in labour cost per animal was seen as progress, since in the decades after World War II making the very small-scale agriculture of the time more efficient, lowering the prices of food, and making the physical work of the farmers and their employees less demanding, was a widespread consensus in the 1950s and 1960s.

However, there was no stopping point for this growth process in terms of animal performance (producing more meat, milk and eggs per animal). This means that the developments went far beyond the threshold of where exploiting the animals and diminishing the animals' quality of life began. The effect of this missing stopping point, and the lack of consideration for the animals, resulted in the situation where the drive to increase farm efficiency and productivity conflicted with animal welfare. Additionally, the availability of automation and computerisation (feeding computers, computerised climate control of the barns and animal houses) had the consequence of reducing the hours

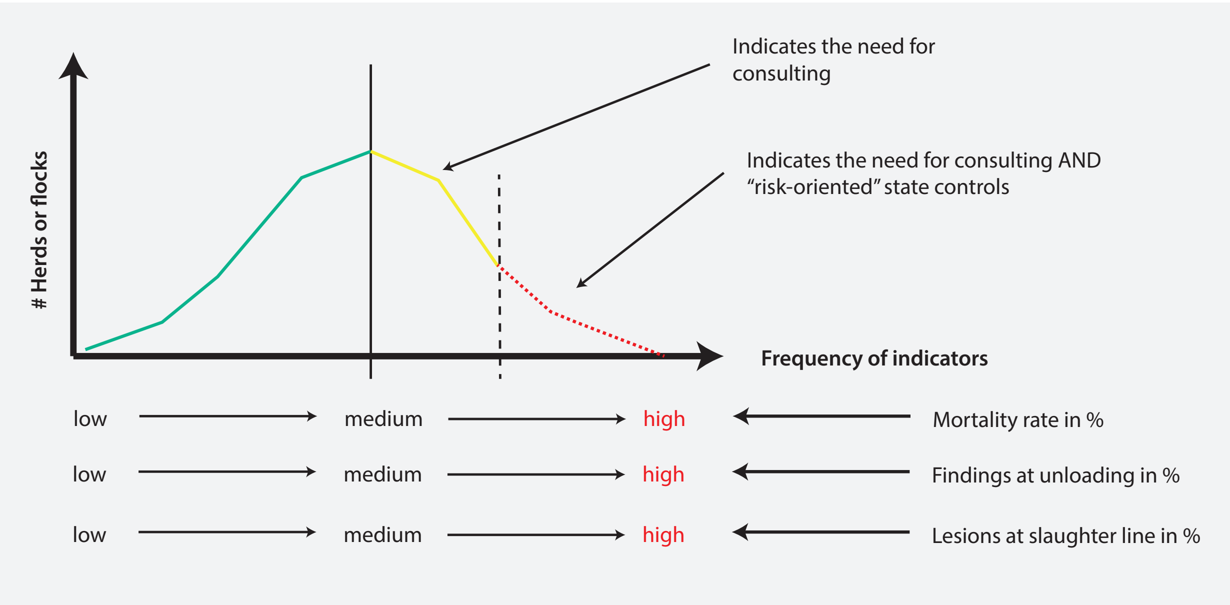

FIGURE 3
A simplified scheme of how to identify herds and flocks that need improvement

of the physical presence of the farmers and caretakers in the animals' direct environment.

Now, with the changing understanding of man's responsibility for the sentient creatures in their custody, we need to counteract the obvious reduction in the extent of animal observation and the shortening of time to care for an individual animal caused by the growth of herd and flock sizes. There is no reason not to regulate by law a minimum "animal care ratio" for given herd and flock sizes. Appropriate research groups could be asked to determine for each food animal species and each age group per species, how many animals per competent person can be sufficiently observed, twice a day, and appropriately be cared for if necessary.

Regulations on how many competent persons should care for how many food animals in larger herds and flocks would also be a guideline for auditing procedures in the framework of delegated self-controls and for the frequency and intensity of the mandatory state inspections of larger animal units by veterinary authorities.

3.3 The use of animal-oriented sensor techniques and automation

Automation and technical support by computers are perceived as being detrimental for the animals' wellbeing (= more and more technology in the barn can be considered to be "soulless"). However, automation and sensor techniques can, of course, be of great value for the animals, if they are developed not to save labour time, but to support the animal caretakers in their responsibility to provide the animals with optimal feed and water, and a healthy climate, and to help farmers to recognise early signs of disease. The sensor techniques allow for identifying subclinical lameness or coughing animals, increasing body temperature, and even ruminal disorders (Rutten et al., 2013). Additionally, they can record behavioural abnormalities such as aggressive ranking order fights in the absence of human observation.

Also more and more farmers have early warning system apps on their smartphones to receive alerts if something in the barn is having adverse effects on the animals, this lowers reaction times and can considerably lower the risk of stress and suffering of the animals.

4 Conclusions

For many animal welfare activists, most animal welfare shortcomings seem to be easily solvable, but solving them in the real world is not easy, since it is a matter of "wicked" problems: many interdependencies with other social issues, many stakeholders with completely different particular interests, and many people who have to change their minds and habits are involved. The more radical animal welfare demands are, the more they provoke resistance and counteractivities by those who are expected to change their attitudes and way of production.

The consequence is that agreeing on small steps in a process of a consensual continuous improvement of the quality of life of our food animals is achieving more (for the animals!) than insisting on drastic ad-hoc systemic changes that result in immediate opposition. Over time, applying small improvement steps like implementing long-known animal-oriented measures such as animal health databases (Van Staaveren et al., 2017), reasonable animal care ratios for large herds and flocks as well as using sensor techniques and automation that make the animal observation and the care for the animals in need better (Benjamin and Yiks, 2019), will lead to gradual systemic changes in the right direction.

The high complexity and the manifold stakeholders prevent the process of gradual improvement unfolding itself, thus, mediating the public discourse on what to achieve and triggering and coordinating the stepwise implementation of well-known animal welfare improving measures must be provided by the political decision makers. The latter means undoubtedly that the gap between the animal welfare demands and the known possibilities to improve the animals' life quality is a serious policy failure.

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POSITION PAPER

Lack of success in improving farm animal health and welfare demands reflections on the role of animal science

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1 Description of problem

Animal health and welfare (AHW) of farm animals is a highly complex issue involving the interests of various stakeholders and conflicts between important societal goals. First of all, farm animals have an inherent interest to sustain their life and prevent themselves from suffering pain or harm. Also, farmers, consumers, and animal scientists have a great interest in the AHW issue. Although decades of efforts by various disciplines of animal science have provided progress in various fields, they have not led to substantial improvements of AHW in farm practice, not even under the enhanced minimum standards of organic agriculture (Krieger et al., 2017). Researchers of animal welfare can claim, at best, that the AHW situation would have been far worse without scientific efforts (LeBlanc, 2013). Indeed, research work has created an enormous amount of scientific knowledge, but while filling many libraries, little of this theoretical know-how about nearly context-independent biological and physiological laws and regularities has been successfully implemented on farms. This contrasts with the enormous investments in the research on improving AHW. Regardless of reasons, be it inappropriate knowledge or insufficient implementation, this contrast questions any further spending of huge amounts of public money on scientific efforts that stubbornly proceed with the same predominant approaches. Here, it is hypothesised that unsolved conflicts between different interests on different scales are a major cause for the lack of improvements in AHW. Some of the conflicting areas are outlined below.

2 Farm animals want to survive

One of the main requirements of all living systems is adaptability to existing or changing living conditions. What makes a difference between biological evolution and animal husbandry is the fact that in the latter humans are responsible for the design of living conditions and the setting of the production goals, thus framing the interactions between farm animals and their living conditions. Survival depends on the ability of an organism to maintain a stable internal environment (e.g. body temperature, blood glucose) for this enables optimal functionality of vital systems during times of external environmental fluctuations and perturbations. Adaptation involves a series of orchestrated behavioural, physiological, and metabolic changes which rely on the availability of adequate resources (e.g. nutrients) as well as sufficient protection against abiotic (heat, cold) and biotic stressors (conspecifics, microbial pathogens). In theoretical biology, an enduring tradition referred to as 'self-determination' places heavy emphasis on the idea that biological systems employ

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a systematic constitutive organisation, the effects of which contribute to the determination and maintenance of its existential conditions (Montévil and Mossio, 2015).

Different concepts and terms describing changing regulatory systems have been coined. From these, allostasis, meaning 'stability through change', has become most widely used (Sterling, 2012). Regulatory mechanisms must change, for instance, in the transition period of dams from pregnancy to lactation, to maintain or achieve a state appropriate for the individual animal for the time of day or year, in response to disturbances, and in relation to individual requirements. Maladaptive and inefficient responses to the complex challenges presented by the living conditions lead to dysfunction and disease, indicating that the ability of the animal to cope is overstrained (Sundrum, 2015). Thus, adaptive responses are an essential means of survival.

3 Competition between animals and in animal's metabolism

Deficiencies in resources and/or protection cause competition between farm animals, not least at the feeding trough. Additionally, competition exists within an organism at metabolic level. Glucose, for example, plays a central role in dairy cows, for which both lactocytes and leukocytes are competing. An increase in demand imposed by milk synthesis or inflammation can cause a mismatch in the regulation of glucose allocation and plays an important role in postpartum immune dysfunction (Sundrum, 2019). With increased milk production and demand for glucose, fertility declines (Spencer, 2013) and digital adipose cushion in hoof tissue decreases, resulting in more hoof lesions and lameness (Oikonomou et al., 2014). Pushing the animal to produce more milk, meat, or eggs causes both increasing AHW problems and a decline of functionality (Rodenburg and Turner, 2012). While the death of an animal indicates an irreversible breakdown of adaptation, clinical signs of diseases, with different degrees of severity, often precede death. Primarily depending on the gap, the responses tend to be either adaptive and promote overall fitness or non-adaptive and variously increase the risk of becoming ill or dying, emphasising the ambivalent nature of stress.

Sensitivity to well-being and the perception of threats are highly individual (self-referential), depending, amongst other things, on size, ranking order, or gender. Animals take advantage of past experiences to prepare for potential challenges and ameliorate them before they occur (Ramsay and Woods, 2016). Behaviours, e.g. avoiding the aggressions of dominant animals, are not ends in themselves but are functionally intended to enable an organism to protect itself and stay alive (Gygax, 2017). Individual learning on the basis of past experience enables anticipatory responses. Correspondingly, an individual animal is the reference system for the appropriateness of the living conditions. The number of possible stressor combinations simultaneously challenging farm animals is infinite. Possible reactions of the animals to the same or different stressors vary greatly due to the large variations in the adaptation capacities. Thus, adaptive success depends not only on the environment as a whole and the responsiveness of the whole organism but on the interactions between both at the individual level (Sundrum, 2015). It is hardly possible to model this process, let alone obtain information that allows for a dependable prediction of outcomes. However, adaptive success can be assessed retrospectively based on the time periods in which an animal was free of signs of production diseases. Even though being disease-free is a necessary but not sufficient condition for well-being, the prevention of diseases associated with pain, suffering, and harm is a sine qua none and has utmost priority when striving for a high level of AHW.

4 Conflicting areas at the farm, regional, and national level

Modern animal production is mainly based on economic principles. A low level of production diseases is not considered an overriding and independent production goal. Instead, diseases are often perceived as an undesirable but apparently unavoidable side-effect of the production processes. The number of animals in a herd completely unable or insufficiently able to cope with their surrounding corresponds with the efforts of management to provide the needed resources and protection measures. Appropriate allocation of resources is essential for both high productivity and minimal level of production diseases. However, such efforts are time-consuming and costly and do not automatically pay out economically. Many farmers are not fully aware of AHW problems on their farms, but many also choose blissful ignorance to avoid their own responsibility in dealing with unpleasant situations for which they see few options (Gigerenzer and Garcia-Retamero, 2017). A problem that is not fully perceived as such and not approached cannot be solved. The fact that failure and preventive costs are production disease-related and strongly affect the economic viability of the farm system is often also ignored (van Soest et al., 2019). Thus, the capability of farm animals to survive, grow, reproduce, and cope with the living conditions play a major role in the sustainability of the livestock system (Blanc et al., 2006). In light of the conflicting aims between productivity and animal protection, where one can suffer to some degree at the expense of the other, an optimal balance between both is the only way forward. However, a self-referential assessment by farmers relying on their own subjective estimations about what might be good for the animals and the sustainability of the farm enterprise is not forward-looking. On the one hand, it is important for farmers to compare cause-effect relationships on their farm with those on other farms. On the other hand, livestock farming is characterised by a wide range of variables and their interconnectedness, affecting animal health and welfare in different ways. Thus, farms are ranging from very poor welfare situations to those where farmers are doing a very good job to protect farm animals from suffering. In general, the level of AHW is largely independent from the performance level (Cook et al., 2015) or the production method (Krieger et al., 2017). This indicates that AHW is an animal protection service which results from the entirety of processes taking place within an individual farm system (Sundrum, 2018). To provide animal protection services, farm managers must ensure that living conditions are adapted to the needs of each animal to prevent excessive strain on their adaptability, which would lead to disturbed animal health and behaviour. Thus, valid statements require a systemic, functional, and result-oriented approach.

A scale ranging from very low to very high mortality rate and prevalence of production diseases in relation to the performance service per farm unit provides orientation. Whether intrinsically motivated or forced by economic reasons, farm management needs to know where and how to direct its efforts and allocate available resources. While production is easily quantifiable, the success of animal protection is not, or at least only by the degree of maladaptation in the form of mortality and morbidity rates in a farm system.

Accordingly, farmers should strive for the optimum balance between production and animal protection. The degree of the quality of animal protection could be categorised and communicated to retailers and consumers. Benchmarking would offer an appropriate approach to provide orientation when establishing farm-specific target figures and simultaneously deal with the issue of unfair competition. The current lack of benchmarking of farm services can be seen as one of the main barriers to fair competition and investment in the improvement of AHW.

5 Role of animal science

One task of science is to seek facts and provide understanding. Different groups of scientists coming to opposing conclusions on the basis of the same facts contradicts scientific principles. Such contradictions would be expected to lead to a fundamental scientific dispute. However, this does not seem to be the case in agricultural and animal science. An expounding example related to the current issue is given by Fraser (2008); here, different groups of prominent scientists reviewed scientific literature about the welfare of sows in gestation stalls and delivered contradicting recommendations. This addresses a dilemma that threatens 'to throw animal welfare science into disarray'. According to Fraser (2008), 'different scientists adopted the different value-based views of animal welfare – basic health and functioning, natural living, and affective states – as the rationale for different scientific approaches to assessing and improving animal welfare'.

Science is certainly not completely value-free, and scientists are not free of self-interest as they compete for research funding. Experts necessarily perceive problems and solutions from within their professional paradigms. They are incapable of forming judgements beyond their specific expertise (Millgram, 2015). The question is not whether but to what degree their perspectives and self-interests influence their conclusions. Scientists have their own discipline-born perspective; impartiality and objectivity oblige them to listen to other views and by so doing create inter-subjectivity. Only in this way can conflicting interests become transparent and understandable and the search for a balance between different interests initiated. However, scientists' primary interest is not necessarily dispute but rather the search for consistency within their own fields. The challenge for scientists is to put aside self-interest and strive for impartiality, independence, and unbiased views. As far as the author is aware, interdisciplinary dispute seldom takes place within agricultural and animal science.

The Welfare Quality® Project, funded by the EU Commission, is the most ambitious attempt at interdisciplinary discourse concerning animal welfare. About 44 scientific institutions from different countries and disciplines were involved (Welfare Quality Network, 2009). It has created species-specific protocols to assess animal welfare at the farm level. Although the attempt is honourable, the results are not convincing for various reasons. The protocols are the result of a compromise to include all criteria agreed to be AHW-relevant by the involved scientists and pragmatic aspects striving for repeatable assessment results on AHW in the stable. The concept necessarily excludes other perspectives, thus revealing a self-referential anthropomorphic approach. The approach follows the perspectives of selected scientific disciplines but disregards both the inherent aim of animals to survive and the self-referential assessment of animals on their well-being in any given situation.

While the AHW-relevant criteria mentioned above are essential for assessments and decisions made by farm management, it should not be disregarded that they only indicate rather than explain the underlying processes. The selection of those criteria implies that other aspects of the problem under study are ignored. This applies to both animal- and farm-related criteria, such as enhanced minimum standards. It logically follows that selected criteria often have insufficient explanatory and no predictive power for overarching aims. Selection of criteria touches upon a core problem of biology (Cassirer, 2000): the 'part-whole-problem'. Within an organism, the different parts and subsystems are not separate from each other but are self- and mutually reinforcing and work together towards the same goal: to keep the organism alive. There is no part that does not need the support and cooperation of nearly all other parts. Consequently, an organism cannot be fully understood without considering the purpose behind the biological processes. Adaptation is a functional and target-oriented process involving the whole organism. Correspondingly, behaviour and emotional states are not ends in themselves but a means to an end. Whether an organism adequately responds to challenges cannot be deduced from single parts. The same applies to the farm system, within which each subsystem is embedded (Sundrum, 2015). The entirety of the system can only be understood through the inherent purpose of the system.

Whether processes are beneficial or not depends primarily on the context in which they take place. Thus, they cannot follow a one-size-fits-all approach but require context-specific external validation. The same is true for the options of balancing the trade-offs between economic interests and AHW in a cost-effective manner. The Welfare Quality concept does not cover the conflicting aims between production and animal protection services and disregards their high relevance for the economic viability of the farm and management decisions.

Thus, it is not able to provide action-guiding knowledge as its approach towards AHW loses sight of the whole and disregards the inherent goals of organisms and farm systems. The functional and teleological approach is not considered with regard to the AHW issue, whereas animal science has adopted this approach when striving for the predominating goal of increasing productivity, although without explicitly naming or acknowledging it.

6 Possible solution

AHW problems arise from overstressing the capacity of farm animals to adapt to farm-specific living conditions. The extent of the problem is directly linked to the lack of efforts by farm management to adequately provide individually required resources and protection. Despite being legally responsible for ensuring appropriate living conditions for farm animals, many farmers are themselves overstrained by the fundamental conflict between the goals of economic viability for the farm system and high levels of AHW. As long as various stakeholder groups (legislators, retailers, consumer, farmer organisations, and, last but not least, scientists) classify mortality and production diseases as undesired but unavoidable negative side effects of production processes, thereby placing responsibility solely on farm management, there is no chance of achieving broad-scope improvements in the field of AHW. Above all, to balance economic and health conflicts in animal husbandry, a low prevalence of mortality and production diseases must first be seen as a separate production goal and then aligned with performance goals so that AHW and performance become a comprehensive production goal.

AHW problems are always context-variant, depending, among other factors, on the hygienic conditions, the degree of genetic selection for high productivity, the specific quality of the offered diet in relation to the genetic production capacity, the individual feed intake, as well as the individual capacity to deal with the gap between supply and demand. Thus, there is a need for a deductive approach, e.g. one that involves first gaining an overview of the degree of the gap between demand and supply and then identifying the predominant weak points in the farm-specific context. Those in charge need to be able to estimate the degree of AHW problems and the need for action in relation to other farms (orientation knowledge). Furthermore, the most influencing factors involved in the multifactorial processes, as well as estimations about the most effective and efficient strategies to overcome problems, have to be identified in the farm-specific context (action knowledge). Farmers are challenged to reduce the biological system overload and the degree of trade-offs.

In the past, intensive selection for increased meat, milk, and egg production has taken place, resulting in substantial increases in productivity and simultaneously causing undesirable side effects with respect to AHW problems in farm animals (Rauw et al., 1998). If genetic selection focuses only on increasing production of meat, milk, and eggs, there is a clear risk of increasing welfare problems related to high production levels, such as mastitis in dairy cows, cardiovascular diseases in broilers, or behavioural problems such as feather pecking and cannibalism in response to fear- and stress-inducing stimuli (Rodenburg and Turner, 2012). Correspondingly, farm-specific breeding goals have to consider the quality of available nutrients and the adaptation capacity of the farm animals in relation to the farm-specific living conditions (Sundrum, 2019).

7 Conclusion

The lack of substantial improvements of AHW problems is not the primary responsibility of animal science. The stagnation is, among other things, a result of missing guidelines and request profiles regarding the level of AHW for farmers and the relentless cheap-price policy in the production chain of food of animal origin. Nevertheless, in light of the long-lasting unsatisfying situation, animal scientists are challenged to reflect on the reasons behind the lack of implementation of scientific knowledge and their own role in the context of livestock production. The unilateral objective of increasing performance is still predominant. Without an extension of the one-sided disciplinary foci in animal science there will be no progress in AHW. All efforts to design future animal production should be redirected to reach the overarching goal of a sufficient productivity level in direct combination with low mortality and prevalence of production diseases. The generation of scientific knowledge with the primary focus on details under standardised experimental conditions is not enough. It is widely disregarding the context and the conflicts between various interests and is not sufficiently suited to solve AHW problems in farm practice. Scientific knowledge requires external validation in the farm-specific context in which the AHW problems emerge. Coping with biotic and abiotic environmental threats and changing living conditions is a performance of the whole organism. Survival without health impairments is the strongest criteria for successful adaptation and a high level of AHW. At the farm level, the rate of mortality and prevalence of production diseases reflect the animal protection service of farm management and the performance of the whole farm system in AHW. The performance in AHW cannot be traced back to single measures. It is resulting from the interconnectedness of various factors whose roles can only be estimated and understood retrospectively in a systemic approach.

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POSITION PAPER

The need for an 'animal ethics turn' in animal husbandry

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In the following paper I argue that there is an urgent need for an 'animal ethics turn' in animal husbandry. There are various reasons for this demand, such as the negative impact of livestock farming on climate change and the fact that current animal protection laws only address minimum standards of animal welfare, which, in some cases, are systematically violated. Some animal ethics approaches such as abolitionism argue that the only moral solution is to completely renounce the use of animals as resources or products. The present paper, however, represents an animal welfare position. It rejects the reduction of animals to a mere means for human purposes as morally offensive and unacceptable. This does not mean to reject the use of animals in any form as ethically objectionable, but demands that humans should always respect animals' pursuit of a flourishing life by responding positively to their species-specific and individual needs and capabilities.

1 Introduction: two examples

a) While attending 'International Green Week 2017' in Berlin, the Catholic Archbishop of Berlin, Heiner Koch, sharply criticised the poor conditions in large-scale livestock farming (Öhler, 2017). He reprimanded pig farmers whose animals never see daylight, who treat the creatures like industrial mass-market goods and slaughter them under cruel conditions. The cattle breeders who brutally violate their animals by transporting them over thousands of kilometres throughout Europe and beyond. In response to this incisive statement, Koch generated a huge number of counter-reactions from farmers' representatives. Finally, the then Federal Agricultural Minister, Christian Schmidt, felt compelled to declare: "With all due respect to the voice of the Church, food production deserves to be considered and discussed in a restrained way. I am, therefore, very surprised at some of the statements. I expect care for our animals, but also for our farmers."[2] Koch reacted somewhat meekly and said that he was aware that the vast majority of farmers would carry out their work with great awareness of their responsibility towards God's creation and thus also towards the animals.

b) On 15 March 2019, the Ulm District Court sentenced a pig farmer from Merklingen in Baden-Württemberg to three years' imprisonment without probation (Herrmann, 2019; ZEIT Online, 2019). According to the court's ruling, several hundred pigs had died as a result of the poor housing conditions or had to be killed on the instructions of the veterinary office due to their acute injuries. Altogether, over 1,600 pigs died on the farm. The 56-year-old defendant is said to have killed two injured animals with a sledgehammer. The poor conditions of animal husbandry on the farm were uncovered in 2016 by an animal protection association. Activists had filmed the animals on the farm. The proceedings against

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them were suspended after a fine of 100 Euros was paid. The farm was closed. The court based its judgment on the argument that in this particular case of detected animal cruelty, protecting animal welfare weighed more heavily than protection against trespassing. An interesting marginal detail revealed that the pig farmer's produce had previously been sold EU-wide using various quality seals, for example, 'quality produce from Baden-Württemberg' and 'animal welfare approved'. The Federal Agriculture Minister Julia Klöckner commented on the Ulm District Court ruling: "Our animal protection laws do not constitute a suggested quality threshold; they are there to be complied with. Anyone who treats animals as though they are merely a commodity, lets them die in desolate conditions or torments them should not be allowed to keep animals. And it is right that those who torture animals and do not obey our laws are punished. Farmers who do not treat their animals properly harm not only the animals, but the entire profession, and there are many farmers who behave in an exemplary manner."

These two examples serve to illustrate the same problem. The livestock farming conditions that Koch reprimanded were neither invented nor exaggerated but correspond to a wide-spread reality. It is also noticeable that farmers' associations usually demonstrate an almost knee-jerk defensive response in line with their policies; either they deny the issue entirely or they defend the farmers by lauding their personal ethos and efforts in guaranteeing animal welfare standards.

In my opinion, many farmers do indeed try to ensure the welfare and health of their animals, but often the concrete conditions and economic constraints do not permit appropriate animal husbandry. The economic output required for a farm to make a profitable income is often at the cost of the health and welfare of livestock. The discussion is often confined to the question of the correct interpretation and enforcement of legal procedures whilst disregarding the question of ethics. Legal requirements are largely based on minimum standards. There are, however, also cases of overt pain and death-provoking cruelty to animals as the second example shows.

This introduction has already named a number of aspects which demonstrate the complexity of the issues within livestock farming. I believe there is an urgent requirement for reform in agriculture. My two main reasons for this are outlined below: the impact of livestock on climate change and animal ethical requirements. The focus of this position paper will be on the second aspect.

2 Impact of livestock on climate change

According to the latest studies, intensive agriculture and industrialised livestock farming account for up to 24% of annual greenhouse gas emissions worldwide – particularly methane and nitrous oxide – and are thus significantly responsible for global climate change (PIK, 2016; Stevanović et al., 2017; Grossi et al., 2019). Furthermore, the livestock sector requires a significant amount of natural resources. An estimated 1.5 billion cattle and domestic buffalo, 15 billion poultry and nearly 1 billion pigs are kept worldwide for human consumption. To feed these animals, huge areas of rainforest are cleared or burned. Soil degradation contributes significantly to global emissions of carbon dioxide. The production of feed, which is often transported between continents, requires enormous amounts of energy and synthetic fertilisers. Soil degradation, loss of biodiversity, and the pollution of soil, water and air are some of the serious consequences. Finally, orientation towards the criterion of economic efficiency largely ignores animal welfare (Gottwald and Boergen, 2014). In order to radically change this system and to avoid environmental trade-offs, there is a need for effective strategies and complex interactions. One aspect is the urgency to establish an animal ethics standpoint. An 'animal ethics turn' in livestock would lead to the reduction of animal numbers in farming and, therefore, change the use of land in many regions, which would consequently represent a significant climate change mitigation (Havlík et al., 2014; Stevanović et al., 2017).

3 The 'animal turn' in our society and animal welfare in animal husbandry

There is currently an ambiguous trend in our society. On the one hand, a so-called 'animal turn' can be observed, i.e. an increasing scholarly interest in animals, their abilities and functions, the relationships between human and non-human animals, and in the role and status of animals in modern human society (Ritvo, 2007). Even a new scientific discipline has been established: Human-Animal Studies (Kompatscher et al., 2017). On the other hand, although we know much more than former generations about the behaviours, needs, requirements, and sensitive, emotional and cognitive abilities of animals, as well as how to keep and farm different animal species appropriately, the economic efficiency of livestock farming is in great conflict with the goals of animal welfare. Livestock farming is mainly orientated towards economic efficiency and compatibility with technical systems. In other words, the technical systems in livestock farming are not adapted to the basic species-specific needs and behavioural patterns of animals, but rather the opposite.

To clarify, this is not only a problem for farming, but also for trade and consumer behaviour. Wholesale and retail trade as well as consumers are indeed co-responsible for the way animals are kept, treated and slaughtered. Owing to the market dynamics of supply and demand, by buying animal products, distributors, retailers and consumers not only implicitly approve of, but directly co-finance how these products are produced on farms and are treated at auctions, in transit and at abattoirs. Analogous to the basic principles of fair trade, it is therefore a matter of sensitising the producers (farmers, butchers, and so on), distributors, retailers and consumers of animal products to the ethical concerns of dealing with animals, and of motivating them to treat animals fairly. Within the complex system of economics, no single party is able to change things for the better by working in isolation. Therefore, there is a need for strong collaboration between all parties. At the same time, there is a need to overcome widespread practices within the livestock industry that still violate existing animal protection laws. In order to reduce painful mutilation in livestock farming and to prevent, for instance, tail-docking pigs, castration without pain management, disbudding calves, sheep and goats without anesthesia or analgesia, etc., animal welfare legislation has been enacted and certain non-legislative initiatives implemented. These include the Council of Europe's recommendations concerning cattle (1988) and national cattle welfare legislation in single EU member states as well as various initiatives of NGOs (Spoolder et al., 2016). Although significant effort has been undertaken and steps have been taken so as to ban painful methods of mutilation and to improve animal welfare, there are still several deficiencies in how these measures are implemented (Spoolder et al., 2016; Schröder, 2019; Goldschalt, 2020). For instance, the EU-Directive 120/2008/EC laying down minimum standards for the protection of pigs still isn't respected in most member states (Nalon and Briyne, 2019). Also the "2010 European Declaration initiated by the EU Commission on the voluntary end of the painful castration throughout Europe by 2012 did not have a measurable effect. And even the German legal deadline of ending castration without anaesthesia, which was set by the German Welfare Act for the 31.12.2018, has been postponed by the German government" (Blaha, 2019) at least until 2021. Furthermore, even where legal requirements are observed, they often only represent the minimum acceptable standards for livestock and, therefore, insufficiently protect animal welfare. At the same time, improving legislation in the field of animal welfare would require more effective systems for verifying legal compliance and punishments for violating the law. This can only be achieved if the concern is upheld by society as a whole, including all aforementioned parties.

3.1 Basic animal-ethical aspects

What does 'treating animals fairly' mean? There are many animal ethics approaches ranging from animal protection and welfare positions to animal rights concepts (Grimm and Wild, 2016; Schmitz, 2017). A strong animal rights stance would argue that justice for animals means stopping using them altogether as resources and products and, therefore, claim that animals should not be used at all by humans. Abolitionism, for instance, represents such an approach, maintaining that on the basis of the principle of equal consideration, all sentient beings – independent of cognitive abilities – share the basic pre-legal right not to be treated as the property of others (Francione, 2000; Francione and Charlton, 2015). Contractarians, based on the theory of justice by John Rawls, argue that animals must be considered as members of the moral community in the hypothetical scenario of an original position where no moral or political principles have been accepted as yet, but need to be found and agreed behind a 'veil of ignorance', i.e. not knowing in which status of gender, race, age, intelligence, wealth, skills, education, religion and species one will be part of the contractual community (Rowlands, 2009; Rosenberger, 2015). These authors, however, go beyond Rawls' position. He said that the basic condition for taking part as a member of the original hypothetical scenario is that a member must be able to comprehend and embrace a contract, to agree freely and to act morally. Rowland and others argue that there is nothing in contractarianism that requires the contract be restricted to rational agents only.

To explain and discuss adequately and comprehensively all the different animal ethics approaches would go beyond the scope of the present paper (for this see e.g. Moling, 2017; Lintner, 2018). I prefer to support an animal welfare stance, which, on the one hand, does not reject the use of animals as ethically objectionable but, on the other hand, clearly recognises the status of animals as moral patients. I, therefore, argue that we have moral obligations towards the welfare of animals, especially of those whose living conditions depend on us or are somehow affected by our way of life. Although it was doubted for a long time, animals actually have emotions and feelings and experience pleasure as pleasant and pain, stress and fear as unpleasant. Furthermore, different hormones in animals can be associated with the neuronal correlates of these emotions. This scientific knowledge and empiric evidence is of moral relevance for our treatment of animals. It is a question of hermeneutical interpretation of the given reality and of moral insights, meaning that inflicting pain on a sentient being is recognised as morally bad, while supporting a flourishing life is morally good. Furthermore, every animal – independently of whether it is a sentient or a non-sentient animal – strives naturally for a flourishing life lived according to species-specific needs and capabilities (Nussbaum, 2006). To respect the pursuit of a flourishing life can be understood as a demand to respect a being according to its species-specific and individual capabilities, in order not to hinder, but rather to allow and even actively promote a flourishing life, especially if it concerns domesticated animals that depend on humans.

On the one hand, to respect this natural pursuit and these different capabilities allows us to ascertain whether an animal is sentient or non-sentient, for example, and on the other hand, to use animals only if, we are both willing to respect and satisfy their basic needs, and to respect and enable their capabilities. Therefore, my position regarding animal ethics can be summarised in the following imperative: "Act in such a way that you never treat an animal merely as a means to an end, but that, at the same time, you always respect both its species-specific needs as well as its sensitive, emotional and cognitive capabilities" (Lintner, 2017).

As Kant says in his categorical imperative even humans can be used as means to an end, but 'never merely' as such. They should always be treated at the same time as an end in themselves. While for humans this means respect for moral self-determination, where non-human animals are concerned – according to the present paper – it means respect for their striving for a flourishing life and, therefore, to consider their species-specific needs as well as their sensitive, emotional and cognitive capabilities. Only if we are willing to respect these needs and capabilities to the best of our abilities, and to respond to them as effectively as possible, are we allowed to use animals for human ends. Although it may not be possible to completely satisfy all the needs and to bring all the capabilities to full development, no need or capability may be suppressed or violated in such a way and to such a degree that the general welfare and health of an animal be neglected or permanently affected (Lintner, 2020).

The following are the most important needs of animals, among others: eating and drinking; defecating; refuge; rest and sleep; social, territorial and aggression behaviour; social grooming; reproduction and rearing of offspring; caring behaviour (Röhrs, 2000). Once again: although it may not be possible to completely satisfy all their needs, no need should be suppressed or violated in such a way and to such a degree that the general welfare, physical fitness and health of an animal are neglected or permanently affected. Practices such as culling day-old chickens, killing cows with mastitis, fattening cattle such as Belgian Blues or broilers, and so on, should be ethically rejected under this perspective because they simply do not ensure, but rather impede, any animal welfare. Conversely, according to the presented approach, it would be ethically justifiable to keep cattle in sheds and housing systems if they permit and guarantee the welfare and health of the animals. In this respect, since healthy animals with good welfare are the most efficient means for production, ethical standards should be of fundamental interest to farmers. Further, by responding to the needs of animals they prevent reducing them to mere means, although – paradoxically – the use of animals as a resource still remains the purpose.

3.2 Animal welfare as essential aspect of sustainable agriculture management

The Farm Animal Welfare Committee (FAWC), an independent advisory body established by the UK Government, started with these 'five freedoms' – basic and vital needs formulated as minimum standards – in order to guarantee animal welfare that implies both physical fitness and a sense of wellbeing: "freedom from hunger and thirst, by ready access to water and a diet to maintain health and vigour; freedom from discomfort, by providing an appropriate environment; freedom from pain, injury and disease, by prevention or rapid diagnosis and treatment; freedom to express normal behaviour, by providing sufficient space, proper facilities and appropriate company of the animal's own kind; freedom from fear and distress, by ensuring conditions and treatment, which avoid mental suffering" (FAWC, 2009: 2).

Even though this 'five freedoms-principle' was formulated already in 1992 (at the basis of the 'Brambell-Report' on the parliamentary enquiry into the Welfare of Livestock kept under Intensive Conditions in the UK 1965) and updated in 1992, it still "offers a useful and practical approach to the study of welfare and, especially, to its assessment on livestock farms and during the transport and slaughter of farm animals" (Manteca et al., 2012: 1). But despite the clear usefulness of this principle, it is far from being implemented on the ground in livestock farming and slaughterhouses.

Furthermore, there are other approaches and projects that aim to guarantee animal welfare. Worthy of mention is the Welfare Quality® project, a five-year European Union research project launched in May 2004. One of its objectives was to develop European standards for animal welfare assessment, based on an animal-oriented parameter system. This objective has been adopted as well by the Welfare Quality Network.

In March 2015, the Scientific Advisory Board on Agricultural Policy (WBA) at the Federal Ministry of Food and Agriculture (BMEL) published a report on 'Pathways to a socially accepted livestock husbandry in Germany'. In the field of animal welfare, the WBA formulated the following points as guidelines for the development of viable livestock husbandry accepted by large parts of the population: "(1) access of all livestock to various climate zones, preferably including outdoor climate; (2) provision of different functional areas with various floor coverings; (3) provision of installations, substances and incentives for species-specific activities, feed in-take and grooming activities; (4) provision of sufficient space; (5) a halt to amputations; (6) routine farm self-inspections based on animal-related animal welfare indicators; (7) a clear reduction in the use of medicinal products; (8) improved level of education, knowledge and motivation of people working in the livestock sector; (9) and greater consideration of functional characteristics in breeding" (WBA, 2015).

A final project that should be mentioned is the 'Dairy Sustainability tool'. This is a scientifically based system that can be used to gather facts about the sustainability of milk production throughout Germany. In this system, animal welfare represents – together with economics, ecology, and social issues – a key criterion for sustainability that is also of relevance to milk production. Animal welfare here is understood in the sense of properly addressing animal needs in order to ensure the health and wellbeing of the cows (Flint et al., 2016; QM-Milch, n.d.).

These examples reflect that animal welfare has become an essential aspect of sustainable management in agriculture. The above-mentioned projects also show that there is not a lack of approaches. However, there is still a lack of application and implementation of animal-welfare measures.

4 Some practical measures

As shown above, the problem in question is complex, and therefore needs various measures and solutions on different levels. The 'animal turn' concept that originated in science, humanities and society regarding the relationship between humans and animals, as well as the role and significance of animals for humans, must have an effective impact on animal ethics in livestock farming. The following are predominantly suggestions for possible measures which aim to reduce the negative impact of livestock on climate change, to establish effective measures to protect the agri-environment and to improve animal welfare conditions in farming.

- Animal welfare requires a forum in which frank communication takes place between farmers, butchers, manufacturers, retailers and consumers of animal products.
- Farmers must communicate openly regarding their endeavours to act responsibly when working with livestock. Improvements in animal welfare can only be achieved by working with farmers while recognising their legitimate financial interests.
- The reduction of meat consumption is inevitable because the high rate of annual per capita meat consumption – e.g. 60 kg in Germany (BLE, 2019; Ritchie and Roser,

2017) – makes intensive livestock farming necessary. There needs to be a general willingness from everyone to reduce his/her meat consumption.

- Following the 'polluter pays-principle', animal products from intensive agriculture and industrialised livestock farming must increase in price through a kind of 'punitive tax' for environmental damage. The income coming from this taxation must be used for the specific purpose of agri-environment measures and precautions as well as for animal welfare projects in farming.
- The increased costs of these products would reduce the actual price gap between these products and animal products from ecological and organic farming with high standards in animal welfare. The lower price difference would render expensive organic product lines and advertising strategies unnecessary. The effect would be a price reduction in organic animal products so that they would be more attractive for consumers from an economic point of view.
- Animal products should be subject to mandatory labelling to include information on the product's origin, the type of farming used, type of livestock keeping used and its ecological footprint.
- In order to promote greater trust among consumers of animal products, farmers should voluntarily adopt a greater willingness to be clear and transparent about how they farm and keep their livestock.
- Wholesalers, retailers and consumers also have to accept more responsibility for animal welfare by obtaining up-to-date information on a product's origin, type of farming and type of livestock keeping, and by being prepared to pay a fair price for organically farmed products and animal products with guaranteed animal welfare labelling.
- Finally, there is a need for legislative measures. The legislation regarding livestock farming issues – including standards for transport and slaughter – should be aimed unequivocally at animal welfare. The above mentioned 'five freedoms' should serve as minimum standards.
- There must be a legal duty to respect these basic freedoms in any pursuit of farming interests in order to respond to the vital needs of farm animals and to promote their physical wellbeing and health.

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POSITION PAPER

Paradigm shift in livestock farming

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1 Problem: The market is leading livestock farming in the wrong direction

Most countries globally have made the decision to allow agriculture and food production to be managed within the context of private ownership and a market economy. Markets are interwoven globally. This has sent out important signals: Farmers are competing on a global scale, and those who do not succeed in increasing their farm's productivity in the future will sooner or later be replaced, whether by a competitor from their own village or from a foreign country.

This competition has driven livestock farmers to continuously strive for productivity increases. The performance of their animals is constantly on the rise, and ever fewer resources (feed, work hours, capital) are allocated per kilo of meat, milk or egg. On the one hand, high resource efficiency helps to alleviate pressure on the natural environment. While on the other hand, it leads to lower prices for the consumer, which increases consumption and has an additional impact on the environment. Over the last 50 years (1967–2017), this has led to worldwide meat consumption increasing by 262 %, while the global population grew by 117 % during the same period (FAOSTAT, www.fao.org/faostat/en; own calculations).

This is a conclusive development within the market economy. It makes animal protein a cost-effective food source for the world's population. However, more and more people are speaking up about the negative external effects of this trend. Their concerns are primarily around environmental and animal protection issues.

On the one hand, negative environmental effects exist on a regional level, since livestock farming is known to have a high local concentration in many countries. In these regions, more excrement and nutrients occur than the locally grown crops can absorb. Transporting slurry to other areas in uneconomical, because they have access to inexpensive mineral nitrogen. On the other hand, many are questioning whether, on a global level, the combination of high population growth and high individual consumption of animal food products necessarily leads to a failure to reach the Sustainable Development Goals. Currently, livestock farming is responsible for 14.5 % of global anthropogenic greenhouse gas emissions (Gerber et al., 2013).

Negative consequences for animal welfare exist for two reasons: Firstly, focussing on a singular breeding goal of 'high production performance' cause impairments in animal health. Secondly, housing systems that are optimised purely on the basis of cost have a negative effect on animal welfare and health (Fleischer et al., 2001; Brade and Brade, 2015; Oberländer, 2015; Swaby and Gregory, 2012; Sandilands, 2011; WBA, 2015). Such erroneous trends will not be eradicated by directing political appeals at breeding organisations and companies constructing animal houses. As long as farmers continue to demand low-cost housing systems and high-performance livestock as a result of economic pressure, genetics companies and building firms hardly have any choice but to tailor their offering to the farmers' demands.

These issues are not only discussed among academics, but have been dragged into the public sphere over the last

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few years by countless environmental and animal welfare organisations. This is where they have the most resonance. A survey of EU citizens, for example, showed that 82 % of citizens felt that animal protection was currently insufficient (European Commission, 2015). The SocialLab research consortium was interested to find out if this differed according to the type of animal, and discovered that in Germany, the majority of the population felt that the way in which all the major livestock groups were housed required improvement. Where conflicts of interest exist between animal welfare and other sustainability goals, the population voted to give animal welfare the highest priority (SocialLab, 2019).

The default ethical standpoint for the majority of the population can be summarised by the following statement: “As long as animals must die for our food, we should grant them a good life beforehand” (Zühlsdorf et al., 2016). The analysis by Luy (2018) shows that the German Animal Welfare Act has strayed from this default position since its last amendment in 1972: Instead of taking the approach of evaluating animal suffering and animal well being (in the sense of a ‘fair deal’ as the population seems to want), the German Animal Welfare Act emphasises the human advantage by stating that ‘No one may cause an animal pain, suffering or harm without good reason’.

Citizens could fulfil their own desire to improve livestock farming conditions by choosing more expensive animal welfare approved products when shopping. If there is sufficient private-sector demand for animal welfare, the market economy essentially provides the potential to muster up a healthy competition for the best possible solution to this requirement. During scientific analyses, around 80 % of consumers revealed a certain willingness to pay more for animal welfare approved meat (Zühlsdorf et al., 2016). However, in a real life experiment in 18 consumer markets, it was found that even with a moderate price supplement, only around 16 % of consumers who shopped at independent retailers actually chose animal welfare approved pork produce. A further 11 % bought the significantly more expensive organic produce, whereas 73 % bought the lower-priced, standard product (Enneking, 2019). The egg production industry has also had its fair share of experience: After the introduction of compulsory egg labelling in 2004, the market share of the cheapest product group (barn eggs/floor husbandry) was still at 58 % in 2017 (BMEL, 2018).

It cannot be concluded from the actual buying habits of the population that the majority of Germans agree with the current state of livestock farming. The goals the majority of society wish to pursue are determined in parliament, rather than in shops. We don’t do without a climate change policy because only a few people choose to buy “green energy”, and we don't get rid of our development policy because only a small proportion of the population act upon fundraising appeals. People founded states in order to establish common goals and to achieve them efficiently. It is the core purpose of politics to establish compulsory ground rules for the economy, in order to meet the state aims (e.g. animal protection). Politicians cannot simply shed this responsibility by referring it back to individual consumers.

2 Proposed solution: National livestock strategy with three core elements

If society is not satisfied with the results of the market economy, then politicians are required to change the economic ground rules. In Germany, however, the economy has progressed independently by establishing the 'ITW' animal welfare initiative, which is essentially a political concept. The key companies and associations along the food chain have joined forces and agreed that the food corporations voluntarily contribute a total of 130 million Euro per year into a fund (ITW, 2018). Farmers are paid an animal welfare premium (per pig or hen) from this fund for introducing certain measures to improve animal welfare. This premium covers the additional costs of increased animal welfare requirements incurred by the farmers.

The concept corresponds to the policy measures that are normally established to improve animal and environmental protection as part of the second pillar of the common agricultural policy, except that the ITW is financed de facto by the consumer and not by the taxpayer.

The food retail industry is currently in the process of developing the ITW concept even further and introducing a label for the type of housing used. Tier 1 indicates the legal standard, tier 2 the ITW standard and tiers 3 and 4 the higher standards. Representatives from large retailers intimate that they intend to drop the legal standard in the foreseeable future. By revealing this publicly, they are putting pressure on themselves, at least in terms of easily identifiable products, but less so for mixed products such as pizza. They will have to pay a price supplement when buying tier 2 products, which is sufficiently high enough for the farmers to cover the cost differential between tiers 1 and 2. During negotiations, the farmers have successfully negotiated for the financial compensation to be paid as a separate animal welfare premium, which they can calculate with assurance, rather than in the form of higher prices.

In parallel, the German Federal Government has come up with a national animal welfare labelling system. This system also has a tiered structure, although with different tier descriptions and criteria. It is intended to be optional for businesses to adopt this system or not. At this point, it is almost impossible to predict how the two concepts will coexist.

In terms of animal welfare politics, it is important that in both systems, the market will lead the majority of production to be established just above the legal standards (tier 2) and that many businesses still remain in tier 1. In this case, consumers above all will feel good about mainly buying “animal welfare approved” products, but the population as a whole will be disappointed to realise after a few years that animal welfare has only gradually improved, rather than fundamentally. The goal of social acceptance in livestock farming will not be achieved in this way (Isermeyer, 2019).

Egg production is an instructive example of this: In 2004, an EU-wide labelling system was introduced for egg production. This led to so-called ’eggs from caged hens’ disappearing from the supermarkets. Furthermore, the market became dominated by the next cheapest alternative: barn eggs. Meanwhile, under the constant price pressure, no suitable housing solution had yet been successful in satisfactorily meeting the animal welfare standards (Thobe and Isermeyer, 2019).

These findings do not contradict the need for a labelling system. They highlight the need for politics and business to be clear that labelling is above all a means to protect the consumer: It enables interested consumers to understand how the animals were kept while they were alive. The fact that animal welfare approved products now form a lucrative market segment is merely a positive side effect and no more. If society wants the whole livestock sector rather than just a 'leading segment' to operate at a higher level of animal welfare, then its goal will not be achieved by a labelling system (Isermeyer, 2019).

In this case, it would be necessary to offer an animal welfare premium for all livestock farms achieving a higher animal welfare standard. According to the estimations of the German Scientific Advisory Board on Agricultural Policy, Food and Consumer Health Protection (WBA, 2015), 3 to 5 billion Euro per year need to be paid for the transformation of the German livestock sector. A sum of this magnitude cannot be made available as a 'voluntary contribution' by the food retailers as with the ITW principle, but requires a legal basis and funding from the government. During the actual implementation (operational auditing, etc.) of a government-funded scheme, it would make sense to incorporate the experience and organisational requirements set up by the ITW.

Various concepts are being discussed for reciprocal financing of the animal welfare premium. One approach could be to impose an 'animal welfare tax' on all animal products. From the farmers' point of view, this option has the advantage that the average revenue would need to be implemented specifically for animal welfare policy purposes, enabling more reliable planning. From an administrative standpoint, it would be easier to incorporate it into VAT regulations. Until now, consumers have paid a lower VAT rate of 7 % on all food. If it were decided to increase the VAT on animal food products to the standard rate of 19 % in future, an additional 6 billion Euro per year approximately would be generated for public funds (Isermeyer, 2019). However, a financial concept is only one of the three main areas of work required to set the – still market-driven – livestock sector on a new course towards higher levels of animal welfare.

The second area of work is around developing housing systems for all types of animal, which (a) work in practice, (b) have moderate additional costs, and (c) achieve good results in terms of animal welfare and emissions. This will not be achievable through the usual research funding and tender invitation procedures. An 'orchestrated' integrated concept is required, which will enable a few dozen test housing systems to be erected on farms, accompanied by the work of scientific institutions. During the design phase, both national and state-level as well as scientific, economic and civil society representatives should be involved from the beginning (DAFA, 2019).

The third area of work relates to amendments to building and environmental regulations. Under the current legal framework, many redevelopment measures (e.g. redeveloping warm housing for pigs into an open-front shed) would not receive approval. The challenge lies in amending approvals regulations to (a) improve regional distribution of livestock farms over time and (b) provide evidence of acceptable emissions ratings in the sheds that have been built.

Regulatory law will undoubtedly also need to be amended in area of animal welfare. Due care must be taken, however according to the way grants are currently handled in the EU. An animal welfare premium may only be paid for animal welfare performance which lies above the legal standard. Making the national standard stricter would lead to lower premiums, and livestock farming being moved abroad as a result. Germany should therefore campaign for a change to the regulation on an EU level: A national animal welfare premium should compensate the total cost difference between (a) a production system that achieves the desired animal welfare performance and (b) a production system that fulfils the European Union minimum standard. As long as this is not yet achieved, the only way out for the German political system would be to only threaten to make animal protection provisions stricter at a later point in time (Isermeyer, 2019).

Above all, two fundamental questions remain to be answered by politicians: Shall we lead the entire national livestock sector away from cost minimisation paths, which are induced by the global market economy? And if yes, what target levels do we want to work towards? Unless the German Bundestag decides to clearly address these two questions, the livestock policy will remain fragmented. The goal of achieving social acceptance in livestock farming will thus remain out of reach.

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POSITION PAPER

Evolution in animal husbandry – fitting animals, fitting systems, or fitting farmers? The role and agency of animal farmers in designing future animal production systems

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1 Animal farming today

Ethical concerns for the welfare of animals kept in intensive production systems and related environmental impacts are prominent among European citizens and are also rising in emerging economies (Fraser, 2014). At the same time, the consumers' preferences for low-cost animal products remain high, leading to an "attitude-behaviour gap" that manifests in a "meat paradox" (Oleschuk et al., 2019) and a "milk paradox" (Wellbrock et al., 2019). This ambiguity creates a field of tension for animal farmers (Wellbrock and Knierim, 2019; SocialLab, 2019), which was recently also politically acknowledged by the German Federal Agricultural Minister Julia Klöckner. She summarised the expectations of the public as follows: "[F]armers should keep animals under the best conditions, but hardly anyone wants to pay more for it. Most people want to feel like eating meat from animals that have never been slaughtered … [T]he creeping bad conscience is usually dumped solely on the farmer" (Klöckner, 2019; translation of the authors). Apparently, there are considerable mismatches between current animal production systems and socially acceptable forms of animal production (BMEL, 2019), and it is argued that the German agricultural system is at a turning point, transitioning from the traditional to the modern (Klöckner, 2019).

The 'traditional-modern' transition anticipated in Germany leads away from the productivist mindset that has guided production over the past 70 years in the EU and the US (Clay et al., 2019) and has created super-productivist rural areas (Mackay and Perkins, 2019). It leads towards a post-productivist form of agriculture supported by a post-modern society, in which animals are increasingly perceived as sentient beings with feelings and individuality rather than as resources or food (Buller and Morris, 2003). At the same time, this transition contrasts the 'traditional-modern' transition in developing countries, where intensive milk, pork, and poultry production systems are increasing in number in order to satisfy the demand for animal products of the growing middle class (FAO/OECD, 2019). What both transitions have in common is that they entail financial and structural insecurities for animal producers because they create an ambiguous socio-economic environment with contradictory production incentives; what farmers would need instead is reliable policy and market frameworks to develop meaningful, long-term production strategies (BMEL, 2019).

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We therefore argue that the role and agency of animal farmers need to be placed at the centre of attention when aiming for a sustainable transition towards socio-culturally acceptable animal husbandry. Following this line of thought, we use empirical findings of the global North and South to illustrate three areas of tension for animal farmers and explore the ethical dimensions of the farmers' agency.

2 Animal husbandry practices

For farmers, livestock has an ambivalent character, being composed of sentient beings and a natural resource at the same time (Gotter, 2018; SocialLab, 2019). Thus, they are operating within a highly ambiguous human-animal relationship, in which subjectively perceived personal values and feelings contrast with objectively verifiable economic and production-oriented results (Jürgens, 2008). This ambiguity leads, for example, to a caring-killing paradox (Reeve et al., 2005) and to a morally difficult behaviour representing a conflict between a person's moral values and their behaviour, which is nevertheless justified to protect their interests (Loughnan et al., 2014). An extreme case of such an ethical conflict is bobby calves and their economically (almost) useless life in intensive dairy production. It was shown in a study analysing online comments that dairy farmers oppose such handling of male dairy calves, despite facing the entrepreneurial challenge (Wellbrock and Knierim, 2019). Individual farmers everywhere try to develop and implement strategies for sustainable animal husbandry in harmony with animal welfare and their own ethical understanding (e.g. suckler-cow herds, double-purpose breeds). However, they often come up against political and market boundaries, so that alternatives remain niche solutions.

3 Rural development

Intensification has created high-intensity, productivist, and even super-productivist landscapes in many regions of the world (Wilson and Burton, 2015). In emerging economies, the evolution of super-productivist landscapes is particularly prominent, characterised by highly intensive production methods and transportation of products over long distances. Super-productivism results in great environmental, social, and economic damage of the rural area they are situated in (Wilson and Burton, 2015). Arguably, the livelihoods of animal peasant farmers, which make up 70 % of the rural poor (FAO/OECD, 2019), are put at particularly high risk through super-productivism as they cannot compete with the associated output quantity and low-cost production. The increasing post-modern view of animals as sentient beings, in Europe as well as emerging economies (e.g. Boogaard et al., 2011; Wellbrock et al., 2019; Cardoso et al., 2018), opens new opportunities for post-productivist forms of animal production, promoting integration of animal production into rural landscapes through alternative, down-scaled, and multifunctional forms of agriculture (Clay et al., 2019). What is needed is research on how to anchor animal production sites regionally, adapt husbandry conditions to the landscape, and link them with other economic sectors such as tourism and services. Focusing on the education, cooperation, and market integration of peasant, small-scale, and multifunctional farmers may in the long-term create more socio-culturally sustainable animal farming systems than investing in large-scale, multinational, and highly industrial agglomerates. Careful consideration of local circumstances is necessary to create production systems that fit the socio-cultural and economic specificity of their place of production.

4 Changing social values

The SocialLab Konsortium (2019) argues that consumers and citizens in Germany paint a picture of 'museum-agriculture' that depicts a romanticised vision of human-animal interactions and the profession of the animal producer. This, as is argued further, is contrasted by reality, in which animal producers keep animals for economic profit and where animal farms are larger than imagined (SocialLab, 2019). At the same time, citizens become more concerned about health issues related to the consumption of animal products and the environmental effects animal production has on the environment and climate. Similarly, in Colombia (Wellbrock et al., 2019), as well as the US, Brazil, and other European countries, citizens prefer extensive, small-scale animal production systems over large-scale industrial production systems. To close such framing gaps between consumers and producers and overcome ethical and value conflicts, it is necessary to develop joint visions and and create dialogue for future animal production systems that are supported by animal farmers as well as consumers and citizens. In Germany and other European countries, farmers have started numerous initiatives to initiate dialogue with the wider society using a range of online and offline communication tools. These include social media channels, blogs, live web-cams, as well as organising farm visits and initiating face-to-face dialogue with non-farming citizens (e.g. 'Ask a Farmer' booths at public fairs). These initiatives help to close the gap between consumers and producers and open doors for dialogue, discussions, and the creation of joint visions.

5 Conclusions

With respect to political interventions, it has become obvious that tensions around animal production systems need to be addressed with an integrative approach in order to achieve socio-cultural sustainability. In practice, sustainable animal production systems are developed by and with farmers and thus, must reflect farmers' roles and agencies as perceived by them and enacted in the social contexts they are situated in, reflecting the values and culture of the society they produce for. The transition to sustainable husbandry systems may thus be facilitated by government policy which supports farmer-led innovation of animal production systems.

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OPEN ACCESS

POSITION PAPER

Lack of knowledge does not justify a lack of action: the case for animal welfare in farmed fish

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1 Description of the problem

Nowadays, 50 % of the world's fish for consumption already originate from aquaculture farms. Predictions indicate that this number will increase to approximately 65 % (Monaco and Prouzet, 2015), which is equivalent to 90 to 100 million metric tons per year by 2030 (World Bank, 2013). Rising production levels are often associated with increased intensification and larger environmental footprints, putting aquaculture at the centre of public debates regarding sustainability and animal welfare. Welfare debates about fish are often focused around one specific question: Whether fish are capable of suffering or experiencing pain, and if so, to what extent. This question addresses the cognitive and mental capacities of fish, which are currently topics of intensive scientific debates (Key, 2016; Browman et al., 2019). Hence, the number of studies and peer-reviewed publications about animal welfare specifically related to aquaculture-reared species has increased significantly over the last decade, indicating the political and public awareness of the topic (Huntingford et al., 2012). However, the scientific study of welfare in farmed fish is still at an early stage compared to that of terrestrial livestock (Huntingford et al., 2006).

It should be noted, that the group of organisms named 'fish' is often treated as a group of animals from the same species. 'Fish', however, comprise organisms from various taxonomic groups and a large number of species, which account for around 60 % of all vertebrate species (Nelson et al., 2016). They inhabit all aquatic ecosystems and each species has developed particular adaptations to living in their particular habitat. Therefore, anatomical structures, physiological traits and behavioral patterns vary greatly between different fish species according to their taxonomic group, and as a perfect adaptation to the conditions of a particular habitat. This enormous diversity has to be regarded when drawing conclusions about 'fish' and each respective species grown in aquaculture.

Whether or not pain perception in fish should remain unproven, and even if it proves to be unexperienceable in fish, there is sufficient assignable evidence to justify the same level of animal welfare in farmed fish as in terrestrial livestock. Recent studies have been able to demonstrate that some fish are capable of solving problems (Balcombe, 2016), using tools (Bernardi, 2012) and learning and deploying avoidance behaviour (Yue et al., 2004; Dunlop and Laming, 2006). Certain specimens have even passed self-awareness tests (Kohda et al., 2019). Fish show physiological and behavioral stress responses that are in some way similar to those in mammals. Accordingly, the European general public expects animal welfare to be generally safeguarded during the rearing and slaughtering of fish.

This article aims to provide an overview by summarising the prevailing scientific opinion from the field of welfare research in aquaculture within the framework of this issue.

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2 Possible solutions

2.1 Evaluating physiological and nutritional demands of farmed fish

Living in water largely determines the body structure, physiology and behaviour of fish. Water is in intimate contact with their gills and skin, therefore its physical and chemical properties directly influence fish physiology. In particular, water temperature, oxygen, carbon dioxide, ammonium and nitrate concentrations may have a direct effect on fish physiology.

In general, fish can adapt to a range of water parameters, however, when their capacity for adaptation is exceeded, fish may suffer from physiological or pathological disorders, which may result in a stress response. The level at which abiotic parameters exceed the adaptive capacity of fish depends on the species and life stage of the fish. When tolerance levels are defined, interactions with water parameters must also be taken into account. Hence, during rearing, water parameters should be monitored and matched to the specific requirements of the fish species being raised. Feeding rates and feed composition must be determined in relation to fish size and species requirements to optimise dietary intake, health, growth, feed conversion and fecundity. The nutritional requirements of the fish species must be properly addressed.

In particular, when new feed ingredients are introduced, such as proteins or lipids of plant or insect origin, the bioavailability of micronutrients and the absence of anti-nutritional factors must be ensured. In general, feed should be provided daily and adapted to the system used in order to reduce the aggressive behaviour of fish when competing for feed. Since feed availability is sometimes limited in the wild, fish have developed various behavioural and physiological adaptations to reduce metabolism during feed deprivation. During routine production procedures such as transport, sorting, stocking and slaughter, short periods of feed deprivation allow clearance of the gut. This reduces fecal contamination of the water, thus improving sanitary conditions. It also reduces the oxygen demand, CO_2 and ammonia excretion of the fish, which helps to maintain water quality during the management procedures.

2.2 Evaluating the ecological and behavioural demands of farmed fish

As mentioned previously, fish cannot simply be compared across species and taxonomic groups. Each species has different ecological and behavioural demands, and varying physiological capacities. Some fish live singularly or territorially for most of the year, while others form large schools. Certain species live in benthic habitats or seek shelter in caves, rocks, corals and aquatic plants, while others inhabit and seek their prey in the open water column. All of these characteristics may alternate depending on the life stage of the fish (juvenile, subadult and adult specimens).

Accordingly, husbandry methods, rearing conditions and stocking density should reflect these specific demands. In general, each fish species should be kept in accordance with their natural behaviours and within a beneficial social structure. The level of domestication in fish species is also known to enhance general husbandry practices, species-appropriate breeding and animal welfare. Trait-specific breeding programmes can enhance growth characteristics and feed conversion, but also immune competence and stress resilience, making fish more adaptive to husbandry methods. When rearing different species in polyculture, care must be taken to ensure that these are compatible in terms of water quality and parameters, as well as social and predatory behaviour. This also holds true for species reared communally for management reasons such as the control of sea lice (e.g. cleaner fish in salmon cages).

2.3 Evaluating rearing systems and husbandry techniques

As highlighted previously, different species of fish have different ecological needs and have adapted to a wide range of conditions and habitats throughout evolution. The types of rearing systems currently applied are limited, and can be classified roughly as ponds, tanks, troughs and net cages of various sizes and materials. With the exception of earthen ponds, these systems are all artificial and barren rearing environments.

The heterogeneity of fish certainly creates the need for further adaptions of rearing systems to fulfill specific natural demands. Environmental enrichment, though critically debated among the aquaculture community, might help to adapt aquaculture rearing systems to species-specific requirements (Näslund and Johnsson, 2016). Feasibility of added substrates and enrichment strategies have yet to be studied more thoroughly, but there are promising initial results regarding their effects on welfare (e.g. Batzina and Karakatsouli, 2012; Batzina et al., 2014). Indeed, enrichment goes beyond the addition of substrates or structures; it also includes the presence or alteration of flow, shade, cover, shelter and hideouts. Naturally, these measures must be incorporated while taking into account hygiene management and the practicability of daily working routines.

In addition to rearing systems, many common aquaculture working routines also have scope for improvement. While natural adaptations and physiological capacities enable some species to do well, even under rough husbandry conditions, others are much more delicate and require special measures. Behavioural abnormalities detected visually or by means of automated alarm systems may indicate suboptimal husbandry conditions way before welfare is put at risk. This also holds true for altered behavioural patterns following certain hatchery techniques, which would indicate that these measures should be evaluated and potentially improved. With regard to evaluation and improvement, staff carrying out daily working routines must be involved in the process first and foremost, so that it may be continuously developed and refined.

2.4 Evaluating staff training, competence and performance

Many of the current cases of poor animal welfare and even animal cruelty in terrestrial farm animals have resulted from poor staff competence, performance and motivation. Staff competence can easily be assured through vocational training, and can be permanently maintained at a high level through continuing education, training and qualification programmes. Such programmes are offered by a variety of different organisations, from government bodies and chambers of agriculture to private consultants.

Staff involved in fish rearing and production must be aware of welfare-related objectives and should receive additional training on welfare-related issues (Segner et al., 2019). Motivation is often closely related to salary, general work atmosphere and a feeling of appreciation. All three are known to increase employee performance and engagement, which directly affect animal welfare. Owners and staff must possess fundamental knowledge about the species-specific needs (see points 2.1, 2.2, 2.3 of this article) of the fish under their care (Council of Europe, 2005).

Without experienced and well-trained staff, cases of poor fish welfare may remain undetected or may be detected too late (Segner et al., 2019).

2.5 Evaluating and monitoring the state of welfare in farmed fish

The public debate surrounding the extent to which animal welfare is safeguarded in livestock farming is extremely controversial. The available information on the state of welfare of reared fish is minimal, especially in aquaculture operations. In order to make reliable statements about the state of animal welfare in fish, a regularly scheduled monitoring system should be established. The system should be based on reliable, valid and practically feasible indicators. The indicators should be specified for each monitored species and surveyed by trained staff at regular intervals. Data on animal-related, resource-related and management-related indicators must be systematically collected. Arlinghaus et al. (2009) suggest that such welfare indicators should focus on objectively measurable items such as behaviour, physiology, growth, fecundity, health and stress. Finally, the collected data on animal welfare in farmed fish should be made publicly available.

Using such data, positive and/or negative trends on the state of welfare in farmed fish can be monitored in the long term. Furthermore, the results of measures and activities initiated for the improvement of fish welfare can be evaluated.

2.6 If in doubt: actions should reflect the code of best knowledge and practice!

In order to safeguard fish welfare, any aquaculture practices or measures should – as a minimum – reflect the possibility that some fish could be capable of experiencing emotions and suffering, just as terrestrial livestock animals (Braithwaite, 2010), and be in accordance with ethical standards (Mackensen, 2011). All welfare-related work and tasks should reflect this and be performed in accordance with the code of best knowledge and practice.

3 Conclusion

Animal welfare is a fundamental societal choice, which commences well before suffering or pain. The welfare of animals under human care starts with the most basic aspects: feed, care and husbandry methods. Accordingly, the debate about whether fish are capable of experiencing suffering or pain should not be considered the pivotal issue in a welfare context. Although understanding the pain perception and suffering capacity of fish is important, it must be considered independently. Welfare should extend beyond this point and include the entire quality of life of the fish. Husbandry and production methods should be led by the biological requirements of fish in addition to public demands, rather than solely economic principles or scientific debates.

Additionally, the growing body of recent scientific findings indicates that fish in aquaculture facilities should be given the same protection as currently afforded to terrestrial livestock. They are all animals under human care. It must be ensured that aquaculture operations follow public ethical opinion and demands in addition to incorporating the necessary regulatory measures and legal frameworks. All participants will ultimately benefit, since good standards in fish welfare will safeguard product quality and healthy foods, which generate maximum revenue and consumer acceptance.

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POSITION PAPER

The relevance of feed diversity and choice in nutrition of ruminant livestock

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In this position paper, we argue that the realisation of forage diversity and feed choice for ruminant livestock should be considered as an essential aspect of animal welfare because selection from an array of different plants is an important experience for such animals. We provide examples that diet balancing with regard to nutrients and plant secondary metabolites is particularly for ruminants so much essential that this ability must be a deeply rooted cognitive and behavioural predisposition. In this context, we assume feed choice to be a behavioural need of ruminants. Therefore, we argue in favour of nutritional concepts, which account for botanical and biochemical diversity and are based on behavioural research approaches. We provide a brief outlook of potential research topics, which we consider important if the societal target of animal welfare is to be reached in European ruminant production systems.

1 Feeding as part of animal welfare

Animal welfare cannot be defined only by the absence of distress like fear, pain, hunger, and disease; it also must include the presence of certain stimuli, including eustress (Villalba and Manteca, 2019), and the opportunity to express key species-specific behaviour (Fraser et al., 2013). The latter is realised in many livestock systems to a very limited degree or not at all. Degrees of freedom in social and reproductive behaviour are extremely low, as is the range of movement and the opportunity to explore the environment compared to situations in wildlife for the same species. A further aspect of behaviour, which appears to be underestimated in its meaning to animals in agriculture, is feed selection, including the experience of taste, smell, exploration, and choice. Using ruminants as an example, the presented position paper argues that feed choice could be a fundamental physiological and behavioural need of herbivores. Therefore, neglecting it in contemporary feeding schemes would imply a serious violation of welfare.

2 Biological background

In their natural feeding behaviour, animals do not primarily optimise the ratio of spent over gained energy. They often rather prefer to explore and to search for less easily accessible feed (Inglis et al., 1997), select not only nutrients but also bioactive plant compounds (Villalba et al., 2010), and thereby maintain diurnal rhythms (Rutter, 2010) and balance metabolic processes (Villalba et al., 2010). There appear to be several evolutionary reasons for the development of such behaviour. For herbivores, the balancing of their diets by combining feed plants with different nutrient profiles is essential for digestive efficiency and metabolic health. Since these nutrient profiles change with phenological stage, the animals have to be able to adapt their behaviour continuously (Westoby, 1978). However, the challenge is not only

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to balance nutrients like proteins and carbohydrates. Herbivores also have to avoid or select potential toxins in certain situations, e.g. when they are needed in low dosages in order to control diseases or metabolic processes (Villalba et al., 2010; Poli et al., 2018). For ruminant livestock, this has also a veterinary aspect (Walkenhorst et al., 2020).

Diet balancing (Westoby, 1978) and targeted selection for or against specific secondary plant metabolites have a further dimension in ruminants: control of the foregut fermentation process. The rumen microbiome is sensible to diet characteristics regarding degradability of carbohydrates as well as energy to protein balances (Snelling et al., 2019), but also concerning bioactive compounds such as saponins (Goel et al., 2008) and polyphenols (Vasta et al., 2019). Balance of nutrients (including their ruminal degradability) is important in order to avoid inefficient utilisation of protein or energy but also to prevent collapse of the rumen, for instance, by rumen acidosis or bloat. However, there are also other differentiated balances, which the ruminant has to maintain in the foregut, for instance in order to protect essential plant metabolites from ruminal degradation. One illustrious example is linolenic acid, which is the only relevant source of omega-3 fatty acid configuration for herbivores. More than 95 % of ingested linolenic acid, which is essential for many functions in the mammal organism (Sinclair et al., 2002), may be lost by derivatisation in the rumen (Chilliard et al., 2007). Given this example, it is our hypothesis that a foregut-fermenting species must by all means ensure that the microbiome in their stomach is balanced so that not too much of essential plant nutrients are degraded or modified and lost. One effective instrument for the animal to control the rumen microflora are bioactive secondary plant compounds (e.g. essential oils, phenols, alkaloids) with antimicrobial properties (Vasta et al., 2019). Experimental evidence shows that dietary secondary plant compounds can protect linolenic acid in the rumen (Vasta et al., 2019), which results in increased linolenic acid concentrations in milk (Kälber et al., 2011), muscle and adipose tissue (Willems et al., 2014). The case of linolenic acid is an example that shows the importance of rumen control by finely dosed ingestion of secondary plant metabolites. We hypothesize that this requires a highly differentiated feed selection ability of the ruminant. The concept of nutrient balancing (Westoby, 1978) must therefore take into account these substances, also considering the trade-off with fermentation efficiency in the rumen, which makes the task for the (wild) ruminant even more challenging.

3 Does feed choice have an emotional implication?

Nutrients, as well as secondary plant metabolites, possess odour and taste properties, such as sweet, bitter, astringent, or sharp but also specifically aromatic (Wichtl, 2009). A neuronal relation between metabolic needs for (or excess of) certain substances and the odour and taste experience is therefore strongly developed in ruminants (Ginane et al., 2011). A sensory feedback, based on genetic determination (Clauss et al., 2010), epigenetic effects (Wiedmeier et al., 2012), and individual experience (Villalba and Manteca, 2019) influences dosed selection or refusal of nutrients and bioactive plant compounds ingested from the natural forage environment in which ruminants have evolved. We should consider that the ability to translate metabolic needs into flavour-guided differentiation of herbal biomass must be deeply rooted in the ruminants' behaviour because it is a precondition of their survival and evolution. This ability is expressed in various examples of self-medication in ruminants (Villalba et al., 2010; Poli et al., 2018). A further aspect of selective eating behaviour is diurnal alteration in preferences as described by Rutter (2010), who found that ruminants decrease their preference for protein-rich forage during the course of the day. Another study demonstrated high sensibility of the diurnal eating and rumination rhythm of dairy cows to even small changes in monotonous mixed rations (Leiber et al., 2015). It seems likely that ruminants are able and show a behavioural need to influence their "gut feeling" in accordance with their sensory feedback by actively choosing not only the composition but also time, duration, and amount of intake.

Diet selection by ruminants has thus at least three interrelated levels of implication: (i) the physiological need for selection, (ii) the translational processes, which connect physiological needs with sensorial experience and action, and (iii) the emotional importance for the animal to display a differentiated explorative behaviour in challenging environments (reviewed by Villalba and Manteca, 2019). We consider the emotional level of behavioural experience to be possibly so much important that the deprivation from feed selection may have a highly negative impact, even if all nutrients and phytochemicals are provided in a perfect diet. If animal nutrition does only account for the molecular composition of diets in order to elevate nutrient efficiency to the max, we must assume that the better the nutritionists work, the worse it will be for the animal as a being which needs to have varying sensorial experience. Scientists, which have worked on selection behaviour of ruminants, have clearly stated the possibility of frustration and poor welfare if feed choice is not possible (Rutter, 2010; Villalba et al., 2010). This implies that the standardisation of feed rations for ruminants, commonly used in most European dairy production systems, including organic, impairs welfare and neglects the principle of enabling species-specific behaviour in livestock husbandry in a rather severe way.

4 A paradigm-shift for ruminant nutrition concepts

"Even after thousands of years of domestication, livestock appear to retain at least some of the survival traits that evolved in their ancestors. Rather than ignore these evolutionary traits, we should endeavour to consider them when designing livestock management systems" (Rutter, 2010).

In the light of the above-mentioned considerations, a paradigm shift in agricultural ruminant nutrition is needed with the primary intention to include the animals' feeding behaviour as an integrative aspect into the concepts for livestock nutrition. The discussion on whether it must become compulsory to diversify and enrich the diets of ruminants and give them opportunities for choice is of particular importance in organic agriculture striving for high animal welfare. How this can be realised largely depends on factors such as farmland resources, animal productivity levels, and trade-off considerations with sustainability issues.

From a researcher's point of view, we need a new feeding recommendation system, which regards the feeding behaviour of animals as a welfare issue. Also, feeding behaviour should be systematically used as an evaluation tool for metabolic needs of the animals, in particular in terms of phytochemicals. This requires a large range of new research, including systematic evaluation of behavioural and metabolic responses of animals to forage plants rich in secondary metabolites and offered separately or integrated into new sward mixtures. Basic research is needed in order to reach a new understanding of ruminant requirements in a dynamic interaction between animal phenotypes and botanical environments (which include barn feeding), respecting temporal patterns of intake and feed choice.

In applied research, practical solutions for the realisation of feed diversity need to be developed and introduced into teaching materials and production standards. Access to pasture swards with high botanical diversity is surely the most direct way to achieve such goals. However, also for winter feeding and for permanent indoor systems, it would be necessary to develop options of forage diversification (more plant species, introduction of browse, sequential offers of different feed qualities, offers on choice). In concentrated feeds, phenol-rich components like buckwheat, spices, or specific oilseeds, but also all kinds of by-products, could be considered. The main target of developments for the practice should be to enable animals to choose their feed or at least to offer feed in sequential variation. On the forage production level, we also need to develop practical solutions for achieving higher diversity (botanical, phenological, biochemical) because the existing knowledge is not yet broadly applicable to agricultural systems.

Depending on different production systems (low-input, high-input, organic, etc.) different approaches are needed to realise feed diversity. If we consider the aforementioned importance of feed diversity for animal welfare, we must also reassess production systems where high milk yields are achieved only on the basis of highly designed diets, which apparently do not provide deliberate feed choices or at least varying feed offers. The question of where diversity and choice can be integrated into diets of high-yielding cows should be an open topic of research. Nonetheless, what we demand is to shift the idea of a perfect diet away from an engineer's work targeted at maximal performance of the ruminal fermentation chamber towards a cooperation project between the researcher, the farmer and the cow with the aim of an optimal balance of the processes in the foregut (Leiber, 2014). Clearly, our approach is much more directed to natural low-input rather than high-input diets. Since the continuation of arable crop inputs into dairy and beef production is challenged for reasons of sustainability (Schader et al., 2015), our suggestion includes a general critique towards high-performance strategies with cattle. Returning to more natural feeding systems would consequently also include changes in breeding goals towards genotypes better adapted to regionally available resources (Bieber et al., 2019).

5 Conclusion

There is evidence that feed selection behaviour has such high importance for the cognitive well-being of ruminants that access to feed diversity should be a compulsory criterion of welfare. Under this paradigm, always feeding total mixed rations would be no longer acceptable, and new feeding concepts that take into account diversity of feeds are required. It appears that a more natural feeding concept for ruminants can result in several positive effects. Besides the animal welfare and health aspect of more diverse feed and natural feeding, the suggested approach could also result in higher biodiversity of pastures and feed crops, as a positive side-effect. Last but not least, product quality also increases when ruminants receive diverse types of forage with high proportions of herbs. We must therefore pay more attention to these aspects, in practice, in research, and in standards, in particular in the context of organic agriculture.

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POSITION PAPER

One calf per cow and year – not a sensible goal for high-yielding cows from either an economic or an animal welfare perspective

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KEYWORDS **calving interval, lactation period, first service conception rate, animal welfare, economics**

1 Problem description

Modern dairy cows deliver a very high performance, which manifests in high daily milk yields all the way through to dry-off. While many farmers are able to successfully minimise cows' metabolic loads during the early weeks of lactation through good transition management, the postpartum (pp.) risk of ketosis, abomasal displacement and mastitis remains high, among others due to cows' immune systems being impaired post calving. This raises questions such as: Do we need to have each cow have a calf each and every year, or does this in fact drive restocking rates up? Can we deliberately delay the timing of artificial insemination, or will this result in reduced pregnancy rates? Will these cows then gain excessive weight towards the end of lactation?

When artificial insemination was introduced, maximal calving intervals were used for determining insemination times. In the early 1970s, Liebenberg (1974) stated that "the calving interval should be about one year". At the time, cows produced about 3,500 kg milk per lactation, i.e. less than half of today's yields. With increasing milk production, it was often no longer possible to remain within this recommended timeframe, and a period of 400 days was consequently determined to be the maximum for good herd-level fertility. "Good" and "poor" fertility management continues to be defined on the basis of this parameter (among others) even today. "Cow fertility deteriorates" with increasing performance. But does fertility actually deteriorate, or does it merely adapt more closely to biological processes? Is it a disadvantage if cows become pregnant again later after calving? From an economic point of view, it was previously accepted – and continues to be widely accepted even today – that each day above a calving interval (CI) of 400 days costs farmers between 2.50 Euro and 3.75 Euro (Lührmann, 2013; Weber, 2019). These numbers were calculated from the herd's average daily milk yield and a voluntary waiting period (VWP) of 42 days. However, the result is reversed if one looks beyond the costs per herd milking day and examines the costs per day of life for example. This paper aims to present this revised perspective. Deliberately extending the VWP (i.e. the period after parturition during which cows are not yet to be inseminated) in high-yielding cows allows the lactation curve to be maintained at a significantly higher level. At the same time, the resulting longer lactation (= longer calving interval) means fewer unproductive days per cow and year, i.e. fewer dry cows and more lactating cows on average over the year. Also, this means

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fewer calvings over a cow's lifetime and thus fewer critical periods. Furthermore, lactation persistency, an issue subject to intense discussion among breeders, increases due to delayed insemination alone, resulting in greater milk yields per milking day.

At the State Research Center of Agriculture and Fisheries Mecklenburg-Vorpommern, extended lactation has come to be a major research focus within the context of overall milk production processes. Expected benefits for cows include not only a higher lifetime productivity per day of life and a longer length of productive life, but also reduced morbidity (lower risk of metabolic diseases and fewer calvings per unit of time). Other expected outcomes are lower rates of reproduction with fewer calves, greater calf value and reduced environmental impacts due to smaller numbers of animals reared and the reduced use of antibiotics both in drying cows off (lower milk volumes at dry-off) and at the beginning of lactation.

If, however, calves (e.g. cross-breeds) deliver higher profits than increased milk yields obtained from longer lactation, or if young cattle can be sold at excellent profits, then short calving intervals can make economic sense, as Kaske et al. (2019) explicitly state. Conversely, substantially longer lactation periods can also deliver economic benefits in terms of rates of reproduction, animal welfare and length of productive life in the context of the cow's lifespan or livestock place respectively.

The results presented here are based on data on the functional characteristics of cows in Mecklenburg-Vorpommerian trial herds included in the ProFit programme of the Rinder-Allianz cattle breeding company. The 30 farms included in the programme have been documenting all herd management interventions as well as oestrus and insemination data since 2005. To date, more than 2 million intervention and diagnostic data on over 120,000 German Holstein cows (DH sbt.) have been evaluated. Special investigations were conducted on one of the trial herd farms, where milk samples were taken from 678 DH cows for progesterone analysis. The samples were analysed using an eProCheck® on-farm device manufactured by Minitüb (Boldt et al., 2015). Measurements of progesterone levels in milk have shown that the start of the oestrus cycle after calving is delayed with increased 100-day yields. At the trial farm, which has an average herd yield in excess of 10,000 kg milk per cow and year, corpus luteum activity only started on the 42nd day pp. in 34 % of the cows (*Figure 1*), indicating that the cows would not be able to become pregnant again at this early stage as they are still acyclic. Early insemination would therefore not be expedient.

Investigations of the relationship between the days to first service (interval from calving to first insemination), the services (number of inseminations) per pregnancy and the interval from first to successful insemination conducted on 21,616 DH cows from 28 farms in Mecklenburg-Vorpommern between 2007 and 2015 identified major differences depending on milk production. With 305-day milk yields of up to 7,000 kg, cows should ideally become pregnant again as soon as possible from the 40th day of lactation onwards (*Figure 2*). Earlier, commonly held beliefs that outcomes would be better the sooner cows were inseminated are therefore unsurprising.

Even with yields of 7,000 to 9,000 kg milk, an interval of 40 to 80 days should be allowed to first service in order to minimise both the number of services per pregnancy and the first to successful insemination interval (see *Figure 3*). However,

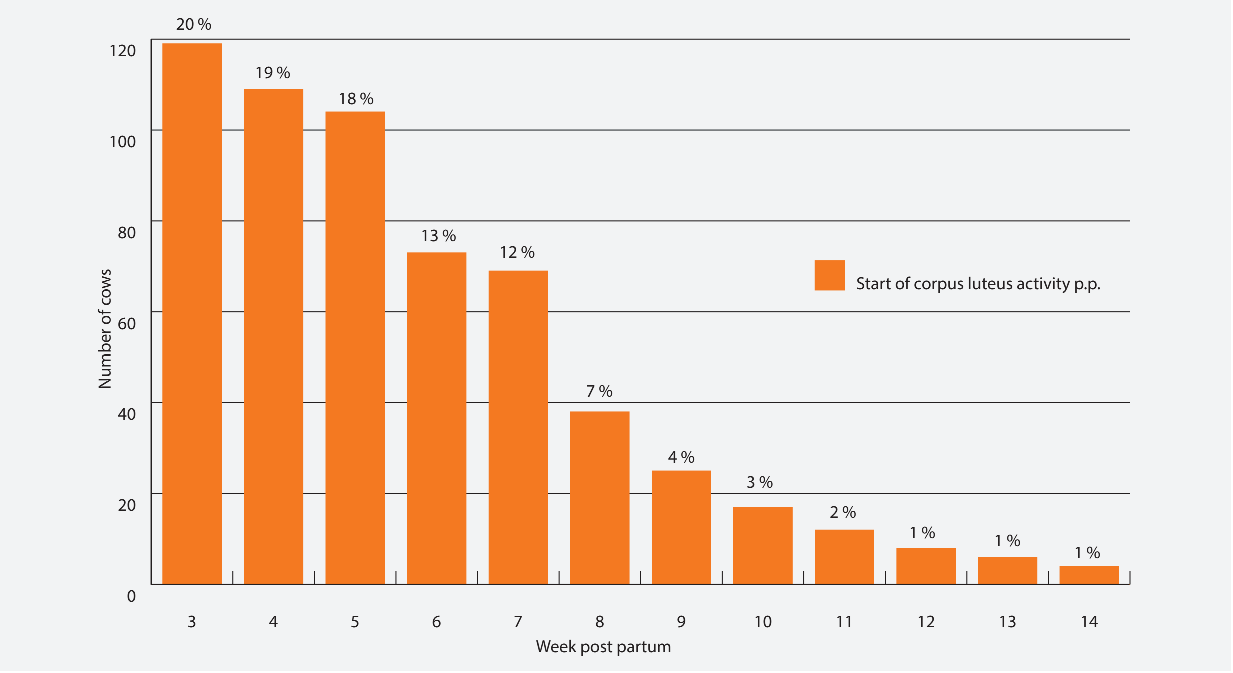

FIGURE 1
Distribution of the start of postpartum oestrous cycle activity based on progesterone levels in the milk of 678 DH cows (Boldt et al., 2015)

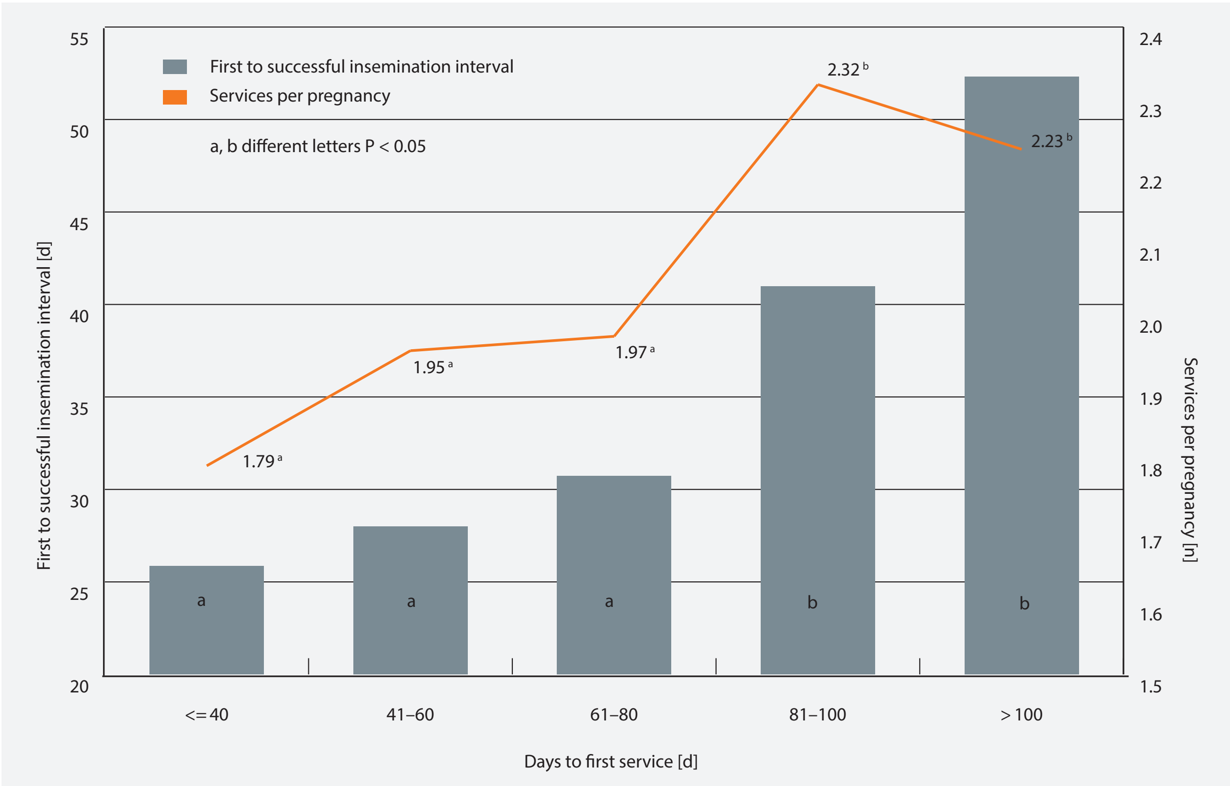

FIGURE 2
First to successful insemination interval and services per pregnancy relative to the days to first service in cows with a milk production of <=7,000 kg; LSMEANS; fixed effects: farm, lactation number, health status, month and year of calving (Röhle, 2016)

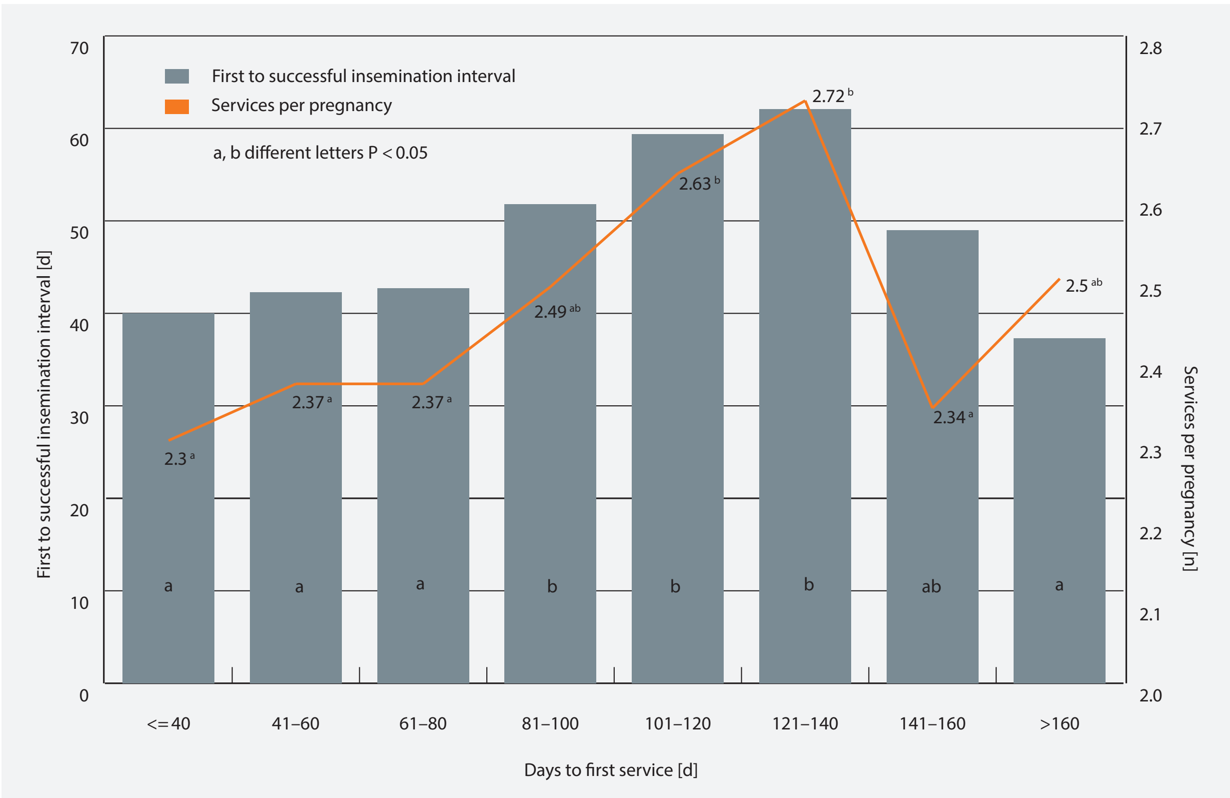

FIGURE 3
Effect of days to first service on the first to successful insemination interval and the number of services per pregnancy in cows yielding 7,001–9,000 kg milk; LSMEANS, fixed effects: farm, lactation number, health status, month and year of calving (Röhle, 2016)

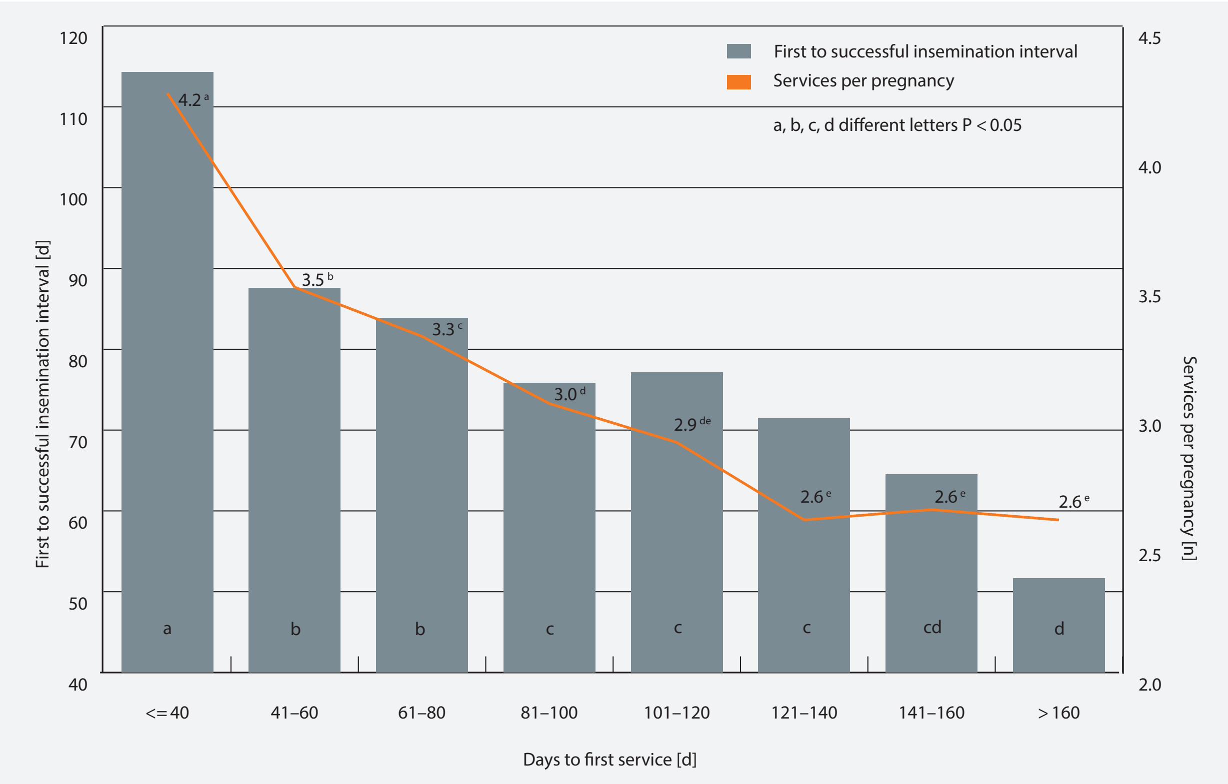

FIGURE 4
First to successful insemination interval and services per pregnancy relative to the days to first service in cows with a milk production of >12,000 kg; LSMEANS; fixed effects: farm, lactation number, health status, month and year of calving (Röhle, 2016)

cows yielding ≥ 12,000 kg milk exhibited the lowest number of services per pregnancy and shortest first to successful insemination interval if they were only inseminated after 120 days pp. (*Figure 4*), and their results were consequently precisely the opposite.

A study from Saxony, where cows were specifically grouped into categories of 40, 120 or 180 days of VWP independently of their milk production, yielded similar results (Niozas et al., 2019). The average herd yield was 11,000 kg. Cows with a 180-day VWP not only produced 1,000 kg more milk in their 305-day milk yield, but also had substantially better heat detection and a first service conception rate of 50 % (vs. 37 % in the cows with a 40-day VWP), and inactive ovaries were found in only 2 % of animals (vs. 16 % in the cows with a 40-day VWP).

2 Possible solution

To date, fertility parameters have consistently been correlated to a single lactation only. Our investigations were aimed at studying cows' length of productive life and fertility holistically. Fewer parturitions with unchanged overall performance could indeed make sense from both an animal welfare and an ethical perspective, as cows stay healthier and live longer. Overall, this should also result in better economic success. Evidence of a longer length of productive life with higher average calving intervals has already been provided (*Figure 5*).

Lifetime efficiency was also highest among cows with calving intervals longer than 430 days. These cows achieved a milk yield per day of life of 16.7 kg, whereas cows calving annually (with a CI of 341 to 370 days) only achieved 15.0 kg milk per day of life.

The economic assessment conducted as part of this study was based on the results of revenue stream analyses carried out on State Research Institute reference farms between 2009 and 2011 (Harms et al., 2018). It should be noted that herd management was generally aimed at minimising calving intervals in these cases. Economic calculations revealed that higher lifetime productivity per day of life is associated with improved contribution margins, even if cows take longer to become pregnant again. Each day added to the calving interval resulted in an increase in lifetime yield by 87 kg ECM and an increase in length of productive life by 2.9 days. These results confirm that cows' performance in conjunction with their length of productive life has a much stronger impact on a herd's profitability than the calving interval, a lower number of calves for sale or a higher number of services per pregnancy. The issue to be clarified is whether there is a sound economic optimum for the calving interval relative to livestock performance. The business calculations performed for this study were based on livestock being classified according to 305-day milk yield. In the yield range up to 9,000 kg, economic success is greatest if cows calve within a period of 340 to 370 days pp.

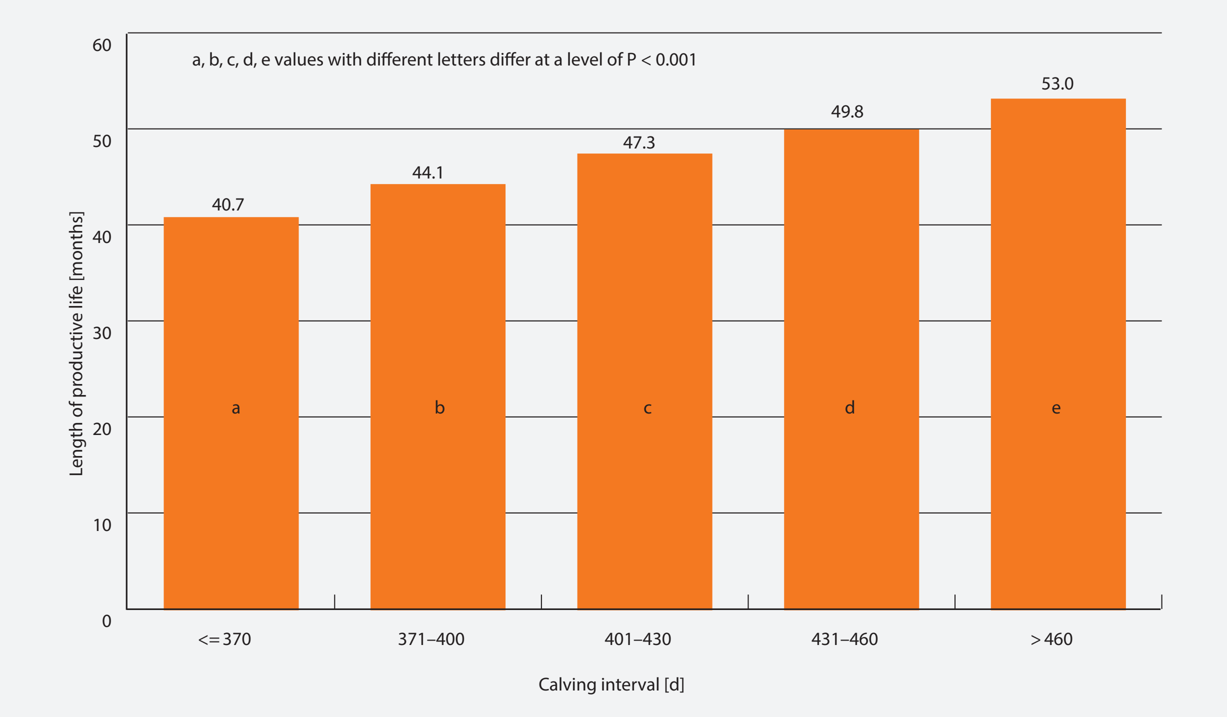

FIGURE 5
Length of productive life of 26,212 culled DH cows with at least 3 lactations relative to the average calving interval; LSMEANS (fixed effects: farm, year of calving, lactation number) (Römer and Boldt, 2019)

TABLE 1
Contribution margin (Euro per place and year) with different calving intervals and milk yields (305–day milk yield) of 26,212 DH cows from 28 farms in Mecklenburg-Vorpommern (Harms et al., 2018)

Milk yield (kg)	Calving interval (days)					
	<340	340–370	371–400	401–430	431–460	>460
<8,000	215	325	308	304	296	294
>8,000–9,000	336	500	463	463	466	398
>9,000–10,000	567	566	572	533	526	459
>10,000–11,000	601	649	674	688	673	569

* Pale green cells indicate the highest contribution margins

Cows with a 305-day yield of up to 10,000 kg are more profitable if they calve again within a period of 371 to 400 days pp. Cows yielding between 10,000 kg and 11,000 kg milk deliver clear financial benefits with calving intervals between 400 and 430 days (*Table 1*).

Investigations from Denmark found the optimal lactation period (+ dry period = calving interval) in terms of productivity and length of productive life to be as long as 490 days, regardless of milk yield (Gaillard et al., 2016). Also the results obtained by Niozas et al. in 2018 and 2019 from a herd producing about 11,000 kg milk clearly show that deliberately extended lactation delivers positive outcomes in terms of both fertility and yields. Individual milk yields were not examined as part of that study.

3 Conclusion

Based on comprehensive data, this study shows that longer calving intervals are not necessarily unprofitable. There is a business optimum for the calving interval depending on individual cows' performance. Cows with 305-day milk yields below 9,000 kg are most profitable if they calve every year. In the yield range up to 10,000 kg, longer pauses of up to two cycles (42 days) result in longer lengths of productive life and deliver higher incomes for farmers. Cows with even higher lactation yields should be given more than 100 days' rest after calving before they are inseminated again. Results from the first milk performance recording allow cows to be allocated to the various yield ranges. However, longer VWPs do not mean that high-yielding cows should be left unobserved. Seamless documentation of all oestruses is essential in order to achieve optimal insemination outcomes after a prolonged VWP, even if not all of the oestruses are used. Deliberately extending lactation requires deliberately delaying the first insemination and must be associated with high milk yield persistency. This can only be achieved if cows have a healthy start to lactation.

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POSITION PAPER

What to do with surplus dairy calves? Welfare, economic, and ethical considerations

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KEYWORDS **bobby calves, dairy bull calves, animal welfare**

1 Description of the problem

The major aim of dairy farming is the production of milk, with the sale of calves and cows of much lesser importance. Thus, it is an enterprise centred on female animals. However, the typical male:female sex ratio of calves born is 50:50, which generates a large number of male calves that are not required on the dairy farms. Additionally, it is estimated that sufficient numbers of replacement females can be produced from 60 % of the lactating herd (de Vries et al., 2008), which means that some of the female calves born on the farm are also surplus to requirements. What to do with these surplus calves, particularly the large number of male calves, has always been a problem in dairying.

There are a number of possible routes for these calves. They may be euthanised on the farm they were born on. They may be reared on that farm for a few days and then transported for slaughter at an abattoir for hides, pet food, or rennet. These calves are known as 'bobby' calves in many countries. Calves may also be reared for veal or beef. Calves destined for veal production are transported to rearer units at approximately eight days of age and slaughtered at about 8 to 10 months of age. Calves reared for beef are typically transported to specialised farms and reared until they reach mature slaughter weight at 18 months or more.

The route for each calf varies between countries depending on the dairying system, calf price, and the consumer preference for veal or beef. In countries where veal is produced, such as the Netherlands, France, and Italy, all surplus calves are used in veal production (Sans and Fontguyon, 2009). However, where there is a viable specialist beef industry and consumers prefer beef to veal, such as in Ireland and the UK, dairy calves may enter the beef rearer system. However, the demand for dairy-bred calves in the beef-rearer market fluctuates according to the number of calves available and the capacity of the beef-rearer farms. For instance, in countries with pasture-based dairying systems, such as Ireland, New Zealand, and Australia, calving occurs almost entirely in the spring. This means that there is a glut of calves at this time, which is more than the beef rearing systems can cope with. Calves may be euthanised on the origin farm soon after birth or sent for slaughter as bobby calves. At other times of the year, they may enter the beef rearing systems. However, in countries such as Sweden and Denmark, with low numbers of specialised beef breed animals, good prices are paid for calves from the dairy herd reared for beef on specialised farms (FVE, 2017).

There are a number of standpoints to consider when trying to decide what is the "right" thing to do with these calves. Firstly, there is the ethical viewpoint that encompasses the societal or personal moral values governing actions and outcomes. There is also the issue of animal welfare to consider. Animal welfare involves the health, basic functioning, and emotional states of animals and their ability to live natural

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lives (Fraser, 2008). There is an important consideration as to whether the animal can achieve "a life worth living" or even "a good life" (FAWC, 2009). There is also the issue of economic sustainability for the farm. The aim of this position paper is to consider each outcome with respect to these standpoints and discuss new options and developments.

1.1 Euthanised on the farm of birth

A large number of male calves are killed soon after birth on the farm they were born on (the origin farm). Statistics are not always available from all countries, but it suggests that up to 22 % of dairy bull calves in the UK (AHDB, 2017) may be euthanised on the origin farm soon after birth. If this is done by a veterinarian or other trained person, and humane methods are used, the welfare of the calf will not be compromised (FVE, 2017). However, if not, slaughter by ill-equipped or fatigued farm staff can have serious implications for calf welfare.

On ethical grounds, however, the creation of unwanted lives in dairying and the ending of lives after a few days are serious concerns that are frequently debated in the media. In terms of economic sustainability, the primary goal of having the cow lactating is achieved via the birth of the calf, and the calf itself is a secondary product. If a good price is not being offered for the calf, early euthanasia may be the only viable option. However, farmers do not like slaughtering calves, so finding a viable market for them is a better option.

1.2 Slaughtered under ten days of age (bobby calves)

As they are low-value animals, they may also not be given good quality housing and treatment on the origin farm during their time there. There are major welfare issues with the transportation, handling, and slaughter of very young calves. Many countries with a bobby calf industry have regulations governing the condition of the animal before transportation and the age at which it can be transported. For instance, in New Zealand, calves must be at least four days of age before they can be transported to the abattoir. Australian regulations require the calf to be five days old. In the EU, calves less than ten days old may only be transported over distances less than 100 km. All countries require calves to be deemed fit for travel. While the mortality rate for the transport of bobby calves is low (0.1 to 0.68 %; MPI, 2017), the transportation and the withholding of feed before transport is likely to be very stressful for these very young animals. A study in New Zealand showed that the calves suffer from dehydration and show signs of scour and respiratory disease (Boulton et al., 2018). This indicates that there are major welfare issues with this use of surplus calves, likely because of the impact of food deprivation and transportation on very young animals.

Economically, the calves have very little value, but the sale of bobby calves is likely to be more cost-effective than euthanasia. Strict legislation could be put in place to safeguard their welfare, but this use of very young calves is unlikely ever to become entirely publicly accepted for ethical reasons, with regular media and public outcries. Again, finding a viable market that allows these calves to be reared to an older age is preferable, as long as welfare is considered.

1.3 Veal calves

Rearing calves for veal or beef production is a viable option, which may gain consumer acceptance if done in a welfare-friendly manner. There are two major types of veal produced in Europe: white veal and pink (or rosé) veal. To produce white veal, the calf is fed predominantly a liquid milk replacer diet and slaughtered at 20 to 26 weeks of age. Calves for pink veal production are fed milk replacer until 8 to 9 weeks of age and then weaned onto a diet that promotes rumen development, which is more typical for a growing calf. However, there are still significant welfare problems associated with the rearing of calves for white veal. The feeding of a predominantly milk diet causes anaemia and other digestive problems associated with feeding milk diet to an animal whose gut should be processing solid feed (EFSA, 2012). EFSA therefore recommends that some solid feed is provided for these calves beyond two weeks of age to allow for the development of healthy rumen function.

There are also issues around the quality of housing provided for these calves. Some producers still house single calves in pens for one to many weeks after their birth. There is growing research showing that isolation is detrimental to the welfare and behavioural development of the calf. When the calves are group-housed, they may not get enough space to sufficiently rest if stocking densities are high (Faerevik et al., 2008). Flooring is also an issue, with concrete and slatted floors causing injuries to the legs (Brscic et al., 2012). In terms of animal welfare, there are clearly concerns about this rearing system, but a good standard of calf welfare can be ensured with good housing, nutrition, and management.

In terms of economics, rearing calves to provide a human food source is a viable use of a "by-product" of the dairy industry. Ethically, this could be seen as a societal good, as long as the animals at least live "a life worth living".

1.4 Rearing surplus dairy calves for beef

Increasing numbers of male and female pure-bred dairy calves and dairy-cross calves are being reared for beef in the UK and Ireland. At least half of the beef produced in England is a product of the dairy herd (AHDB, 2017). Additionally, more calves in traditional veal production areas are being reared for beef than previously (Sans and Fontguyon, 2009). In the UK and Ireland, this form of beef production is being coordinated by specialist companies which have contracts to supply beef to retailers and supermarkets. In this case, calves are procured from dairy farms at 1 to 4 weeks of age and transported to specialist rearer units. The calves may be moved directly from the dairy farm to the rearer if an agreement between the farms exists, or, more typically, they are transported to a collection centre, where batches of calves of a similar age are assembled and then transferred to the rearer units. The calves are initially fed milk replacer and then weaned onto a solid diet. The calves may stay on these units until slaughter or may be transferred at 3 to 6 months to a finishing unit. These calves are affected by a number of health and welfare issues. Firstly, because surplus dairy calves have a low monetary value, the dairy farmer has no vested interest in ensuring that the surplus calves is in prime health and condition even when they are sold to rearer units. The calves may be transported over long distances (between Ireland and Spain, for instance), so it is important to ensure adequate rest, feed, and water during the period of transport. Calves from different farms and from different countries may be mixed together. Calves may then be exposed to diseases to which they have no immunity. Being transported is stressful for calves, which makes them more susceptible to disease. The outcome is that there is often high occurrence of disease in the days after arrival at the rearer unit (Taylor et al., 2010). While the rearing of calves for beef is an ethically good way of utilising surplus calves and an efficient way of producing beef, tight regulations surrounding the transportation and care of the animals and further research into how to limit disease are required.

2 Possible solutions

2.1 Better breeding: sexed semen and choice of sires

The first action that could be taken is to reduce the number of male calves born. This can be achieved through the use of sexed semen. The use of sexed semen in a herd can mean that 90 % of the calves born are female (Holden and Butler, 2018). In the early years of the use of sexed semen, conception rates were low (de Vries et al., 2008). However, in recent years, new technologies for producing sexed semen have substantially improved its fertility (Vishwanath and Moreno, 2018), which should make its use more widespread. Sexed semen is not always available for all bulls, particularly those of high genetic merit. The use of sexed semen will not entirely eliminate the problem of surplus calves, as other strategies are needed to reduce the numbers of unwanted females, but would go a long way to reducing the numbers of unwanted males.

The use of beef sires, such as Wagyu or Aberdeen Angus, in dairy herds would produce both male and female calves that have a higher value for the beef and veal markets (FVE, 2017). Beef-cross calves grow faster and produce a carcass that is more acceptable for the veal and beef market (Coleman et al., 2016).

2.2 Consumer perception and consumer choice

There is a major societal trend toward the use of convenience foods (Kearney, 2010). There is also a greater call for good standards of animal welfare in veal and beef production (EC, 2019). Eating quality beef from dairy-beef calves is equal to that of pure-bred beef animals, although the visual aspects of the meat (yellow fat in Jersey animals, for instance) may be poorer than those of specialist beef breeds (Coleman et al., 2016). However, if the meat from these animals was used in processed food, this would overcome the problem. If beef products that use veal or calves from dairy-bred sources could be manufactured, this would add value to the surplus calves. This would likely improve their care to a higher standard (Sans and Fontguyon, 2009) and would also mean that fewer would be euthanised on origin farms.

If data on the condition of calves on arrival at the abattoir was collected, it could provide valuable feedback to the haulier and farmers to drive improvement. Arguably, the drive for cheap food results in certain classes of animal, such as male calves, having a low value. Educating consumers on animal welfare may result in greater respect for the animal.

2.3 Keeping calves with cows

A system that is comparatively uncommon, but is praised for its high ethical and animal welfare standards, is the practice of keeping calves with their mothers. In this system, the calves are kept with the dam for 3 to 5 months after birth, and then they are weaned. This system allows for the development of a strong cow-calf bond, which has nutritional and behavioural benefits for the calf. Calves reared with their dams have up to three times higher growth rates in the 14 days after birth compared to calves reared without the dam (Flower and Weary, 2001). However, this may be partly due to the practice of feeding separated calves a restricted amount of milk to encourage the consumption of solid feed. Because of the high level of milk intake, dam-reared calves experience a more pronounced growth check once weaned (Fröberg and Lidfors, 2009; Roth et al., 2009), which is also seen in conventionally reared calves on a high milk allowance. Calves reared with their dams show better social response to threats from older cows in situations of aggression (Buchli et al., 2017), suggesting that the system benefits the development of social behaviour. Appropriate social strategies are important in modern dairy farming as cows are often kept in large groups, in indoor spaces which contrasts with the living conditions of their wild counterparts. Dam-reared calves are also more likely to eat novel food types (Costa et al., 2014), engage in more positive behaviours such as social play (e.g. Wagner et al., 2013), and are better at changing learnt patterns of behaviour (Meagher et al., 2015).

There has been some concern about keeping immunologically naive calves with adult cows. The adult cows may be carrying disease, but not showing symptoms, and pass the disease to the calves. A review suggested that there are some studies showing higher levels of disease and some showing no difference (Beaver et al., 2019). This suggests that careful health management is needed, but that disease challenges can be overcome. The high growth rates suggest that beef production can be a viable outcome of cow-calf systems. The product will appeal to consumers with high ethical standards. Little economic analysis of these systems has been carried out, and this is needed to determine whether beef production from these systems is economically viable. However, raising calves in this way is arguably the most ethical and welfare-friendly way of rearing calves for meat production.

3 Conclusions

The large numbers of surplus calves, particularly male calves, killed soon after birth on dairy farms continues to be a major problem. The public is opposed to this practice for ethical reasons, and it therefore poses a major reputational risk to the dairy industry. There are a number of ways to address this problem. Firstly, the use of sexed semen could markedly reduce the number of male calves produced. The use of beef sires in the dairy herd may also increase the demand for and the value of calves from the dairy herd. Secondly, we can find ways to rear these calves for meat production in humane and ethical farming systems. It is unlikely that the public will ever entirely accept the transportation of very young calves for slaughter, so rearing systems of high standards should be promoted. The increasing number of dairy calves being reared for beef is encouraging, but disease and transportation stress issues need to be dealt with. The minority practice of keeping calves with cows has high ethical and welfare value. Full economic analyses are necessary to determine how this system can be adopted more widely.

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RESEARCH ARTICLE

Cow calf contact in dairy herds viewed from the perspectives of calves, cows, humans and the farming system. Farmers' perceptions and experiences related to dam-rearing systems

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HIGHLIGHTS

- **Dam-rearing is practiced in a wealth of different systems.**
- **A study based on research interviews revealed four main perspectives to address, namely those of the calf, the cow, the human, and the farming system.**
- **Dam-rearing contributes to nutrition, care, and learning and meets many aspects of the organic IFOAM principles, particularly regarding fairness.**
- **Farmers need to reorganize the dairy farming system including their own way of viewing their animals in systems, which allow contact between cows and calves.**

KEYWORDS **organic dairy farming, dam-rearing, mother-bonded calf rearing, extended suckling systems, cow-calf contact, farmer practices, farmer experience**

Abstract

A common practice in dairy farming is to remove the calf from its mother a few hours after birth. The public debate on the subject has increased, and views on whether the calf should be allowed to stay with its dam for weeks are debated among citizens, farmers, and advisors. The aim of this article is to present, analyse, and discuss experiences and arguments on dam-rearing of calves through interviews with actors, primarily farmers, involved in organic dairy farming in four European countries. The interviews showed that dam-rearing is practiced in a wealth of different systems, and four main points of view should be considered: that of the calf, the cow, the farmer, and the farming system. Three important qualities of cow calf contact systems are described from the animals' perspective: 1) nutrition, 2) care, and 3) learning.

The discussion included ethical considerations referring to the principle of fairness as expressed by the International Federation of Organic Agriculture Movements (IFOAM). Well-balanced and managed dam-rearing systems are suggested to contribute significantly to the physiological development and natural behaviour of mother cows and calves. The calves obtain capacities and skills through learning from the dam and others in the system. Major efforts are required when organising suitable calf- and cow-friendly dam-rearing systems, and farmer observations must be more careful because they take place in a group and therefore need to account for complex situations. In doing this, the farmer shows animals respect, and treats them justly as part of the ethical alliance between animals and humans cohabiting on a farm. Farmers' trust in the capabilities of the animals – such as the cow's ability to look after the calf and the calf's capability to live in a complex dairy system – 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. "Being in control" in new ways than previously was identified as a key for human learning in these systems as a part of the shifting focus when observing animals and spending time with cows and calves differently. In a cow calf contact system, the humans need relies to a higher

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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.

1 Introduction

Under natural conditions, cattle live in herds, in which they synchronise their activities such as grazing, ruminating, and resting together. The pre-parturient cow will seek isolation to calve in sheltered areas (Lidfors et al., 1994); here, strong bonds between calf and dam develop within hours of birth. Disturbance increases the risk of mis-mothering (Edwards, 1983), although the dam (here defined as the mother cow) is hormonally prepared to care for her calf until 6 to 14 months of age (e.g. discussed by Flower and Weary, 2001). When returning to the herd, the calf stays within the herd and is cared for and nursed by its mother five to nine times daily in the first weeks of life (Jensen, 2011; Fröberg and Lidfors, 2009). The bond is both nutritional and social and also encompasses social learning and exchange of affiliative behaviours (Mogi et al., 2011; Newberry and Swanson, 2008).

These aspects of natural needs, motivations, and behaviours have been largely ignored in organic dairy farming, although they refer to principles of care, fairness, ecology, and health (IFOAM, 2005). The practice of separating cow and calf immediately after birth has been broadly accepted as a normal practice of professional dairy farming. This is based on main arguments that especially address: 1) risks of disease transfer; 2) the amount of saleable milk, which there is less of when the calf is drinking ad libitum (Meagher et al., 2019); 3) that calf and cow may find it more traumatic and suffer being separated when the bond has been established and built up over a period of time, compared to separation immediately after birth (Weary and Chua, 2000; debated by Johnsen et al., 2016); and 4) that there is less human contact with calves in mother-bonded systems, and this can potentially lead to more difficult handling ('wild animals' or aggressive behaviour towards humans when a cow wants to defend her calf). These arguments seem to justify not only the separation of calf from cow immediately after birth but also the abrupt way in which it normally happens. However, over the last few years, interest in cow-calf contact systems has been growing, and more people have increasingly questioned early cow-calf separation in dairy farming. On the other hand, some farmers have practised dam-rearing for decades, e.g. in Dutch systems, following the so-called 'family herd concept' (Dixhoorn et al., 2010; Verwer et al., 2018). Furthermore, an increasing number of ethological studies have pointed to the benefits for the calves of having access to maternal care, learning, and socialising (Mogi et al., 2011). Several studies have documented higher growth rates of calves in dam-rearing systems, partly explained by the higher amount of milk (Grøndahl et al., 2007; Ivemeyer et al., 2016; Kälber and Barth, 2014). Practical experience has also shown benefits of cow-calf contact systems in terms of lower disease incidence and mortality rates when compared to artificially reared calves (Wagenaar and Langhout, 2007; Kälber and Barth, 2014). An increasing number of herds have started adopting different forms of cow-calf contact systems, some of which are dam-rearing systems, partly as a response to the growing public debate and awareness about ethical alliances between humans and farmed animals.

With regard to the legislation in organic farming, mother-bonded rearing or any other form of cow-calf contact system is not addressed beyond the source of milk: "All young mammals shall be fed on maternal milk in preference to natural milk, for a minimum period of three months for bovines including bubalus and bison species and equidae, 45 days for sheep and goats and 40 days for pigs"[5]. The EU regulation applies in France and the Netherlands with no further specifications. In Denmark, calves must stay with their mothers for a minimum of 24 hours, and calves must be in groups (a minimum of two animals) from the age of one week, but no further specifications apply. Norway is not a member of the EU but follows the EU regulations with some additional regulations, for example, the calf should suckle its mother for three days. Furthermore, according to the Norwegian national regulation generally on cattle husbandry, calves should be able to drink from calf feeders with artificial teats until they are one month old if the suckling period is shorter than one month[6]. According to the organic guidelines, separation should happen gradually: "Dam and calf should be separated gradually after the suckling period. Having some physical contact during the separation process reduces stress for both dam and calf"[7]. Some private organic labels in some European countries mention cow-calf rearing or prolonged suckling, sometimes with specific rules. For instance, the Norwegian Animal Protection Label states that calves must be together half of every day for the first six weeks. Besides, some on-farm processed dairy products mention different forms of cow-calf contact systems.

Studies have shown that dam-calf rearing requires changes in the daily practices and long-term priorities of farms when compared to systems with early separation of calves and cows. Farmers may need to observe and interact differently than when rearing calves separately from the cows, which can be challenging. Perceptions, experience, and strategies shape the priorities of individual farmers, and advisors and colleagues may be influential as farmer partners. Hence, besides technical aspects, the transition to new innovative practices needs changes in human and social perceptions and actions (Padel et al., 2015; Ivemeyer et al., 2015).

Growing interest and curiosity about dam-rearing is making it relevant to explore the possibilities for implementing these systems in different types of farming systems. The required changes in daily practice when shifting to novel systems, including the ways of observing animals and perceiving animal husbandry, calls for a focus on experiences

[5] The Commission Regulation (EC) No. 889/2008 of 5 September 2008, Chapter 2, Section 3, Article 20.1.

[6] Norwegian Regulation No. FOR-2004-04-22-665 on cattle farming.

[7] https://www.mattilsynet.no/om_mattilsynet/gjeldende_regelverk/veiledere/veileder_for_okologisk_landbruk.2651/binary/Veileder%20for%20økologisk%20landbruk (in Norwegian; p 34)

and concerns regarding the management of cows and calves in dam-rearing systems.

This article aims to present, analyse, and discuss experiences of and arguments on dam-rearing of calves through interviews with organic dairy farmers in four European countries. The analysis in particular focuses on ethical considerations related to the organic IFOAM principle of fairness as a lens through which calves, cows, farmers, and sustainable farming systems can be viewed in the discussion of contradictions around fitting animals or fitting (dairy farming and food) systems.

2 Materials and methods

2.1 The GrazyDaiSy project and its research approach

The GrazyDaiSy project is a European CORE Organic project that aims at developing innovative, resilient, and sustainable organic, grazing-based dairy systems within different economic and agro-ecological contexts within Europe. It focuses, among other things, on the rearing of cows with young stock, e.g. allowing mother-infant contact. In this study, we focused on dam-rearing systems, which in this study we understand as calves being together with their own mother for a minimum of two to three weeks after birth. This article explores the perceptions, practices, challenges, and benefits of dam-rearing in four different European countries (France, Norway, the Netherlands, and Denmark), which represent each a special context for cow calf contact systems. The study is based on semi-qualitative research interview methods in Denmark, Norway, and France in combination with an analysis of 12 years of on-farm research on the topic in the Netherlands.

2.2 Data collection and analysis

In Denmark, 15 interviews were conducted (see *Table 1*): (A) 11 face-to-face digitally recorded and transcribed interviews in June to August 2018 with Danish farmers who either had some experience in dam-rearing or had expressed interest in dam-rearing systems but who used other calf rearing systems (from early separation to foster cow systems), and (B) 4 over-the-phone interviews with farmers who had participated in a study trip to the Netherlands and Germany to explore cow-calf contact systems (interview length 32 to 53 minutes). All interviews were (A) transcribed or (B) summarised and then analysed by the first-author in Nvivo® using

TABLE 1

Description of the interview methods and the first analysis done per set of interviews. After this, a joint analysis was done across the seven sub-studies, where a common frame was used to analyse the results from the perspectives of the different actors: calves, cows, farmers, and farming system.

Country	Study	No. farmers	Method of interview	Method of analysis per set of interviews
DK	(A) Perceptions of dam rearing and experiences of calf management	11	Semi-structured qualitative face-to-face interviews, voice recorded and transcribed	Analysed by the first-author in Nvivo® using meaning condensates, which were collected into themes for each of the studies (A and B), which were analysed separately.
	(B) Impressions of cow-calf contact systems after a study trip to the Netherlands and Germany	4	Semi-structured qualitative phone interviews, noted down during the interview	
F	Farmer experiences with cow-calf contact systems	3	Semi-structured qualitative face-to-face interviews, voice recorded and transcribed	Each farm described as a case study. All case studies were summarised, highlighting similarities and contrasts, opportunities and challenges.
N	Farmer experiences with cow-calf contact systems	5	Semi-structured qualitative face-to-face interviews carried out by two persons, one of which took notes directly on the computer while interviewing	
NL	(A) The Family Herd project (2007–2011)	15	Semi-structured qualitative face-to-face interviews and structured online questionnaire	
	(B) In-depth personal interviews with dairy farmers with several years' experience in dam-rearing systems (2008–2009)	20	Semi-structured qualitative phone and face-to-face interviews, noted down during the interview	
	(C) An MSc study (2018–2019) by Anne van Wijk: "Visions of Dutch dairy farming on cow-calf rearing"	15	Semi-structured qualitative face-to-face interviews, voice recorded and transcribed	

meaning condensates that were collected into themes at two levels specifically developed within sets A and B. In Norway, five qualitative interviews were conducted in June to July 2018 with farmers who used dam-rearing systems on their farms. The interviews were conducted by two persons, one of which noted the responses directly while the farmer talked to the other interviewer. The notes were sent to the farmer for checking afterwards. In France, three farmer interviews were part of a more extensive interview survey in May to June 2018 involving 20 organic farms. Interviews were voice recorded and transcribed. These three interviews were all with farmers who kept calves with their mothers for at least two weeks. In the Netherlands, several studies have been conducted over 12 years (2007 to 2018), including several documented interview studies. In this manuscript, we include the results of the following studies, which all contain results from different type of qualitative interviews with farmers: 1) the Family Herd project (2007 to 2011; 15 farmers), 2) in-depth personal interviews (2008 to 2009; 20 dairy farmers with several years' experience in dam-rearing systems), and 3) an MSc study (2018 to 2019; 15 farmers with different levels of experience with dam-rearing systems).

After the individual detailed analysis of each set of interviews, an analysis across all four studies was conducted, based on the themes that emerged from across the different studies. In this analysis, the four different points of view, namely that of the calf, the cow, the farmer, and the farming system, came clearly out, and could be described and allow discussion across studies.

3 Results and discussion

3.1 The system's perspective in a wealth of diversity

In practice, the interviewed farmers had experience with a broad range of cow-calf contact systems, including dam-rearing systems, and beyond. Some were mixed or hybrid systems, where calves stayed with their mother for a couple of weeks and then were taken care of by foster cows, or where each cow would nurse two to four calves, one or two of which could be her own. In this article, we focus on the systems where calves stay with their dam. Three main systems were studied across different countries:

1) permanent contact between the mother cow and her calf (except for separation during milking);
2) limited suckling contact, determined by the farmer, for example, either during the day or night hours or for a few hours twice daily (typically after machine milking); and
3) one-sided access in systems where either the calf or the dam can determine the contact by entering and leaving the area where they can stay together.

All three main dam-rearing systems have several types of sub-systems, depending on practical possibilities in the farming system and preferences of the farmer. Different ways of and procedures for separating cow and calf were also described, ranging from abrupt separation in combination with weaning to gradual or two-step separation and weaning by means of fence-line systems or use of nose-flap. Another possibility is through transition from mother cow to foster cow or through hybrid systems.

3.2 The calf's perspective

3.2.1 Nutrition, care, and learning as three main perspectives

Farmers across countries came up with a range of arguments regarding the benefits for the calf in the dam-rearing systems and the reasons for having dam-rearing systems from the calf's perspective. Many emphasised good calf health and referred to both physical, mental, and emotional health, which almost can be seen as directly linked to three main perspectives emphasised as important for dam-reared calves: nutrition, care and learning.

Regarding nutrition, farmers highlighted the advantage of the calves having access to milk at the right temperature and in an amount that matched their needs. If the calves lived in systems with permanent access, they could also suckle as often as they needed to.

Some of the interviewees emphasised care as "something more to these systems than cows just being feeding machines" or used expressions similar to this. One of the terms mentioned was care, especially in terms of the cow licking the calf for a long time, the cow protecting or guarding the calf, and other type of physical contact. For example, two Norwegian farmers let cow and calf spend the first five to six days after birth alone to bond in a calving pen before they let them into the group with the other cows and calves with free access to their grazing area. Here, they experienced the calf running around and being closely followed by the cow everywhere the first day in the group. Because of this experience, other cows and calves did not bother these young calves.

Some interviewees mentioned learning as important, in more general terms meaning "learning to be a cow", "learning to get around in the system", but also in more concrete sense meaning "learning to graze", "learning about the fence", or "learning to walk to the fields on a walkway". Interviewees who emphasised learning referred to systems where cows and calves stayed in the system which was built for cows, and where the cow could guide the calf, and the calf could follow the cow, for example, when grazing or seeking shade. Learning was more restricted in special indoor cow-and-calf areas but could include, for example, learning to eat roughage. One of the Danish interviewees, who had seen dam-rearing systems in practice for the first time (during the study trip mentioned in Section 2.2), explained that she had always thought of a cow-calf contact system as being separate from the 'normal dairy system'. However, after having seen it work in herds, she now thought of the potential importance of learning: "Is it a learning site for the calf to be with the cow? […] they should not stay in the cow-house, was my previous thinking, but now I think that they also learn something from that. Whichever way, I think that the calf should be better planned for in the system, and it should be thought of as a 'calf system'" (Int-17B). Learning was also mentioned as a special aspect of social life and as a practical, convenient feature:

it is good for both calf and farmers if the calf can learn better to fit smoothly into the system later in life, for example, by learning about electric fences, walkways, cubicles, and different feedstuffs. In other words, the calf's relationship with its mother, fellow calves, and the other animals in the herd is the learning environment for the calf.

3.2.2 Being born as a calf not intended to stay in the herd

Most of the dam-rearing systems referred to by the interviewees kept the bull calves in the herd for only a few weeks before selling them off to other herds, such as fattening herds. The farmers described this as unavoidable because they did not have the space and capacity for keeping the bull calves. The same would happen to the female calves that they did not want to keep as replacement heifers. Therefore, some farmers preferred to separate these calves from their mothers early. One major reason was that the calves would have to drink from buckets in the farm that received them, and that requires the time and effort of the workers or farmers in the new place if the calves were used to only suckling. However, some farmers delivered calves to farms where the receivers appreciated their size and robustness and seemed to manage to get them into the system regardless of whether they had suckled for their first living weeks or not. Under most circumstances, bull calves and heifers that were not intended to be kept in the system were separated abruptly from their mothers. This aspect was brought up and debated in more of the interviews with the Danish farmers, who had been introduced to cow-calf contact systems during the study trip. They talked about it as a 'dilemma' in these systems: they tried to give the heifer calves a good start in a cow-calf system, but all the calves selected to go out of the herd experienced the stress of abrupt separation and loss of the mother early in life.

3.3 The cow's perspective

3.3.1 Mother cow often not in focus

Some farmers focused solely or mostly on the calf's health and the above-mentioned needs: nutrition, care, and learning. However, some farmers mentioned better mental and physical health for cow and calf; for example, Norwegian farmers experienced that there was less milk fever and retained placenta when the calf stayed with the mother, which they saw as an argument for having dam-rearing systems. The main focus on calves also became apparent in hybrid or foster cow systems, where it was important that the calf was doing well and bonded successfully with the cow, but it was of less importance whether the cow was the mother or foster cows. In other words, the mother cow's loss of her calf was mentioned less, or not at all, if compared to the mentions of the benefit of the calf being with "a cow", which could also be a foster cow.

3.3.2 Is the mother cow motivated to care?

A group of the interviewed Danish farmers who had been on a study trip to the Netherlands had stayed overnight at a Dutch farm with a dam-rearing system. In the morning, they had walked into the cow-house, where they had watched calves and cows starting the day: "The calves were lying in a small group to the right, and they had been there since the evening [when also having looked into the cow-house; Ed.]. When we came in, the cows walked over to the calves and started licking them – as if the cows wanted them to drink. She might want to get rid of some milk" (Int-10B). This statement indicated that in this case the cows took the initiative to nurse the calves.

3.4 "What is the best time to suffer?"

The views on how the separation causes suffering in cows in comparison to calves are interesting in terms of the time when the separation is done. Many of the Danish interviewees had expressed interest in dam-rearing but had no experience with it, and they expressed concern that the separation was more traumatic the longer the calf and cow had been together. They referred to the fact that both cow and calf are more silent when separated earlier. This was expressed by the Danish Int-5B: "[…] and the break is probably not so big when they are four days old. I believe that the break feels bigger the older they are. Otherwise, one should wait until they are completely able to take care of themselves."

The above statement was focused on the calf's perspective, but the stress of the dam also had to be considered. One of the Danish farmers (Int-17B, who did not have a dam-rearing system but who participated in the study trip to see such systems) proposed an argument that the time with the calf may help the mother cow to 'postpone' the stress: "And still: what about the cow – it is her stress. It is really difficult to figure out what she gets out of all this […] there are some diseases around calving that they avoid. That is a time where they are maybe less stressed – and maybe there is something about their hormonal pattern. Then there is an advantage that their stress comes a bit later." Two French farmers perceived that cows were more depressed when separated from their calf soon after birth. The French farmer B recognised that cows made less noise because they were too sad, but he perceived them as angry when they were separated later (at three weeks), stating that they expressed their stress and fear more easily.

3.5 What is 'natural' about dam-rearing systems?

Many of the interviewed farmers referred to cow calf contact systems as meeting natural needs, and both arguments and questions were brought up in the interviews using the terms 'natural' or 'naturalness'. For example, the question of high-yielding dairy cows with deep or low udders (unsuitable for suckling for a calf) that produced so much milk that the calf was at risk of overdrinking was raised by several interviewees across the countries. The question of what is natural in a dairy herd was consequently posed.

A major discussion arising from the interviews with farmers from all studied countries is about who should or would approach the other in one-sided access systems – the cow or the calf or both, with reference to how it would be in a natural system. A second question was how this could be designed in a dairy herd. It was commonly argued that the mother would seek the calf during the first days, but that later the calf would approach the mother when hungry. One of the interviewees said: “It is maybe more natural that the calf is the one finding the cow after 14 days, but this also depends on whether they have a cow-house that is suitable“ (Int-3B). Many similar statements and discussions came up, articulating that it might be more natural to let the calf be the one to approach the cow. However, it was also stated that this would require a calf-friendly system, for example, slatted floors designed for calf hooves, more hygienic floors, and less risky housing designs (e.g. to prevent young calves from being squeezed by cows in heat, or by floor scrapers). Many interviewees argued that they would prefer a system where the calves could stay all the time, and the cow could leave and come. This was not based on an argument about naturalness or whose interest it was to approach the other, but more practical arguments such as mentioned above. Completely different conditions and challenges exist in systems where calves and cows can stay together on grass, and where the cows in some cases give birth to calves.

3.6 The farmer’s perspective: learning to navigate

3.6.1 Dam-rearing can give farmers pleasure, pride, and motivation

More of the farmers stated something similar to the statement in the headline. The Norwegian farmer 3 added the following: “It is incredibly inspiring […] Cow and calves together give motivation. I am prouder of being a dairy producer.“ In France, a farmer phrased it as “a pleasure“ to see calves suckling their mothers. These and similar statements indicate that experiencing calves and cows being together was highly motivating for the farmers and added quality to their lives, and helped them overcome inconveniences and challenges connected to the cow-calf contact system. However, a recent Dutch MSc study (the Dutch Study C, see *Table 1*) included interviews with two farmers, who had left the system. They explained this using the term feralisation, which meant that their animals became more difficult to handle for humans.

3.6.2 The balance between trusting the animals and being laid back

In the interviews with French and Norwegian farmers, as well as in several Dutch studies, the confidence and trust in calves’ and cows’ abilities to adjust and adopt to the systems became apparent. This trust was shown at several levels. For example, the French farmers told that their calves in dam-rearing systems had diarrhoea, but they recovered spontaneously and it was not critical, nor did it require action from the farmer. The Danish interviewees who participated in the study trip and visited Dutch and German dairy farms with dam-rearing were confronted with different types of cow-calf contact systems, which they found challenging (e.g. slippery floors, iron bars in the cubicles of the cow housing system, etc.). Calves had access to or lived in housing systems originally designed for cows. They perceived that the Dutch farmers trusted that their animals could manage in those systems, and when they had asked the Dutch farmers questions about management in cow-calf contact systems, it became evident to them that the Dutch farmers had many years of experience that the animals normally did fine in the systems. The visiting Danish farmers questioned themselves whether the farmers were sufficiently in control or, as some of the farmers expressed it, “too laid back” regarding supervision of the calves and cows in these dam-rearing systems. At the same time, they acknowledged that the calves looked so well that the farmers apparently could trust that the calves would find their way in the complex systems. However, the interviewed Danish farmers in the Danish Study B emphasised that even when the calves seemed to do well in the cow herd, they thought that more efforts should be made to organise a system which would be more friendly to small calves.

3.6.3 Some farmers feel uncomfortable when not in control

Some interviewed farmers had experience with bucket feeding of calves. In such system, the farmer is able to tell exactly how much milk each calf consumes. Although some farmers put forward the argument that their dam-rearing system was easy to manage, most interviewees with practical hands-on knowledge of dam-rearing systems emphasised the need to re-think time and efforts rather than save time and work. They still needed to spend time with and among the calves. One major reason was to make them used to humans. One of the major concerns among many farmers was calves becoming wild as heifers and cows. Although some farmers had experienced this, others had had the opposite experience. For example, the Norwegian farmer 3 claimed: “Calves that have been with their mother become calm and confident as grown-ups.“ It was not followed up in the interviews how the experiences may have been seen in the light of different practices, but a Danish farmer stated: “Well, now, milk feeding is not the only way in this world to be in contact with your calves. You can simply go there and talk with them and walk between them, and then they also get to know you and don’t become wild“ (Int-22A).

Observing animals in dam-rearing systems according to some farmers’ descriptions also required a re-thinking of focus and a more general view of how they move and react. Having calves in the cow herd was different from calves in smaller boxes with fewer animals, where the calf and its immediate surrounding and status are easier to observe, for example, in its first critical hours. The French farmers all experienced that the calves became more wild after having been with their mothers for three to four weeks. However, they also experienced that they were relatively easy to make confident with humans after separation (although this in some cases was achieved by tethering them for a couple of days, which can also be strongly criticised according to the IFOAM principles and legislation). Farmers also realised that they were not entirely in control in the same way as they used to be when they gave the milk in the bucket. When bucket feeding the calves, they could measure how much milk each calf received, and could check whether it actually drank it. In the dam-rearing systems, they had to rely on their ability to observe the animals and, so to speak, shift focus from input-based (the amount of milk fed) to outcome-based measures (how the calf looked like and did it seem to have a full belly).

Farmers who had built up experience with dam-rearing systems over a long time realised that they had been through this change of perception, and had learned to watch the calves and cows in another way. However, farmers who saw dam-rearing systems for the first time (such as the Danish group of farmers being confronted with the Dutch systems) described a feeling of uncertainty and discomfort when thinking of it. This made them question whether such systems, for example, could be managed sufficiently if different employees had to share the supervision of the system.

3.6.4 Overview of the most important pros and cons regarding dam rearing systems across participating countries

Pros and cons regarding dam-rearing systems across the four countries participating in this study are outlined in *Table 2*. The interviews showed that four different perspectives were considered: calves, cows, the human caregiver, and the system understood as the cow calf contact system as part of the farming system. The table is based on articulated experiences, which vary highly among farms and systems. This explains why completely contradictory statements come up, for example, that animals are both calmer and wilder in dam-rearing systems.

As can be seen in *Table 2*, the system's perspective is complex, and the pros and cons in each type of system are closely linked with the farmer's preferences and the different physical conditions and opportunities.

3.6.5 Methodological considerations

The aim of the present study was to reveal and examine farmers' perceptions of and experiences with dam-rearing systems. We wanted to analyse and discuss how dam-rearing systems could contribute to improved animal welfare and sustainable future farming systems, and the interview studies present a broad view across different countries and contexts. Although part of the same research project, the data collection was mainly guided by practical possibilities and resources and was therefore quite heterogeneous. Interestingly, the studied countries represented widely different levels of

TABLE 2

Overview of pros and cons for dam-rearing across countries, mostly with inputs from farmers and actors with experience in dam-rearing systems in Norway and France, as well as interviews with Dutch farmers in three different studies from 2005 to 2019. The table is based on the statements of farmers and organised by the authors to show the perspectives of each involved actor: calves, cows, farmers, and the farming system.

Perspective	Pros	Cons
Calf's	Can drink as much milk as they need, at the right temperature, in their species-specific way (slow suckling), as often as they want, depending on circumstances Less mortality Care and stimulation from the dam Good and more balanced growth Farmers experienced healthy and robust calves, which seemed to have a high immunity to diseases Heifers do not suckle each other (experience from Montbéliard herds) Learn to eat hay, grass, solid feed earlier Respect the fences, walk on walkways Get used to the daily rhythm, routines, and sounds of dairy systems Better roughage intake	Show strong signs of stress and can be very noisy at separation Lose more weight at separation Some farmers tether calves after separation for some days to make them less wild Excessive growth; fat calves Dangerous for the calves to be among cows in the herd as some of them do not accept calves of other cows
Cow's	Calmer herds with more social animals Highly motivated to be active after giving birth Caring, protecting and fulfilling a natural need Lower frequency of disease just after birth	Show strong signs of stress at separation and call for the calf
Farmer's	Calm and confident animals Different types of work with more attention to animals Satisfying to see calves suckle their mother; 'beautiful to see'; proud to be dairy farmer "It is more natural" Possibilities to diversify (special brands of meat and milk)	"Wild", difficult calves More work, e.g. if they are on pasture Difficult to keep eyes on calves when they are in the herd Dependent on the system: difficult to teach calves to drink from a bucket after late separation (if they have to) Calves drink "a lot of milk" Difficult to machine milk; poor milk let-down The farmer may get less milk, hence lower income, which can be critical in a farm where the main income is milk
System's	Possible to organise in many different systems, where considerations depend on: Robot vs milking parlour Seasonal vs even all-year-round calving patterns Priorities regarding full-time access vs part-time access Possibilities for common grazing Building layout in general	If one-sided access: doubt about whether the calf should find the cow, or the cow should find the calf Dimensions in the housing system can be difficult to calculate for both cows and calves of different ages

experience among farmers on dam-rearing, which gave us a unique opportunity to cover a wide range of perceptions and experiences. The rather heterogeneous data material allowed us to discern some common lines, views, and concerns. However, we need to emphasise that the methodology of combining and analysing across different samples and interviews, as well as the relatively few interviews per country, clearly presents challenges. We need to emphasise that the results should be seen through these lenses. Until now, little documented research has been done on the perceptions, practices, and experiences of farmers regarding cow-calf contact systems. In this article, we present some interesting potential ways of viewing the field of dam-rearing, rather than drawing firm conclusions.

4 Final discussion: Are dam-rearing systems fairer to the animals?

The results of this study (including the summary of pros and cons in *Table 2*) indicated that dam-rearing systems can be organised in ways that support the health and welfare of the animals, as well the farmers' need to feel pleasure working with and in their farming systems. However, some risks associated with having small calves in cow housing systems were highlighted, such as slatted floors and iron bars between cubicles.

One interesting point to raise when discussing the suitability of these systems for future organic dairy systems is how to bring the organic principles described by IFOAM (2005) into the debate. These principles are intended to serve as an ethical guiding framework for organic agriculture. Although the four principles are intertwined and strongly connected, and although all of them are relevant to the focus area of this article, we consider the principle of fairness to be particularly relevant for the discussion at the center of this article. The formulation, "this principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behaviour and well-being", may guide a development of animal systems which allow contact between mother animals and offspring.

When we view dam-rearing systems as they were presented according to the perceptions and experiences of farmers and through the lens of fairness, the contact between calf and mother can be seen as a significant contribution to the physiological development and natural behaviour of both. The mother cow is strongly motivated to nurse, protect, and care for the calf. It can be argued that it is unfair to the cow to lose her calf and that cows show clear signs of stress when this happens. The calves obtain capacities and skills through learning from the dam and others in the system, adding to their life opportunities. Using the term 'life opportunities' in the context of calves opens additional questions and considerations. It could for example include earlier learning being in groups of adult animals, which may make them more confident to explore their surroundings. To be fair to the calves, the farmers must minimise any risk in the farming system and organise it to benefit all animals. Major efforts are required when fitting the farming systems to the needs of both cows and calves. By doing so, the farmers show the animals respect and treat them justly, which is also highlighted in the principle of fairness and can be seen as part of the ethical alliance between animals and humans in their shared world and farm framework. This could include organising a gentle separation in a way that mimics nature and allows for care and contact; however, one can argue that separating cow and calf after a few weeks or months does not mimic nature because natural separation would happen at 7 to 14 months of age.

The interviews also revealed some issues of potentially unfair discrimination that need solutions in future farming systems. This relates in particular to the difference between calves staying in the herd and calves leaving the herd (typically bull calves), and to their mothers, which have to go through early and abrupt separation. The construction of having two classes of calves can be questioned from a fairness perspective.

To make dam-rearing systems fair for everybody, much practice development, education of advisors and farmers, and research on specific topics related to dam-rearing systems is still necessary. Dam-rearing systems take place in multiple contexts, and this needs to be taken into consideration when developing practices and making choices of ethical importance.

5 Conclusions

When farmers react to, consider, and organise a dam-rearing system, their priorities and perceptions can be described using four different perspectives: 1) the calf's perspective, 2) the cow's perspective, 3) the farmer's perspective, and 4) the farming system's perspective.

Three important qualities were described from the animals' perspective: 1) nutrition, 2) care, and 3) learning. Seen from the calf's perspective, its physiological need for nutrition and emotional needs for care and protection were highlighted, and the possibility for learning early in life. These three qualities were partly echoed also when seeing it from the cow's perspective, although care for and protection of the calf were described as strong needs. A need to develop systems that are suitable for both cow and calf, especially with low risk for the calf's welfare, was identified. Some critical issues that need solutions were also revealed. One major critical issue was the often early and abrupt separation of dams from calves that are intended to leave the herd (typically bull calves). Regarding the farmer's perspective, it was remarkable that farmers from the participating countries expressed the satisfaction and pleasure of working with and in dam-rearing systems as a strong driving force to keep dam-rearing systems.

The interviews showed how humans' trust in the animals' capabilities, such as the cow's capability to take care of her calf, and the calves' capabilities to find their way in complex cow housing and grazing systems, seemed to induce a shift of focus for the management of the system. Farmers with dam-rearing systems spend their time with cows and calves differently if compared to when they were feeding the calves with milk in buckets. "Being in control" in a cow-calf contact system relies to a higher degree on the ability to observe and judge a complex situation rather than, for example, giving the calves exactly the same amount of milk of a specific temperature at the same times every day.

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OPEN ACCESS

RESEARCH ARTICLE

For the future of pig farming: a transdisciplinary discourse organised as a future workshop

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HIGHLIGHTS

- **We present here a transdisciplinary, professionally moderated and scientifically supported multi-stakeholder discourse organised to encourage new ideas for pig housing systems and management processes that aim at achieving future social acceptance.**
- **The aim is to provide inspiration for pig production systems that meet the basic standards of animal welfare, farmers' needs, and societal demands.**
- **Moreover, it summarises the experiences of the discourse process**

KEYWORDS **pig production, pig husbandry, animal welfare, future workshop, transdisciplinary discourse, social acceptance**

Abstract

Germany is the largest pig producer in the EU, and many German farmers earn their living in the pig production sector. Current pig husbandry is characterised by intensive production systems, which have been subject to increasing public criticism over the recent years. Criticism often refers to the increased economic efficiency of such production systems and the simultaneous negligence of animal welfare and other sustainability aspects.

However, in order to ensure successful and sustainable pig production in the future, broad social acceptance of this sector is indispensable. In this context, the integration of different stakeholder groups into the development of new pig housing and management systems could be a promising approach. The present study provides results of a transdisciplinary, professionally moderated and scientifically supported multi-stakeholder discourse that was organised as a future workshop to encourage new ideas for pig housing systems and management processes.

Our study presents two types of results. On the one hand, it provides suggestions for pig housing and management systems that meet basic standards of animal welfare and farmers' needs as well as societal demands. On the other hand, it summarises the experiences of the discourse process that may inspire future planning and implementation of multi-stakeholder approaches in similar fields.

All developed pig housing and management systems have been agreed upon by all stakeholders involved and are characterised by enhanced space and mobility, separated functional areas, outdoor areas, continuous roughage supply, and organic materials for rooting and manipulation, as well as showers for the pigs.

1 Introduction

In recent years, livestock production has increasingly become the subject of extensive public criticism, with animal welfare turning out to be a focal point of interest in many European countries, including Germany (Bergstra et al., 2017; de Barcellos et al., 2013; Eurobarometer, 2016; Krystallis et al., 2009; Weible et al., 2016). Nowadays, sufficient and cheap food supply is no longer enough to legitimise livestock production (Clark et al., 2016; Grunert et al., 2018; Spooner et al., 2014; Vanhonacker et al., 2009; SocialLab-Konsortium, 2019). Rather, in order to meet long term social acceptance, not only economic considerations but also wider ethical requirements must be taken into account (Hölker et al., 2019; Hölker et al., 2019a; Janssen et al., 2016).

Due to economic, work safety, hygienic, or food safety reasons, pig production has evolved into one of the most efficiently organised processes in animal production. However, the requirements of those production processes prevent

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animals' natural behaviour. For a sustainable future of German pig production, pig farming practices and societal demands for more pig-friendly housing and production systems must be brought together.

According to several surveys of pig-producers, many conventional pig farmers in Germany face the challenge of adapting their production systems to societal demands, farmers' and animals' needs (ISN, 2018). Talking to pig farmers, it becomes obvious, that many of them put a lot of passion into their work and are sensitive about topics related to livestock production (Wildraut and Mergenthaler, 2018; Wildraut et al., 2018a). They are fully conscious of the fact that their work is increasingly monitored and discussed by society at large. Currently, however, there are many conflicting goals and legal hurdles which hinder pig farmers from adapting their housing systems to public demands.

For example, more space and mobility for sows is linked to rising piglet mortality (Grimberg-Henrici et al., 2018; Grimberg-Henrici, 2018a), which is not only detrimental to the piglets' welfare but also has an economic impact. Moreover, in most regions with dense pig production, the provision of outdoor access is often not possible due to emission regulations (Keck and Schrade, 2014; Mielke et al., 2015; Vermeer and Hopster, 2018). Increased space for individual animals, enriching elements or showers, the provision of organic material and roughage seem to be too expensive at current price levels (Dawkins, 2017; DLG-Kompakt, 2019; Winkel and Heise, 2019).

Against this background, a transdisciplinary, professionally moderated and scientifically supported project (2017 to 2019) was initiated to deal with the following question: how should conventional pig production be designed in future in order to enhance animal welfare, meet social acceptance, and at the same time realise practicable solutions for farmers?
The aim of the present study was twofold:
1) to develop virtual pig housing and management systems for all production stages, taking into account animal welfare needs, social demands, and farmers' needs as well;
2) to find out whether a transdisciplinary multi-stakeholder approach, such as a future workshop, is a suitable method for the development of new housing systems in livestock production.

In the next section, the project's approach following the methodology of future workshops as well as the project's process are presented. The results section is divided into a subsection describing the developed concepts for future pig production systems and a subsection summarising the discourse of process experiences. The limitations of the project are outlined before the conclusion and implications section.

The paper addresses farmers as well as policymakers and other stakeholders, who are willing to participate in the development of pig production systems that are aligned with social demands as well as animal welfare and farmers' needs. Furthermore, it is intended for all those who are interested in the use of qualitative transdisciplinary discourse approaches in the field of livestock production.

2 Approach

The project was designed as a future workshop to initiate and enhance a structured and professionally moderated transdisciplinary multi-stakeholder discourse. The method of future workshops is renowned for its facilitation of discursive multi-stakeholder processes in many different public fields of interest. Future workshops are a method of participatory research when multiple stakeholders are asked to develop a vision of the future in an atmosphere designed to promote creativity (Jungk and Müllert, 1989).

Apart from the four main phases (introduction, critique, utopian, and realisation phase) a future workshop usually includes, the project presented in this study (2017 to 2019) comprises an additional fifth phase (finalisation phase) shown in *Figure 1*. All five phases were scientifically supported, evaluated, and documented with written minutes and audio

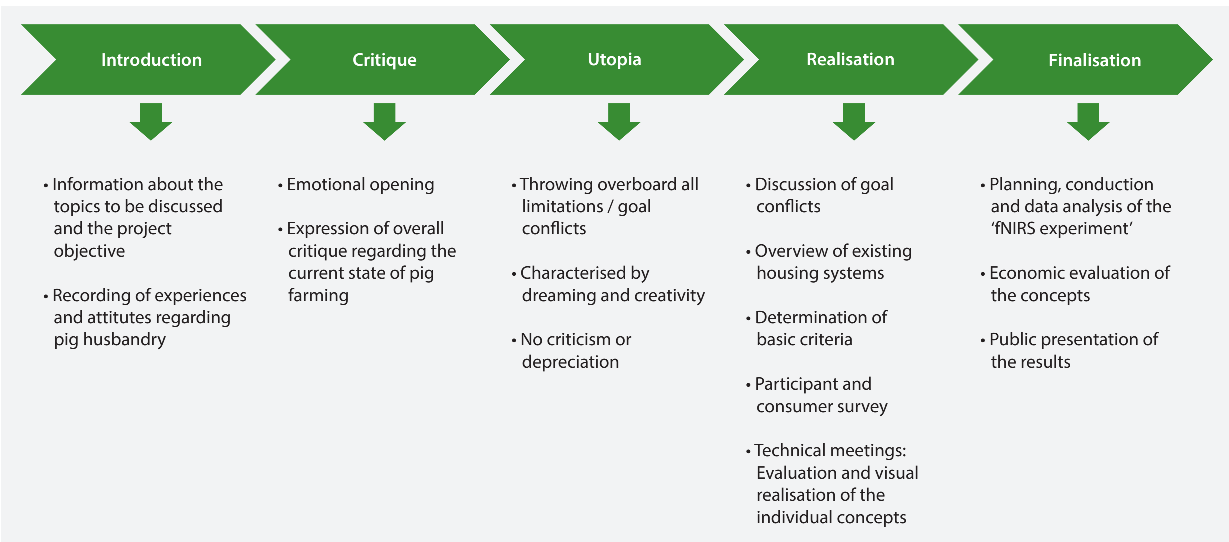

FIGURE 1
Overview of subjects discussed during the individual project phases (Source: own compilation 2020)

and graphic recordings. A total of eleven workshop days were organised, spread over the different project phases. The subjects discussed during the individual phases are shown in *Figure 1*. All of them were professionally moderated, which ensured a neutral approach and balanced handling in the performance of workshop participants. Moreover, the leading project scientists could concentrate fully on the preparations for the workshops, their evaluation, the follow-up, planning the next steps, deciding on the participant composition, as well as the coordination and briefing of the professional moderator. The scientists qualitatively analysed each workshop phase, triangulated the results achieved with other experts and participants, and then added information to the discussions from literature research.

The project partners were members of three disciplines (animal production and breeding, agribusiness/agri-food marketing, and neuroscience marketing), a leading pig farmers association, and a pen construction company.

The selection criteria for workshop participants were defined in agreement with all project partners and included socio-demographic aspects, soft skills, and discussion expertise. Each of the participants received an incentive for their participation in addition to a travel expenses allowance. The invited workshop participants made up a transdisciplinary, multi-stakeholder group of German pig production, including pig farmers from all production stages, members of agricultural chambers, and consultants and experts in both pig production and pen construction. There were also scientists from different fields such as precision livestock farming, agribusiness, marketing, ethics, consumer and market research, and representatives of supermarket chains. Many participants were invited to all workshops, but some only to specific ones according to their field of expertise. On average, twenty people took part in each workshop.

The introduction and critique phase workshops were held with two different participant groups: one with farming stakeholders only and one consisting of consumers and marketing experts. All the following workshops were held with heterogeneous stakeholder groups.

The utopian phase was used to construct ideas of how to overcome the already identified current critical situation in conventional pig production. The main idea of the workshops here was to throw overboard all usual restrictions and limits and to encourage free associations, dreams, and utopian ideas instead. These ideas had to become more realistic and feasible only in the following realisation phase of the future workshops. The task of this phase was to identify techniques for implementing the ideas and figure out how goals that might conflict could still be met.

In order to concretise the actual design of the developed ideas for pig housing concepts, a special working group was established. This consisted of participants of the future workshop with special technical and practical expertise such as farmers, pen construction experts, members of agricultural chambers, and researchers. In total, five so-called technical meetings were held in order to enable appropriate consideration of all aspects that are important for the concrete technical realisation of the housing concepts. Although the primary focus was on animal welfare, social demands and feasibility aspects were also taken into account and, subject to the clarification of questions regarding financing and approval, virtually realised with current technical means.

The feedback from the technical meetings in the form of precisely developed housing concepts were presented to all the other future workshop participants and jointly discussed. This feedback process took place several times, so that all participants could agree on the final housing concepts.

In addition to the workshops and technical meetings, two surveys were conducted to support the feedback process and provide additional information and inspiration to the workshops. First, in October 2018, an online survey with German residents was completed in order to identify the degrees of acceptance of several conventional and innovative pig production processes and concepts. Moreover, citizens' attitudes towards different conflicting goals in pig production (animal welfare vs. resource protection; animal welfare vs. costs) were analysed. The participants were selected using quotas representing average German population by gender, age, school leaving qualifications, and size of the place of residence. The sample comprises 1.101 datasets that were analysed.The analysis showed that 73 % do not perceive current conventional pig production as animal welfare friendly. The main reasons stated are the lack of space and outdoor access, the lack of straw and other organic litter, as well as the perceived bad treatment of animals. Eighty percent of the citizens surveyed are of the opinion that current circumstances of pig production need to be changed to a more transparent system. Notwithstanding their clear demands, citizens appreciate that many of their expectations might not be met.

These results are also shown by other studies confirming citizen demands for the physical integrity of pigs, a more natural environment for them (especially the ability to show natural behaviour such as rooting and wallowing), and animal-friendly interaction in pig production no matter what the consequences are for the farmers (efficiency, work safety), the environment, and resources (Dawkins, 2017; Rovers et al., 2018; Ryan et al., 2015; SocialLab-Konsortium, 2019; Sonntag et al., 2017; Sonntag et al., 2018).

Secondly, in October 2018, an online survey was conducted, which all thirty-six active future workshop participants completed. In addition to content-related aspects of the housing concepts to be developed, the survey included questions on the chosen discourse method. Important findings were made in two respects: on the one hand, content-related results were analysed and included in the further discourse process, which contributed significantly to the development of the housing concepts. On the other hand, results showed that most of the participants consider the future workshop method as a suitable instrument in developing new housing systems for pigs and other farm animals. They would also participate in follow-up meetings or similar projects. This overall positive evaluation could be important in terms of planning future multi-stakeholder discourses processes concerning livestock production.

During the finalisation phase, the project report, final presentation, and public relations work was done.

3 Results

3.1 Developed housing and management systems for all production stages

As only a holistic approach could ensure pig welfare throughout their whole life cycle, housing and management concepts were developed for all production stages, from pregnancy and farrowing pens to pens for pigs fattening. Several versions for each production stage were designed. These are presented in the simplest way in order to maximise individual inspiration. A customised analysis of advantages and disadvantages has to be done, of course, before realising any of the housing systems. Here, we refrain from this due to the considerable heterogeneity of German pig production systems, as well as different economic and regional characteristics of each concept.

In the following, the key elements of the developed pig housing and management systems are presented as visualisations (*Figure 2*) and described in more detail. Pig farmers therefore have the opportunity to choose housing concepts according to their individual needs. All concepts have been planned as new constructions rather than conversions. However, individuals could check and calculate whether converting old buildings could be viable. For this purpose, an Excel tool was developed to calculate individual construction costs per m² or per animal, for both piglet production and pig fattening. The calculation tool is available on the project homepage (https://www.uni-goettingen.de/de/575789.html) and can be used by any interested farmer. The idea of the project was less to develop designs for pigsties, which are planned down to the last detail, but rather to provide inspiration and a few practical design options for pig housing and management concepts. Due to the strong individual characteristics (e.g. regional differences) of the farms, several key elements were included in order to provide a basic guideline for farmers. However, final and more detailed design and investment decisions have to be taken by each farmer themselves according to their specific needs.

Key elements that all developed housing concepts must include:

- Increased space and mobility for pigs and lower stocking density:
  Sow and piglets: a limitation of the fixation time of sows to a few necessary (in terms of work security) days. The farrowing pen should be at least 6 m². It should be an oval space for the sow (2 m x 1.60 m) to turn around in the pen freely and to express nesting behaviour. The space is larger than in current conventional standards in German systems but not too big so that piglets remain safe and do not lose their orientation.
  Fattening pigs: each animal has more than 1.1 m² space so that producers can receive the second level of the German animal welfare label.
- Separated functional areas for eating, sleeping, defecating, and being active.
- Outdoor access for all pigs above 30 kg weight.
- Continuous supply of roughage and organic materials for rooting and manipulation.
- Showers (at least for all fattening pigs).

Individual options can be selected for the following areas listed below.

- **Concepts for the service area** (which all aim for the shortest fixation period for sows):
  1. Approximately 70 cm wide places to eat and lie down when the sow is only fixated for insemination.
  2. Approximately 75 cm wide places to eat and lie down in several classes when the sow is fixated for 5 to 10 days.
  3. Insemination in the group (constant group). Sows are restrained for as short a time as possible and have more space and access to the outdoor area.
  4. Insemination in the farrowing pen. This allows the sows to stay longer with the piglets and does not require them to change pens.

- **Concepts for the pregnancy area (pregnant sows):**
  1. Separated functional areas, barn area with slatted floor, an outdoor area (see *Figure 2a*).
  2. Separated functional areas, barn area with slatted floor, an outdoor area (useful as pregnancy area and bearing area), constant group of sows.
  3. Separated functional areas, barn area with slatted floor, no outdoor area, straw bedding, open house, natural ventilation, constant groups of sows.
  4. Automated sow feeding system, barn area with slatted floor, deep straw bedding, natural ventilation.
  5. Automated sow feeding system, barn area with slatted floor, forced ventilation, an outdoor area.

- **Concepts for the farrowing area:**
  In total, various variable-restraint pens with a size of at least 6 m² and a group pen for nursing sows with an option for an outdoor area were designed:
  1. Variable-restraint pen without an outdoor area
  2. Group pen for nursing sows with an option for an outdoor area and a flap for piglet management options are (see *Figure 2b*):
  a. Twenty-eight days of suckling, afterwards weaning of the piglets and putting them in the flat deck.
  b. Thirty-five days of suckling (piglets can stay longer with the sow and have extended suckling time), after that piglets stay 2 to 3 days without the sow in the farrowing area.
  c. Thirty-five days of suckling (including insemination in the farrowing area). Piglets can stay longer with the sow, have extended suckling time, and due to the insemination in the farrowing area there is no need to change the location of the sow.
  d. After 1 or 2 weeks of suckling in the „family area"sows and piglets have access to a group pen with an option for an outdoor area.

- **Concepts for fattening pigs:**
  1. Two-rowed open-air barn but without an outdoor area (see *Figure 2c*).
  2. Open-air barn with a courtyard.
  3. Large groups with an outdoor area.

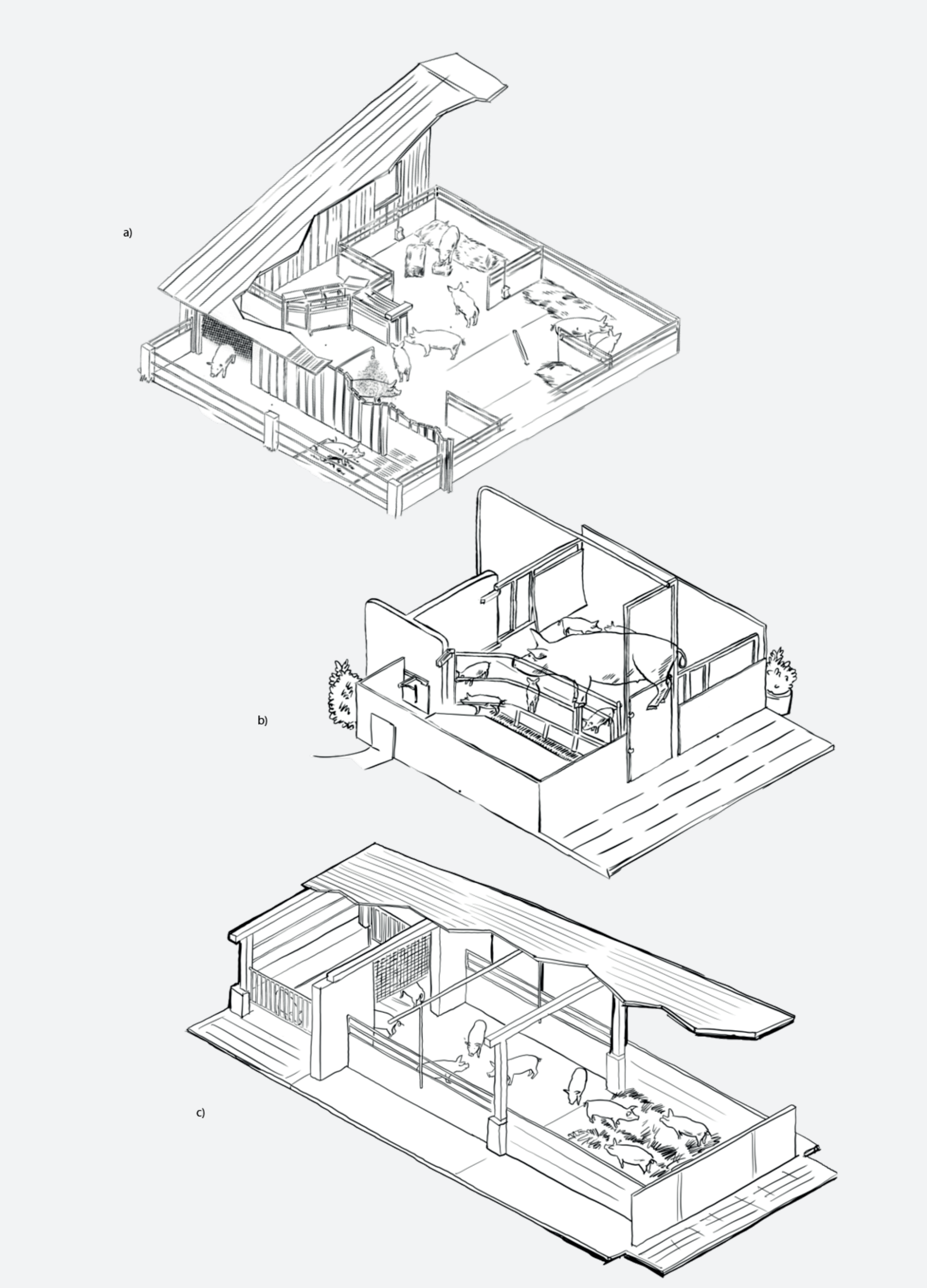

FIGURE 2
Exemplary sketches of developed pig housing concepts (described in more detail vis-a-vis):
a) pregnancy area; b) farrowing area; c) pig fattening area
(Source: Flaneur.de / Windisch 2019)

3.2 Experiences from the discourse process

All of the concepts presented for future pig housing and management were mutually agreed upon by the members of the diverse group of stakeholders involved in the intense transdisciplinary discourse that was organised as a future workshop from 2017 to 2019.

One of the first consensual decisions was to focus the entire process of the project on animal welfare needs since it has been shown that there is a general agreement among farmers, citizens, and scientists that the level of animal welfare in pig husbandry could be improved. One of the main demands of farmers as well as citizens is to reduce the number of iron construction parts in barns, especially in the farrowing crate. However, this demand could not yet be met. In the short term, it seems very complicated to reduce the fixation of sows due to workload and safety. Nevertheless, this issue has to be addressed in the long term specifically through breeding, changing management processes, farmers' working attitudes, or future technical developments.

Concerning the defined key elements which all concepts must include, the experiences from the discourse have shown that farmers' first reaction was often related to financial aspects, followed by scepticism about technical solutions and the added value of marketing. While farmers often focus their interest concerning pig production on performance aspects, citizens often argue from a perspective focusing on more natural production. They wish pig production to be as natural as possible, having in mind pictures of happy rooting pigs, sows in close contact with their piglets etc. They conclude that if animals have had a good life, the resulting products must be good as well. There is still a great need for mediation between the different stakeholders' views and for explaining the relationship between production costs and impacts on sustainability. It will be important to find neutral and trusted communicators that are uninfluenced by lobby from any side.

The main public demands concerning animal production, such as more space, access to outdoor areas, organic material, and the possibility to express basic natural behaviour patterns, are not at all new. However, it still seems to be very hard for pig farmers to recognise them as a chance for future development instead of critique. Long term changes in societal values and the human-animal relationship are not yet fully realised by the sector's stakeholders. Many still do not feel their license to produce to be in danger. From the farmers' perspective, there is a widespread distrust of public demands because consumers are accused of not behaving according to their stated attitudes. Moreover, citizens are often unable to define their demands in exact terms. From the citizens' perspective, production side stakeholders are often accused of not keeping their promises. They might speak of outdoor access but in reality only provide a continuous supply of litter, meaning a minimum of organic material and not straw ad libitum. Clear definitions, explanations, and well-designed communication might help, but solutions often remain missing. Moreover, there are several goal conflicts alongside public demands. For example, providing outdoor access for all pigs above 30 kg seems at first sight to be very beneficial for their welfare. However, it might well bring about other problems, such as emissions, questions of animal health and food hygiene. Therefore, there is still a pressing need for future research and political decisions to further develop German pig production in a sustainable way.

3.3 Limitations

Due to the fact that economic aspects of the concepts presented here have been widely neglected for the sake of creativity and innovative discourse, it cannot be taken for granted that any of the concepts could be realised by an average producer without financial support or price adjustments. Moreover, the construction of pens with outdoor access will probably remain very difficult in the near future due to regulatory hurdles.

Besides the consensual concepts presented here that were developed during a multi-stakeholder discourse, there were also versions of them which would only be possible for some producers or could only be feasible in the long term.

4 Conclusion and Implications

The complex problems of current pig production in Germany cannot be solved by simply changing barn construction or production management concepts. The results of the project show how much more still has to be done in changing stakeholders' perception about the sustainability of the sector. In the highly emotional debate about the future of pig production in Germany, it is important to find solutions in a timely manner that disperse the current backlog of investments and bring planning security for farmers concerning political decisions, regulations, as well as their financial situation.

The methodology used in a future workshop has helped to clearly structure the discussion process. In the participant survey, the majority confirmed their satisfaction with the project structure and organisation as a future workshop. Thus, the consensual definition and realisation of future pig production concepts in the course of a transdisciplinary discourse process, can be suitable as the first step towards a more socially acceped pig production.

However, animal welfare measures that are only slightly better than the current legal standards will not maintain nor restore social acceptance. Fundamental changes in conventional pig farming combined with a reduction in the number of animals raised are necessary instead. This requires a rethinking on the part of pig farmers, with the focus on the well-being of their animals and a change in marketing channels. Environmental law and agricultural law must go hand in hand to achieve solutions. The agricultural sector and politicians should not just leave these challenges for future generations but dare to think in a visionary manner now. Clear political decisions concerning support for future pig production and solving goal conflicts have to be made now. The results of this project, as well as the wide stakeholder network built during it, can support this by maintaining and deepening public discussion about sustainable pig husbandry in Germany in the future.

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Evolution in animal husbandry – Fitting animals or fitting systems?

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RESEARCH ARTICLE

Performance of organic entire male pigs from two sire lines under two feeding strategies Part 1: Growth performance, carcass quality, and injury prevalence

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HIGHLIGHTS

- **Fattening of entire male pigs from Duroc and Piétrain sire lines under organic conditions led to satisfactory performance and carcass characteristics.**
- **Feeding potato starch resulted in slightly lower meat yield compared to the control feed.**
- **Aggressive behaviour was low under the studied management strategies.**

KEYWORDS **Duroc, Piétrain, raw potato starch, growth performance, carcass quality**

Abstract

Castration of young male pigs in organic husbandry systems without anaesthesia contradicts animal welfare principles and consumers' perception of organic animal husbandry practices. On the other hand, fattening of boars can result in undesirable performance, meat and carcass qualities, and aggressive behaviour resulting in injuries.

The objective of the present study in organic boar fattening was to test the effect of two terminal sire lines (Duroc vs Piétrain) and two feeding strategies (without vs with 10 % raw potato starch starting from the live weight of 95 kg prior to slaughter) on performance and carcass quality parameters as well as animal welfare.

Daily weight gain, feed conversion, dressing rate, carcass lean, and injury prevalence were measured in a total of 280 boars (65 Duroc Control, 73 Duroc Potato starch, 68 Piétrain Control, 74 Piétrain Potato starch). Testing was performed under organic housing and feeding conditions using German Landrace x German Large White sows which were artificially inseminated using Duroc or Pietrain sires, respectively. Statistics are based on ANOVA (proc glm) by SAS 9.4.

Concerning performance and carcass quality, the results confirmed the known differences between the terminal sire lines also in organic entire male pigs; Duroc was superior in daily weight gain, while Piétrain was superior in dressing percentage and lean meat content. Feed conversion ratio did not differ between sire lines and the offer of raw potato starch prior to slaughter remained without noteworthy effect on daily feed intake, feed conversion ratio, and carcass quality. Injury prevalence was generally low, thus indicating no concerns of animal welfare when fattening entire male pigs under organic conditions.

1 Introduction

Castration of male piglets is a standard practice in central European pork production to avoid the occurrence of boar taint in meat, which is an off-odour that can decrease consumer liking (Bonneau et al., 1992). Since animal integrity is an important factor in organic husbandry, the practice of castration conflicts the organic farming principles. The castration of young male pigs without anaesthesia contradicts consumer expectations of organic husbandry practices, which is that they are animal-friendly and as little pain as

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possible is involved in pig farming. According to EU regulations on organic pig husbandry, the use of analgesia and/or anaesthesia during castration is mandatory (EU 2018).

In Germany, the termination of pig castration without anaesthesia was planned by 2018 but was postponed until 2021 because the existing alternatives were deemed as non-applicable to the common practices in pork production. Fattening of entire male pigs could be one way to achieve animal integrity and meet the consumer expectations of organic animal husbandry systems. However, fattening of boars entails economic and animal welfare challenges. Regardless of the better feed conversion ratio of boars, classification and billing systems of slaughter companies sometimes discriminate boar carcasses. Furthermore, an increase in injuries might occur due to sexual and/or aggressive behaviour of boars (Rydhmer et al., 2006). Nevertheless, the occurrence of boar taint is the main problem in marketing the meat of entire male pigs. Boar taint, which is described as a sweaty, musky, faecal, or urine-like odour by consumers sensitive to the compound, is caused by the accumulation of skatole, androstenone, and, to a lesser extent, indole in the fat of entire male pigs. It has been shown that skatole and indole formation and accumulation in pigs can be reduced by feeding strategies that influence the amount of energy and tryptophan available to the gastrointestinal bacteria (Wesoly and Weiler, 2012). Amongst others, the inclusion of potato starch in the diet has such an effect (Chen et al., 2007; Øverland et al., 2011; Pauly et al., 2008; Zamaratskaia et al., 2005). Androstenone is a pheromone and can accumulate in the fat of pigs. Androstenone levels are mainly determined by genetic factors and age at puberty and differ between genotypes (Zamaratskaia and Squires, 2009). For instance, Duroc genotypes are associated with higher androstenone concentrations in fat than other genotypes. Both factors can be taken into account by different management choices that are made in conventional and organic pig fattening systems. Therefore, the aim of this study was to compare the effect of two terminal sire lines Duroc and Piétrain and the use of raw potato starch on growth performance, carcass quality and the occurrance of injuries while rearing of entire male pigs under organic conditions.

2 Materials and methods

2.1 Trial design and animals

The trial was performed at the eco-certified research farm of the Thünen Institute of Organic Farming (Trenthorst, Germany) from September 2012 until October 2015. Eight trial runs were conducted during this period. The 280 male growing-finishing pigs originated from the institute's sow herd consisting of 50 German Large White x German Landrace crossbred sows. For artificial insemination (AI), Duroc (Du) and Piétrain (Pi) boars were used. All pigs were marked with ear tags. At the beginning of the fattening phase, entire male pigs were randomly split into four treatment groups representing the combination of two different feeding strategies (use (+) vs non-use (-) of raw potato starch during late fattening) and two different terminal sire lines (Du vs Pi). The following allocation was obtained: Du+ (Du experimental group, 73 entire males), Du- (Du control group, 65 entire males), Pi+ (Pi experimental group, 74 entire males), and Pi- (Pi control group, 68 entire males). Due to the limited availability of organic potato starch and imbalances in the gender-distribution of some litters leading to a shortage of male progeny, the distribution of trial groups during the trial runs was uneven. *Table 1* shows the distribution of trial groups during the trial. The intended fattening period ranged from 27 kg to 115 kg bodyweight.

TABLE 1
Distribution of trial groups during the trial runs

Trial run	Du +	Du -	Pi +	Pi -	Total
1		18		20	38
2			30		30
3	30		9		39
4				39	39
5			27		27
6		36			36
7	34	2			36
8	9	9	8	9	35
Total	**73**	**65**	**74**	**68**	**280**

Du: Duroc; Pi: Piétrain; +: with potato starch; -: without potato starch

Across the four treatments (Du+, Du-, Pi+, Pi-), the trial started with a total average of 29.3 kg bodyweight (SD: 7.6 kg), the finishing period started with a total average of 56.5 kg bodyweight (SD: 8.4 kg), and the trial ended with a total average of 115.7 kg bodyweight (SD: 6.1 kg). Potato starch offer for the experimental groups (Du+, Pi+) started with a total average of 91.4 kg bodyweight (SD: 10.5 kg) and lasted for 27.9 days (SD: 10.8 d) until the end of the fattening period.

2.2 Housing, feeding, and slaughtering

The suckling period was divided into two parts: individual housing per sow and litter, which lasted 14 days, and group suckling with stable groups of 3 to 5 sows and their progeny for a period of 35 days. During the following rearing period animals were not regrouped. The experimental fattening unit comprised four pens for a maximum of ten animals per pen. Each pen consisted of an indoor area with 1.5 m^2 $animal^{-1}$ and an adjacent outdoor run with 1.1 m^2 $animal^{-1}$. Both compartments had a solid concrete floor with straw as litter material. Manure was removed twice a week with a subsequent straw replacement. In almost all cases, the indoor area was kept clean. Animal to feeding place ratio was 1:1 with a feeding trough on the left and the right indoor partition, each for five growing-finishing pigs. A watering place and a roughage rack were located on the longitudinal side of the outdoor run of each pen.

The feeding regime consisted of pelleted diets of 100 % organic origin with maximum use of farm-grown feed ingredients (cereals, grain legumes). With respect to the two fattening phases, diet types were a grower diet with

81 % farm-grown ingredients, a control finisher diet without raw potato starch with 91 % farm-grown ingredients, and an experimental finisher diet containing 10 % of raw potato starch kg^{-1} feed in proportional exchange to the amounts of cereals and grain legumes of the control finisher diet. This led to a 2.6 % lower content of protein in the experimental diet, while energy content did not differ between diets.

The diets were optimised for metabolic energy (MJ ME) and the content of the first limiting amino acid lysine according to the recommendations for grower-finisher pigs reared under organic conditions of Zollitsch et al. (2002). The concentrate was offered twice daily according to a feeding curve based on live weight. Feed was offered semi ad libitum from 25 to 30 kg to 50 kg and restricted from 50 to 115 kg live weight resulting in a daily amount of 1.4 to 2.2 kg animal^{-1} and 2.4 to 2.9 kg animal^{-1}, respectively. As the offering of roughage is mandatory in organic pig feeding, all animals received grass-clover silage throughout the whole fattening period with a daily amount of 1 kg fresh matter animal^{-1}. Composition and analysed values of the trial diets are shown in *Table 2*.

All pigs received the same grower and control finisher diet until the first pig of the experimental group reached 95 kg body weight. The pigs were marked individually when they reached > 113 kg body weight, and only those pigs were slaughtered the next day. Animals were separated pen-wise and transported at 5:40 am to the nearby (13 km) small family abattoir, where they were unloaded pen-wise and immediately slaughtered by the use of the electrical stunning method.

TABLE 2
Composition and analysed contents of the experimental diets and grass-clover silage

Composition (%)	Grower		Standard finisher				Experimental finisher		Grass-clover silage	
Trial run	*1–7*	*8*	*1*	*2 + 3*	*4–7*	*8*	*2, 3, 5, 7*	*8*	*1–8*	*(1 kg day^{-1})*
Live weight range	*25–50 kg*		*51–115 kg*				*95–115 kg*		*25–115 kg*	
Wheat	0.0	27.0	0.0	0.0	0.0	26.0	0.0	23.0		
Barley	27.0	24.0	32.0	19.0	18.0	32.0	25.0	29.0		
Triticale	24.0	0.0	22.0	22.0	22.0	0.0	23.0	0.0		
Beans	15.0	15.0	13.0	26.0	26.0	18.0	17.0	16.0		
Peas	15.0	15.0	25.0	25.0	25.0	18.0	17.0	16.0		
Soycake	14.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0		
Rapeseed cake	0.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0		
Sunflower seed cake	2.0	0.0	3.0	3.0	3.0	0.0	3.0	0.0		
Citric acid	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0		
Mineral	2.5	2.5	2.0	2.0	3.0	3.0	2.0	3.0		
Potato starch	0.0	0.0	0.0	0.0	0.0	0.0	10.0	10.0		
Analysed contents (%)	**$\bar{x}$**	**SD**		**$\bar{x}$**	**SD**		**$\bar{x}$**	**SD**	**$\bar{x}$**	**SD**
Number of analyses	*9*		*10*				*9*		*5*	
Dry matter	91.2	0.63		91.4	0.53		90.7	0.66	26.3	6.58
Crude ash	5.8	0.30		5.3	0.38		5.0	0.57	10.8	0.57
Crude protein	18.9	1.07		17.7	1.33		15.1	0.46	17.9	1.88
Lysine	10.6	0.59		10.2	1.14		8.3	0.39	-	-
Methionine	2.5	0.21		2.0	0.13		1.9	0.08	-	-
Cysteine	3.2	0.28		2.8	0.14		2.5	0.12	-	-
Threonine	6.8	0.65		6.2	0.53		5.2	0.19	-	-
Tryptophan	1.9	0.15		1.6	0.10		1.4	0.04	-	-
Crude fat	2.4	0.85		2.0	0.51		1.7	0.53	2.6	0.69
Crude fibre	6.2	0.78		6.7	0.74		6.0	0.50	26.2	2.83
Sugar	3.9	1.04		3.7	0.26		3.0	0.40	-	-
Starch (OM)	42.9	1.47		45.8	1.47		50.0	0.82	-	-
Starch breakdown (OM)	17.0	3.57		15.0	2.14		17.2	2.62	-	-
Calculated energy content* (MJ ME/kg^{-1})	12.9	0.35		12.8	0.31		12.8	0.17	-	-

$\bar{x}$: mean; SD: standard deviation; OM: original matter; MJ ME: metabolisable energy in mega joule; *metabolisable energy calculated according to Society for Nutritional Physiology (GfE, 2008)

2.3 Data collection

Feed samples were obtained every second week and combined into a mixed sample within diet type and production cycle, and analysed for its composition. Grass-clover silage composition was based on five samples (see *Table 2*). Feed and grass clover samples were analysed in the laboratory of the Thünen Institute of Organic Farming. Starch content and starch breakdown as indicators for the digestibility of the starch were analysed in a commercial laboratory. Performance and carcass quality data collection followed the federal standard of German pig testing stations (ZDS 2007). Bodyweight was individually measured every Monday with an electronic animal scale throughout the whole fattening period to calculate individual daily weight gain. Feed conversion ratio (only concentrate) was calculated for the growing, finishing, and total fattening phases as a group average according to the documented feed consumption per group (accumulated daily quantity of concentrate offered without weighing the feed refusals in relation to the weight gain per group). Dressing percentage was calculated from warm carcass weight and final body weight. Lean meat content was estimated 45 min p.m. using FOM pistol (Fat-O-Meat'er® S89k) between the second and third last rib of the left carcass half. The day after slaughter, the left half of the carcass was used to record carcass quality and meat quality traits. Electrical conductivity was measured between the 13th/14th rib using Matthäus® LF-star pistol. Minolta® CR-300 was used to record meat lightness (L*) of Musculus longissimus thoracis et lumborum (LTL) of the 13th rib. Muscle (MA) and fat area (FA) of the 13th rib were measured by distance standardised photography and subsequent digital planimetry (Matthäus® SCAN-STAR K).

To determine the consequences of fattening entire male pigs on animal welfare, the carcasses of all pigs were evaluated after scalding for scratches or injuries as signs of aggressive behaviour. An employee of the research station evaluated both sides of carcasses following the protocol of Ekesbo (1984). The evaluation was done for the whole body within a range of 0 (no scratches/injuries), 1 (slight scratches/injuries), and 2 (severe scratches/injuries).

2.4 Statistical analysis

Normal distribution of data residuals was confirmed graphically and statistically with the Shapiro-Wilk test. Data analysis was carried out using SAS 9.4 (Proc GLM) considering genotype, feeding, and genotype*feeding interaction as fixed effects, which always remained in the model. The included covariates were body weight at the trial start, weight at the start of the finishing phase, and weight at the beginning of potato starch feeding for the corresponding fattening performance phases. Slaughter weight was included as a covariate for the measurements of carcass and meat quality. These tested covariates remained in the model if significant. For the pairwise comparison of LSQ-means, the Tukey-Kramer test (significance level $p < 0.05$) was used.

The prevalence of injuries as described by the integument scoring was analysed using Fisher's exact test. Scores of 1 and 2 were combined due to their low frequency. Genotype and feeding regime were used as independent variables, while scoring value was the dependent variable (significance level $p < 0.05$).

3 Results and discussion

Table 3 shows the LSQ means for growth performance and carcass quality in relation to genotype and feeding regime.

The daily weight gain of Du sired pigs significantly exceeded the performance of Pi sired pigs. Feeding potato starch reduced the daily gain of Du pigs, while Pi pigs achieved higher daily gains. As Du pigs genetically have higher growth potential, they might be more sensitive to reduced nutrient density than Pi pigs (Edwards et al., 2006; Morales et al., 2013). Pauly et al. (2008) found no differences in daily gain of Swiss Large White entire male pigs when feeding 30 % potato starch seven days prior to slaughter under Swiss environment- and welfare-friendly conditions. In our study, the potato starch period prior to slaughter lasted 28 days on average, which might explain the differences in daily gain due to the longer exposition to feed reduced in nutrient density.

Feed conversion did not differ significantly between terminal sire lines or feeding strategies over all fattening periods, except for the first finishing period, which might be ascribed to a drop in the daily gain during one of the trial runs. The feed conversion ratio was in accordance with Grela et al. (2013), which was 3.16 kg feed kg^{-1} gain for organically fed pigs; this illustrates the inferior feed conversion ratio of organically fed pigs to conventionally fed pigs which was found to be between 2.38 and 2.69 kg feed kg^{-1} gain in the studies of Otten et al. (2013) and Pauly et al. (2008). Direct comparison of feed conversion ratio with other studies has to take into account that feed intake in this study was semi ad libitum, not measured individually, and feed residues were not weighed back. In general, the growth performance of the entire male pigs used in this study was at a satisfactory level for organically kept and fed pigs.

Dressing rate of Pi sire lines was 2.2 % higher than in Du sire lines, while Pi origins significantly exceed Du origins in lean meat content by about 1.2 %. Pi pigs are commonly known to have higher muscularity and lean meat percentages; however, the achieved dressing percentages (77 to 78 %) are low compared to conventionally kept Pi sire line pigs (e.g. 83 % , Gispert et al., 2007). The low overall dressing rates could be due to the mandatory use of roughage in organic pig feeding. Roughage increases the weight of the gastrointestinal tract and reduces the calculated dressing rate (Holinger et al., 2018). In this trial, the pigs received an average of 1 kg grass-clover silage per animal day^{-1}. The use of raw potato starch resulted in a significant reduction of dressing rate by 1.1 % points, while lean meat percentage did not differ between feeding strategies. The effect of feeding raw potato starch on pig intestines has been described by Fang et al. (2014) and Nofrarías et al. (2007), who found that the long-term intake of raw potato starch increased the weight of the large intestines and resulted in positive changes in the colonic microbiome. Genotype influenced the meat

TABLE 3

Effect of sire line (Duroc, Du vs Piétrain, Pi) and feeding strategy (with (+) vs without (-) raw potato starch on growth performance and carcass quality of entire male growing-finishing pigs (LSQ means and significance levels)

										P-Values		
	Du	Pi	+	-	Du +	Du -	Pi +	Pi -	SEM	Sire line	Feeding	Sire line x Feeding
Growth performance *(n animals)*	*138*	*142*	*147*	*133*	*73*	*65*	*74*	*68*				
Daily weight gain [g]												
Total trial period	**883**	**805**	**832**	**856**	**852**[b]	**914**[a]	**812**[c]	**798**[c]	7.4–11.2	**<0.001**	**0.026**	**<0.001**
Potato starch finishing	**958**	**854**	**886**	**926**	**904**[b]	**1013**[a]	**868**[bc]	**840**[c]	11.7–18.1	**<0.001**	**0.021**	**<0.001**
First finishing period	**936**	**856**	**894**	**897**	**905**[b]	**967**[a]	**884**[b]	**827**[c]	10.7–16.3	**<0.001**	0.851	**<0.001**
Early fattening period	**784**	**722**	765	742	774	794	709	735	9.3–14.0	**<0.001**	0.085	0.832
(n pens)	*15*	*15*	*16*	*14*	*8*	*7*	*8*	*7*				
Daily feed intake [kg feed]												
Total trial period	2.36	2.32	**2.29**	**2.38**	2.32	2.39	2.26	2.37	0.02–0.03	0.254	**0.006**	0.629
Potato starch period	**2.81**	**2.70**	2.77	2.74	2.85	2.78	2.69	2.71	0.03–0.04	**0.006**	0.511	0.301
First finishing period	**2.54**	**2.42**	2.42	2.54	2.51	2.57	2.33	2.50	0.04–0.05	**0.041**	0.051	0.318
Early fattening	1.78	1.74	1.70	1.81	1.74	1.82	1.67	1.80	0.04–0.07	0.535	0.119	0.660
(n pens)	*15*	*15*	*16*	*14*	*8*	*7*	*8*	*7*				
Feed conversion ratio [kg feed^{-1} kg weight gain]												
Total trial period	3.09	3.11	3.01	3.19	3.05	3.13	3.00	3.25	0.07–0.10	0.868	0.072	0.325
Potato starch period	4.27	4.14	4.21	4.20	4.43	4.11	3.99	4.30	0.17–0.28	0.602	0.984	0.239
First finishing period	2.77	2.82	2.72	2.87	**2.84**[b]	**2.69**[b]	**2.60**[b]	**3.04**[a]	0.06–0.09	0.552	0.105	**0.002**
Early fattening	**2.24**	**2.45**	2.33	2.36	2.23	2.24	2.43	2.48	0.06–0.10	**0.034**	0.762	0.864
Carcass quality *(n animals)*	138	142	147	133	73	65	74	68				
Dressing rate [%]	**75.5**	**77.7**	**76.1**	**77.2**	75.2	76.1	77.0	78.3	0.14–0.21	**<0.001**	**<0.001**	0.261
Lean meat content [%]	**54.2**	**55.4**	54.8	54.8	54.2	54.2	55.3	55.4	0.22–0.35	**0.006**	0.875	0.841
Meat area, LTL [cm^2]	**40.5**	**42.2**	**41.0**	**41.8**	40.1	40.9	41.8	42.6	0.27–0.44	**<0.001**	**0.047**	0.989
Fat area, LTL [cm^2]	13.6	13.1	13.5	13.2	13.9	13.3	13.0	13.1	0.21–0.35	0.094	0.507	0.264

Du: Duroc; Pi: Piétrain; +: with potato starch; -: without potato starch; LTL: Musculus longissimus thoracis et lumborum
Significant differences within sire line or feeding ($p < 0.05$ Tukey-Kramer test), different indices (a,b,c,d) within row indicate significant differences between sire line x feeding groups

area of the LTL in Pi origins, yielding larger meat areas of the LTL. Pi sired pigs are known to have high protein accretion rates (Gispert et al., 2007), which they seem to achieve under organic conditions as well. The meat area of the LTL of the trial group pigs was lower by 1.8 % compared to the control group pigs. The reducing effect of the potato starch diet on the meat area of the LTL in this trial cannot be ascribed to the potato starch itself but could be a result of the different protein content and lysine/energy ratio, which were lower during the potato starch feeding period. Reduced loin meat areas when feeding diets were lower in protein or lysine/energy ratios also have been described by Castell et al. (1994), Kerr et al. (2003) and Zhang et al. (2008).

The prevalence of scratches as a sign of aggressive behaviour was low in general and was significantly ($p < 0.01$) higher for Pi pigs (*Figure 1*). Although intact male pigs tend to show more aggressive behaviour, Rydhmer et al. (2006), Vanheukelom et al. (2012), and Holinger et al. (2015) found only small differences in injuries between females, castrates, and entire male pigs. In the current study there was no effect of feeding potato starch on the prevalence of scratches. This low prevalence of injuries in this study might be due to avoiding the regrouping of the animals throughout the complete fattening phase as well as the group suckling of piglets, during which the animals are already acquainted with each other. Furthermore, enriched housing conditions (as

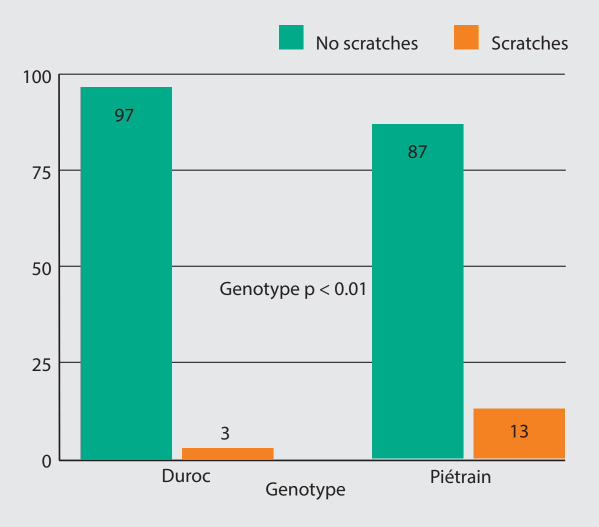

FIGURE 1
Prevalence of scratches (%) in relation to genotype

they are likely to be found in organic pig keeping) are known to reduce the occurrence of injuries and/or aggressive behaviour in pigs (Lindgren et al., 2014; Prunier et al., 2013; Scott et al., 2006).

4 Conclusion

Fattening of entire male pigs under organic conditions led to satisfactory performance and carcass qualities. The results of performance and carcass quality revealed differences between Duroc and Piétrain sire lined pigs. Apart from slightly lower dressing percentage, feeding raw potato starch during the end of the fattening phase had no noteworthy effect on performance and carcass characteristics. Concerning the influence of sire line and raw potato starch on boar taint, we refer to the companion paper "Organic fattening of entire male pigs from two sire lines under two feeding strategies Part 2: Meat quality and boar taint" (Werner et al., 2020).

The low prevalence of injuries found in this study indicates that fattening of boars under certain management strategies (stability of animal groups since the rearing phase, space and occupational material, feeding of roughage) is possible without negative influences on animal health and welfare.

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RESEARCH ARTICLE

Organic fattening of entire male pigs from two sire lines under two feeding strategies Part 2: Meat quality and boar taint

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HIGHLIGHTS

- **The use of Duroc or Piétrain sired pigs and the feeding of raw potato starch influenced the content of boar taint-related compounds in pig fat to a different extent.**
- **The contents of androstenone and skatole in the fat influenced the sensory evaluation of the samples.**

KEYWORDS **androstenone, skatole, Duroc, Piétrain, raw potato starch**

Abstract

Fattening of entire male pigs can result in boar taint and affects growing performance as well as meat and carcass traits. The objective of the present study was to test the effect of two terminal sire lines (Duroc, Du vs Piétrain, Pi) and two feeding strategies (without (-) vs with 10 % (+) raw potato starch 28 days (SD: 10.8) prior to slaughter) on meat quality parameters as well as the occurrence of boar taint in meat. Animals were reared under organic housing and feeding conditions using German Landrace*German Large White sows and nine Duroc and seven Pietrain Artificial Insemination-boars. The electrical conductivity 24 h p.m. (EC24) between the 13th and 14th rib, meat colour (L*, a, b), intramuscular fat content (IMF), and fatty acid composition of IMF, as well as the amount of skatole (SKA), indole (IND), and androstenone (AND) in the shoulder fat, were measured in a total of 280 boars (65 Du-, 73 Du+, 68 Pi-, 74 Pi+). A trained sensory panel performed an olfactory evaluation of the fat. No differences were found in terms of the physical parameters of meat quality. The content of the IMF was significantly higher in Duroc than in Piétrain offsprings. Regardless of the diet, AND was higher in Du than in Pi (920 vs 680 ng g^{-1}). The content of IND was similar for Du and Pi, and the use of raw potato starch had a reducing effect on IND compared to the control diet (3.6 vs 7.8 ng g^{-1}). The content of SKA was the highest in Pi- (94.0 ng g^{-1}), while its levels in Pi+, Du-, and Du+ were similarly low (38.0 ng g^{-1}). Concentrations of IND and SKA were generally low in the samples. Sensory evaluation of the fat samples showed no difference between the trial groups. In conclusion, the use of Piétrain as terminal sire line seems suitable to reduce the level of androstenone in boar meat. Although the use of raw potato starch reduced the amount of indole, feeding the diet containing 10 % of potato starch led to inconsistent results regarding skatole contents in Piétrain and Duroc due to a significant genotype*feeding interaction.

1 Introduction

Boar taint is an off-odour that can decrease consumer liking of pig meat. To avoid boar taint, castration of male pigs is a standard procedure. To minimise the pain during castration, the use of analgesia is mandatory, while anaesthesia is (as per today) not legally required. However, the ban of castration without anaesthesia in Germany was already planned for

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the end of 2018 but has been postponed until 2021 because the existing alternatives were deemed as non-applicable to the common practices in pig meat production. One alternative to castration is the fattening of entire male pigs. While advantages of fattening entire male pigs under conventional conditions can be found for growth performance and carcass quality, negative consequences on the fat composition and meat quality due to the occurrence of boar taint are also well known (Bonneau, 1998). Studies on the consequences of fattening entire male pigs on growth performance, carcass, and meat and fat quality under organic conditions, which differ from conventional pig farming mainly concerning feed composition (use of roughage, no synthetic amino acids) and husbandry conditions (spatial requirements, outdoor access) are scarce.

The occurrence of boar taint is mainly attributed to skatole and/or androstenone, and, to a lesser extent, indole that accumulate in the fat of entire male pigs (Lundström et al., 2009). The amount of skatole in the fat of entire male pigs is higher than in gilts and barrows (Zamaratskaia et al., 2006) due to reduced skatole degradation in the liver caused by the negative feedback of the male sex hormone testosterone (Babol et al., 1999). Skatole and indole are produced by microbial degradation of L-tryptophan in the caecum and colon (Jensen et al., 1995). However, skatole formation in the large intestine can be reduced by feeding strategies that provide non-praeceacally-available dietary energy for the growth of skatole-associated large intestine microbiota. This results in the available tryptophan being used for the synthesis of microbial protein and not for the production of skatole (Zamaratskaia and Squires, 2009). Among others, raw potato starch has such an effect (Chen et al., 2007; Lösel and Claus, 2005; Pauly et al., 2008; Zamaratskaia et al., 2005). Androstenone is an androst-16-ene steroid, produced in Leydig cells of testes (Squires et al., 1991), and functions via saliva as a pheromone between the boar and the sow during reproduction (Perry et al., 1980). Breed types differ in androstenone content. For instance, Duroc genotypes are associated with higher androstenone concentrations in fat than growing-finishing pigs of other origins (Fredriksen et al., 2006; Xue et al., 1996).

Therefore, the aim of this study was to compare entire male pigs of the two terminal sire lines Duroc (Du) and Piétrain (Pi) and the use of raw potato starch and their combination in terms of their influence on meat quality and the occurrence of boar taint in meat under organic conditions. Thereby, we tested the hypothesis that the use of Piétrain as the terminal sire and offering a diet containing 10 % potato starch in the finishing phase can reduce the occurrence of boar taint in organic pigs.

2 Materials and methods

2.1 Trial design

The trial was performed at the eco-certified research farm of the Thünen Institute of Organic Farming (Trenthorst, Germany) from September 2012 until October 2015. We split 280 entire male growing-finishing pigs into four treatments representing the combination of two different feeding strategies, use (+) vs non-use (-) of raw potato starch before slaughter, and two different terminal sire lines (Duroc, Du vs Piétrain, Pi). Due to restrictions in the availability of organic potato starch and male progeny in some farrowing seasons, the four treatment groups could not be distributed equally among the eight trial runs. This led to unbalanced trial design. For a detailed description of the trial design, see our companion paper "Performance of organic entire male pigs from two sire lines under two feeding strategies. Part 1: Growth performance, carcass quality, and injury prevalence" (Werner et al., 2020).

2.2 Animals, housing, feeding, and slaughtering

The 280 male growing-finishing pigs originated from the institute's sow herd consisting of 50 German Large White x German Landrace crossbreds via artificial insemination (AI) using nine and seven individual Duroc and Piétrain AI-boars, respectively.

The feeding regime consisted of pelleted diets of 100 % organic origin with the aim of a maximised amount of farm-grown feed ingredients (cereals, grain legumes).

All pigs received a grower and finisher diet similar in nutrient density and composition until the first pig of the experimental group reached 95 kg live body weight. From this point on, pigs of the experimental groups received a finisher diet with 10 % raw potato starch for the rest of the fattening period, whereas the control groups received the finisher diet without the raw potato starch continuously. For a detailed description of the animals used and their keeping, feeding, and slaughtering, see our companion paper, part 1 (Werner et al., 2020).

2.3 Meat quality

Collection of meat quality data followed the federal standard of German pig testing stations (ZDS, 2007). The day after slaughter, the left carcass side was used to assess meat quality traits. The pH of the loin muscle (Musculus longissimus thoracis et lumborum (LTL)) was measured 24 h after slaughter near the 13th rib using Knick Portamess 913. Electrical conductivity (EC24) was measured between the 13th and 14th rib using Matthäus® LF-star pistol. Minolta® CR-300 was used to record meat lightness (L*) and colour values (a, b) of the LTL at the 13th rib level. To determine the intramuscular fat (IMF) content of the LTL, the muscle was withdrawn at the 13th rib and analysed according to the German Code for Food (LFBG 2014, §64). Fatty acid composition of IMF and subcutaneous shoulder backfat (SF) was analysed by gas chromatography with flame ionisation detection after extraction with chloroform/methanol according to Nürnberg et al. (1997) and transesterification into fatty acid methyl esters with trimethylsulfonium hydroxide as described by Schulte and Weber (1989).

Drip loss was determined using 10 g of the LTL obtained at the 14th rib following the EZ-DripLoss method (Rasmussen and Anderson, 1996). Samples were stored for 48 hours.

2.4 Boar taint and olfactory assessment of fat samples

Subcutaneous SF including rind (15 cm x 25 cm from the dorsal split line) was extracted one day after slaughter. It was vacuum-packed and stored at -20 °C until further analyses.

Androstenone, skatole, and indole contents in the SF were analysed by SPE-GC–MS (solid-phase extraction and gas chromatography/mass spectrometry) using deuterium-labelled internal standard as described by Meier-Dinkel et al. (2016a). Inter- and intra-day variation coefficients ranged from 3.8 to 9.1 % and 1.2 to 14.6 %, respectively, and therefore complied with the recommendation of the European Commission (< 15 %).

The SF of each animal was assessed by a group of 10 panellists that were selected based on their ability to perceive boar taint compounds (androstenone and skatole) and trained to detect off-odours characteristic to "boar taint" (androstenone and skatole odour) as described before (Meier-Dinkel et al., 2015; Mörlein et al., 2016). The olfactory acuity of the panellists towards androstenone and skatole was assessed using smell tests (repeated discrimination of the odorants in a triangle test; 10 ng androstenone or 5 ng skatole diluted in 20 µg propylene glycol vs odourless propylene glycol presented on smelling strips). All training and evaluation sessions were completed in the Laboratory for Sensory Analysis of the Göttingen University. For olfactory assessment of SF samples per assessor, individual subsamples of about 3 g (all fat layers, skin, hair, and meat removed) were heated for 80 s at 450 W in a microwave and immediately served. Each sample was labelled with a 3-digit code, and samples were served randomly. Samples were scored on a scale from 0 (no deviation from standard) to 5 (very strong deviation from standard). A sample was classified as olfactory tainted if the mean score was > 2. In each assessment session, 10 assessors out of a pool of 12 scored 30 fat samples individually; samples were presented in random order to each panellist.

2.5 Testes weight

Testes, including the epididymis, were removed after exsanguination and scalding and weighed immediately.

2.6 Statistical analysis

Data analysis of meat quality was carried out as ANOVA with the General Linear Model (Proc GLM, SAS software package version 9.4) considering genotype, feeding, and the interaction of genotype*feeding as fixed effects. For meat quality assessment, slaughter weight was used as a covariate. For boar taint analysis, slaughter weight, age, and testes weight were used as covariates. The LSQ-means were compared using the Tukey-Kramer test (significance level $p < 0.05$). Due to an extremely skewed distribution, data on androstenone, skatole, and indole concentrations were transformed (androstenone: reciprocal, skatole and indole: decadic logarithm). The interpretation of the results is based on the back-transformed values.

The chi-square test was used to compare the sensory prevalence of boar tainted fat samples between sire lines or feeding regimes.

3 Results and discussion

3.1 Meat quality

Table 1 shows the results for meat quality parameters. Slaughter weight as a covariate had a significant effect on all meat quality parameters except for electrical conductivity, mono- and polyunsaturated fatty acids in the muscle, and mono-unsaturated fatty acids in the SF.

Significant sire line x feeding interactions were found for pH 24 h p.m., redness, yellowness, drip loss, and mono- and polyunsaturated fatty acid content in the muscle. Sire line and feeding both significantly influenced intramuscular fat content of the muscle as well as the content of mono- and polyunsaturated fatty acids in the SF. Sire line significantly influenced meat lightness and the content of SFA of the muscle.

pH 24 h p.m. was significantly higher for both sire lines when feeding the control diet, with Pi sire lined pigs yielding the highest values. This is in contrast to Pauly et al. (2008) and Fang et al. (2014), who found no influence on muscle pH when feeding potato starch to entire male pigs or barrows. In any case, the measured pH values do not indicate inferior meat qualities in all trial groups.

Results for meat colour are inconsistent. While the meat of Du sire line pigs had higher a-values and lower b-values when fed the potato starch diet compared to the control diet and therefore slightly darker meat, it was vice versa in Pi sired pigs. Nevertheless, the meat of Du sired pigs was lighter than the meat of Pi sired pigs under both feeding regimes, whereas feeding raw potato starch had no significant influence on meat lightness. Latorre et al. (2009) also found that Du pigs had lighter meat when compared to Pi sired pigs, whereas a-values were distinctly lower and b-values higher than measured in this study.

Drip loss in control-fed Du pigs was significantly higher when compared to all other trial groups, whereas in Pi origins drip loss in control fed pigs was lower when compared to potato starch fed pigs. While Fang et al. (2014) found lower drip losses in pigs fed raw potato starch, Pauly et al. (2008) found higher drip losses in pigs fed raw potato starch. There were no significant differences in electrical conductivity between the sire lines or feeding strategies, and the measured values do not indicate inferior meat qualities.

Du origins significantly exceeded Pi origins in intramuscular fat content by 0.5 percentage points, and the test diet generated intramuscular fat contents that were 0.4 percentage points higher than those generated by the control diet. This is in accordance with several studies showing that including Du genotypes in fattening pigs can lead to higher IMF contents of the meat (Alonso et al., 2009; Alonso et al., 2015; Morales et al., 2013; Mörlein et al., 2007). As protein and/or lysine deficiency can lead to higher IMF contents in the muscle (D'Souza et al., 2008; Pires et al., 2016), the influence of feeding on IMF in this study can be ascribed to the lower content of protein and lysine in the trial vs control diet (15.1 % vs 17.7 % and 8.3 % vs 10.2 %, respectively). The IMF contents found in this study mostly exceeded the range of 1.5 to 2.5 %, which is regarded as optimal in terms of palatability (Fortin et al., 2005).

TABLE 1

Meat quality (LSQ) of entire male pigs depending on two different genotypes of the terminal sire line (Duroc, Du vs Piétrain, Pi) and two different feeding strategies (with (+) vs without (-) raw potato starch at the end of the finishing period)

	Du	Pi	-	+	Du-	Du+	Pi-	Pi+	SEM	Sire line	Feeding	Sire line x feeding
Animals *(n)*	*138*	*142*	*133*	*147*	*65*	*73*	*68*	*74*				
Ec 24 h p.m.	3.21	3.03	3.13	3.11	3.29	3.12	2.96	3.11	0.07–0.10	0.067	0.903	0.097
pH 24 h p.m.	**5.55**	**5.58**	**5.60**	**5.53**	**5.57**^{b}	**5.53**^{c}	**5.63**^{a}	**5.52**^{c}	0.01–0.01	**0.003**	< **0.001**	**0.001**
L*	**52.20**	**51.20**	51.80	51.60	52.14	52.17	51.44	50.93	0.21–0.30	**0.001**	0.430	0.363
a	10.60	10.63	10.55	10.67	**10.20**^{b}	**11.00**^{a}	**10.90**^{a}	**10.40**^{ab}	0.15–0.22	0.901	0.583	**0.005**
b	**2.15**	**3.21**	2.77	2.59	**2.70**^{bc}	**1.60**^{d}	**2.80**^{b}	**3.60**^{a}	0.14–0.20	< **0.001**	0.349	< **0.001**
DI (%)	3.65	3.32	3.60	3.37	**4.11**^{a}	**3.19**^{b}	**3.08**^{b}	**3.55**^{b}	0.14–0.23	0.122	0.285	**0.001**
Animals *(n)*	*91*	*83*	*79*	*95*	*39*	*52*	*40*	*43*				
IMF (%)	**3.03**	**2.45**	**2.58**	**2.89**	2.89	3.16	2.28	2.62	0.09–0.14	< **0.001**	**0.019**	0.790
SFA IMF (%)	**39.30**	**38.40**	38.80	38.80	39.31	39.26	38.35	38.37	0.15–0.24	< **0.001**	0.945	0.892
MUFA IMF (%)	53.56	53.50	**52.99**	**54.07**	**52.60**^{c}	**54.60**^{a}	**53.40**^{b}	**53.60**^{b}	0.19–0.30	0.858	**0.001**	**0.001**
PUFA IMF (%)	**7.16**	**8.14**	**8.18**	**7.12**	**8.10a**	**6.20 b**	**8.20**^{a}	**8.10**^{a}	0.21–0.33	**0.003**	**0.001**	**0.005**
SFA SF (%)	37.00	36.60	36.80	36.80	37.05	37.04	36.64	36.58	0.18–0.28	0.114	0.899	0.947
MUFA SF (%)	**45.10**	**46.70**	**45.30**	**46.50**	44.33	45.79	46.33	47.15	0.19–0.26	< **0.001**	< **0.001**	0.248
PUFA SF (%)	**17.90**	**16.60**	**17.80**	**16.70**	18.61	17.18	17.02	16.26	0.17–0.27	< **0.001**	< **0.001**	0.188

EC: Electrical conductivity; L*: Luminosity; a: Redness; b: Yellowness; DI: Drip loss; IMF: Intramuscular fat; SF: Shoulder fat; SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids
Different indices (a,b,c,d) indicate significant differences within sire line x feeding interaction

The content of SFA in the IMF of Du origins was significantly higher than in Pi origins and did not differ between feeding regimes. Percentage of MUFA in the muscle was significantly higher in Du pigs that were fed the test diet, while the content of PUFA was significantly lower in this group when compared to all other trial groups. This is in accordance with the results of Fischer et al. (2010), who found lower PUFA levels in the IMF when the IMF content of the muscle increased. Contents of PUFA in IMF were generally low compared to values found by Schwalm et al. (2013) and Grela et al. (2013) for organically kept pigs.

3.2 Boar taint and olfactory assessment of fat samples

Table 2 shows the results of the analyses of boar taint components in the SF samples. Androstenone content in SF of Du origins significantly exceeded its content in Pi origins, whereas the feeding strategy had no significant effect on androstenone content.

Breed differences for androstenone contents are known (Frieden et al., 2011), with Du breeds yielding higher values than others (Tajet et al., 2006; Xue et al., 1996). As the formation of androstenone is linked to the sexual maturation of pigs, this is ascribed to the earlier onset of puberty in Du origins. The levels of androstenone in Du origins found in this study are lower than those reported by Tajet et al. (2006) and Xue et al. (1996). Age at slaughter as a covariate had a significant effect on androstenone levels found in this study. Older animals (> 180 d) had slightly lower androstenone contents in fat than younger ones. This is in contrast to Thomsen et al. (2015), who found no influence of age on androstenone levels in boars. While Bonneau et al. (1987) found an effect of age on androstenone levels in young, light boars, in older boars the influence of body weight was more pronounced than the age effect. An effect of slaughter weight can be ruled out as it was fixed at 115 kg live weight, see our companion paper, part 1 (Werner et al., 2020). As the formation and metabolisation of androstenone are usually not influenced by dietary factors, an effect of feeding potato starch on androstenone levels was unlikely.

The content of skatole in the SF differed between sire line and feeding regime. In contrast to results of Dalmau et al. (2019), Babol et al. (2004) and Xue et al. (1996), skatole content in the SF of Du origins was lower compared to Pi origins and did not differ between feeding strategies. Values for Pi origins fed with the control diet significantly exceeded (2.45 times) the values of all other trial groups. Pi origins had a lower daily feed intake and the lowest daily gain when fed the control diet (Werner et al., 2020). Therefore, the age at slaughter was higher for those animals. Although not significant, the slightly higher age (191 d) of Pi origins fed the control diet compared to all other groups might have contributed to those values. Zamaratskaia et al. (2004) described an age-related rise in skatole values in pigs from 180 d upwards. Hence, it is unclear whether the lower skatole values of the Pi origins in the trial group are due to the feeding of potato starch. Furthermore, skatole values of Du origins did not differ between feeding strategies. Lösel and Claus (2005) found

TABLE 2

Contents (ng g^{-1} shoulder fat) of androstenone, skatole, and indole in entire male pigs from two different sire lines (Duroc, Du vs Piétrain, Pi) and two different feeding strategies (with (+) vs without (-) raw potato starch at the end of the finishing period)

	Du	Pi	-	+	Du-	Du+	Pi-	Pi+				
Animals *(n)*	*138*	*142*	*133*	*147*	*65*	*73*	*68*	*74*				
Mean									**SD**			
Androstenone	1152	958	1122	992	1187	1122	1062	863	802–994			
Skatole	29	67	69	29	30	28	107	30	50–140			
Indole	6	5	8	4	8	5	8	3	5–19			
LSQ Means (transformed values)									**SEM**	**Sire line**	**Feeding**	**Sire line x feeding**
Androstenone†	**522**	**595**	551	567	514	530	587	603	15–23	**0.001**	0.467	0.970
Skatole‡	**12**	**26**	**25**	**12**	**12**^{b}	**12**^{b}	**39**^{a}	**12**^{b}	3–4	**0.002**	**0.023**	**0.002**
Indole‡	3	2	3	1	3	2	3	1	0.5–0.7	0.456	**0.009**	0.481

† transformed with reciprocal value, ‡ transformed with the decadic logarithm
Significant differences within sire line or feeding ($p < 0.05$ Tukey-Kramer test), different indices (a,b,c,d) within row indicate significant differences between sire line x feeding groups

a reducing effect of feeding potato starch on skatole levels with application rates from 20 % onwards, which is twice as high as in this study. Taking into account that Aluwé et al. (2009) found no effect of feeding 10 % potato starch on skatole levels of boars, it can be assumed that the percentage of potato starch fed in this study was too low to show a reducing effect on skatole levels. Yet, in this trial, skatole values were low compared to other studies carried out under conventional conditions (Aldal et al., 2005; Borrisser-Pairó et al., 2016; Claus et al., 1994). This could be ascribed to the offering of roughage, which is mandatory in organic pig feeding. Silage is known to have positive effects on intestine health due to its fibre content, and fibre-rich feedstuffs can reduce the formation of skatole in the large intestine (Hansen et al., 2008). As the skatole contents in this study were already low due to the feeding of roughage, it is possible that the feeding potato starch showed no further reducing effect. A further trial was conducted recently to answer this question.

Similar contents of indole in subcutaneous SF were found in both sire lines, whereas feeding raw potato starch before slaughter reduced indole content by 54 % compared to the finishing diet without raw potato starch. This is in contrast to results of Aluwé et al. (2009), Pauly et al. (2008), and Chen et al. (2007), who found no effect of feeding potato starch on indole levels. The authors of those studies assumed that the various types of bacteria responsible for the synthesis of indole were not affected by raw potato starch, as it was the case for skatole in these experiments. The question remains whether the feeding of silage in this trial interacted with the content of potato starch in the experimental diet. This could have an influence on the composition of bacteria in pig's intestines and therefore on the formation of indole.

The prevalence of boar taint depends on the method of categorisation. Rejection thresholds for taint in meat products are often the result of consumer studies, where chemical analyses and sensory evaluation are collated. Chemical rejection thresholds between 0.15 and 0.25 µg g^{-1} fat for skatole and between 0.5 and 3.0 µg g^{-1} fat for androstenone have been discussed (Bonneau and Chevillon, 2012; Lunde et al., 2010; Lundström et al., 2009). *Figure 1* shows the distribution of the analysed contents of androstenone and skatole in the fat depending on the sire line and feeding regime in this trial.

Mostly Pi origins fed the control diet exceed the chemical cut off values for skatole content (e.g. low cut-off = androstenone < 1.50 or skatole < 0.20 µg g^{-1} liquid fat and high cut-off = androstenone < 2.00 or skatole < 0.25 µg g^{-1} liquid fat). Values higher than the cut-off values for androstenone were found in samples from all origins and feeding regimes. Comparing these results to other studies is difficult as breed, feeding system, and different methods of laboratory analyses may have an influence on androstenone and skatole levels (Ampuero Kragten et al., 2011; Mörlein et al., 2015). However, as results of sensory analyses and chemical composition often differ (Meier-Dinkel et al., 2015) and the sensitivity to boar taint is highly variable between individuals, the classification of boar tainted meat for consumer purposes only based on chemical composition could be deceptive. *Table 3* shows the percentage of the taken fat samples classified as having deviant odour by assessors highly sensitive to androstenone or skatole odour. In total, 21.8 % of all samples were classified as deviant (sensory mean ≥ 2; scale ranges from 0 to 5), i.e. with noticeable androstenone or skatole odour. No significant differences were found for the prevalence of boar taint in fat between sire lines or feeding regime.

According to the distribution of chemical analyses (see *Figure 1*), the percentage of skatole-tainted samples was significantly higher in Pi origins. Androstenone and skatole contents in fat clearly influenced the sensory scoring thereof.

However, the comparison of chemical analyses and sensory evaluation scores reveals that for this study sensory classification of up to 10 % of the samples was a false positive or false negative. Furthermore, the classification of boar

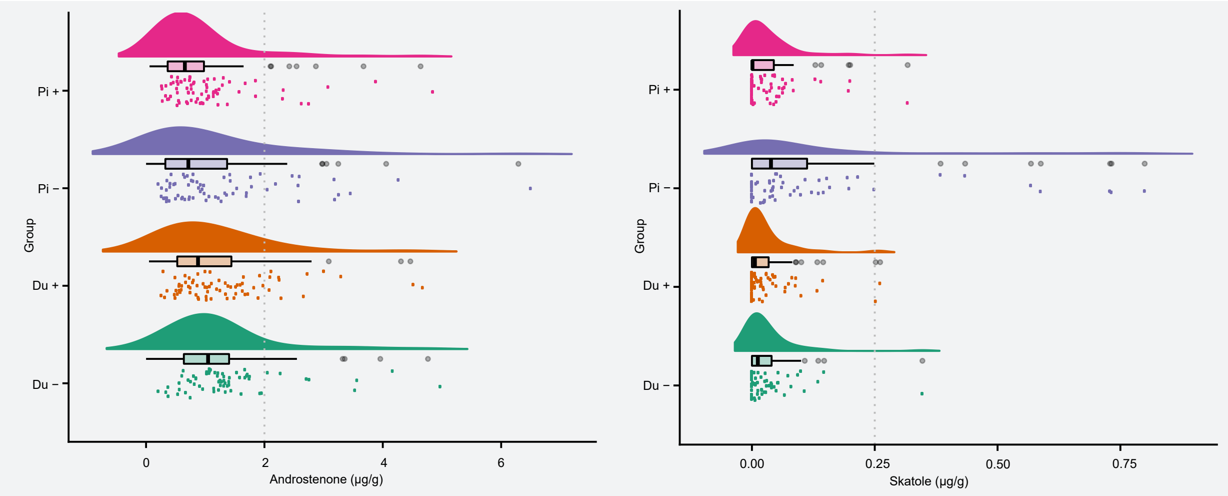

FIGURE 1
Distribution of androstenone and skatole concentrations (µg g-1 shoulder fat) according to sire line and feeding group (Du: Duroc; Pi: Pietrain; -: without potato starch; +: with potato starch) within chemical cut-off values (dotted line) of 2 µg g-1 for androstenone and 0.25 µg g-1 for skatole respectively

TABLE 3
Percentage of fat samples without/with noticeable boar taint depending on sire line (Duroc, Du vs Piétrain, Pi) or feeding strategies (with (+) vs without (-) raw potato starch) as classified by trained sensory assessors

	Du % [n]	Pi % [n]	Total % [n]	- % [n]	+ % [n]	Total % [n]
X^2	*(1, N = 280) = 0.095, p = 0.758*			*(1, N = 280) = 0.00005, p = 0.99*		
Standard	79.0 [109]	77.5 [110]	78.2 [219]	78.2 [104]	78.2 [115]	78.2 [219]
Deviant †	21.0 [29]	22.5 [32]	21.8 [61]	21.8 [29]	21.8 [32]	21.8 [61]
Total	49.3 [138]	50.7 [142]	100 [280]	47.5 [133]	52.5 [147]	100 [280]

† Deviant = Sensory value (mean) ≥ 2. Original scale from 0 (0 = no aberrant odour) to 5 (5 = very strong aberrant odour) compared to standard fat. Scale point 2 (noticeable smell of androstenone or skatole) was referenced using a smelling strip

carcasses based on chemical cut-off values or sensory panels by trained assessors might lead to the rejection of a higher percentage of boar carcasses than necessary due to consumer sensitivity towards boar-tainted meat. Meier-Dinkel et al. (2016b) showed that consumers seemed to be less sensitive to sensory defects of meat than trained panellists. Overall, consumer liking of the boar meat presented in a tasting decreased if the expert panel fat score was ≥ 3. Considering above-mentioned chemical and sensory categorisations of the fat samples, e.g. low cut-off, high cut-off, and deviant odour (≥ 2), 21.8 % or 14.3 % of the boar carcasses from this trial would be considered at risk for decreased consumer acceptance due to noticeable off-odours. Raising the threshold for the definition of sensory deviant to a mean value of 2.5 or 3.0 would lead to a reduction to 11.8 or 6.4 % of rejected carcasses, respectively (see *Table 4*).

TABLE 4
Prevalence of deviant fat samples (with boar taint) depending on different classification levels (sensory assessment and analytical cut-off values), n = 280

Classification	Definition of "deviant"	% [n]
SENS *	Mean of assessment ≥ 2	21.8 [61]
	Mean of assessment ≥ 2.5	11.8 [33]
	Mean of assessment ≥ 3	6.4 [18]
CHEM LOW	Androstenone ≥ 1.5 or Skatole ≥ 0.20 µg g-1	21.8 [61]
CHEM HIGH	Androstenone ≥ 2.0 or Skatole ≥ 0.25 µg g-1	14.3 [40]

* Original scale from 0 (0 = no aberrant odour) to 5 (5 = very strong aberrant odour) compared to standard fat. Scale point 2 (noticeable smell of androstenone or skatole) was referenced using a smelling strip

3.3 Testes weight

No significant differences were found for testes weight between sire lines or feeding regime and their interaction. Mean testes weight was 688 g and 704 g for Du and Pi origins, respectively. Boars fed the control diet had lighter testes than boars fed potato starch (689 g vs 703 g). A highly significant but weakly positive correlation ($p < 0.001$; $r=0.25$) was found between testes weight and analysed androstenone content in the SF. Aldal et al. (2005) found that testes weight was higher for pigs with high androstenone values at slaughter and that testes weight was correlated with testes volume. Bekaert et al. (2012) and Bernau et al. (2018) found that testes volume was correlated with the chemical and sensory content of androstenone in fat, respectively, but stressed that time of measurement has to be taken into account and additional factors could improve the accuracy of prediction. To use testes weight as a precise predictor for the occurrence of boar taint, individual on-farm correlations would have to be calculated as breed, environment, and management clearly influence the development of both factors.

4 Conclusion

Skatole levels in the fat of entire male pigs were considerably low in this study, which might be attributed to the organic feeding conditions. The feeding of roughage in particular could weaken the reducing effect of potato starch on skatole levels. As Pi origins had significantly lower androstenone contents compared to Du origins and the meat qualities of boars in this study were satisfactory considering the extensive feeding regime, the use of this breed under organic conditions without additional measures concerning feeding strategies seems feasible.

The contents of androstenone and skatole in the fat influenced the sensory evaluation of the samples, whereas the sire line and feeding had no significant influence on sensory classification. The percentage of animals exceeding the frequently used chemical or sensory cut-off values for potentially boar-tainted meat was high in this study (up to 21.8 %).

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RESEARCH ARTICLE

Welfare of dairy cattle in summer and winter – a comparison of organic and conventional herds in a farm network in Germany

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HIGHLIGHTS

- **On average, dairy cows on organic farms showed a better welfare status in the Welfare Quality® principles 'Good Housing', 'Good Health' and 'Appropriate Behaviour'.**
- **Pasturing, high space allowance and littering might be crucial for high animal welfare levels.**

KEYWORDS **dairy cows, animal welfare, farming system, Welfare Quality®**

Abstract

Dairy cow welfare in 19 organic and 15 conventional farms in distinct soil climate regions of Germany was examined using the Welfare Quality® assessment protocol for dairy cattle (WQ®). In comparison to other studies, this one is outstanding in that (a) the WQ® protocol was carried out twice per farm (in the winter period 2014/2015 and in the following summer period) and that (b) some parameters were measured directly on pasture, if pasture access was provided on the farm during the summer period. At the level of WQ® principles, significantly lower scores (Mann-Whitney U test, $P<0.05$) were found in the summer period for 'Good Feeding' (more very lean cows and insufficient water provision). Higher scores for 'Good Housing' (reduced duration of lying down movements and more cleanliness of cows) were recorded in summer compared to the winter period. Furthermore, significantly higher mean scores were found in organic herds at the level of the WQ® principles in 'Good Housing' (in summer period), 'Good Health' and 'Appropriate Behaviour' (in both periods). For the underlying criteria and measures, the organic farms had, on average, higher scores for resting comfort (lying behaviour, not parameters of cleanliness) especially in summer, fewer lame animals (in both periods) and fewer animals with ocular discharge (especially in the summer period). Also, the better scores for 'Absence of pain induced by management procedures' which are related to disbudding of calves and the respective pain management on the farms influenced this result. Additionally, less agonistic behaviour (number of head butts) and a lower avoidance distance (in terms of more 'cows that can be touched') were observed in organic farms in both periods. The ranges of all values and scores of WQ® assessment were broad in both periods and farming systems. Generally, the results show that the impact of management factors individual to farms on animal welfare is high.

1 Introduction

Animal welfare is understood as a multidimensional concept with three superordinate dimensions: i) basic health and function, ii) natural living, and iii) affective states (Fraser, 2008). Although the importance attributed to each of the three dimensions of animal welfare is controversial, it is widely accepted that all of them should be considered for a comprehensive assessment of animal welfare (BMEL, 2017).

Especially in recent years, animal welfare has gained much attention from the general public in debates about sustainable livestock farming, including in Germany. Animal welfare, including that of dairy cows, is a high priority in organic farming, as explicitly stated in the organic standards of the European Union (Commission Regulation (EC) No 889/2008 and Regulation (EU) 2018/848). For example, the stocking density in buildings should provide for the comfort, the well-being, and the species-specific behavioural needs of the animals, and animal-health management should focus mainly on disease prevention. Hence, several conditions are set

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in organic farming to support a high standard of dairy cow welfare. The question, however, arises whether dairy cow welfare is better on organic farms compared to conventional farms in practice. So far, published studies investigating the effect of the farming system on this topic have mostly focused on particular aspects of welfare, such as lameness (Weller and Cooper, 1996; Rutherford et al., 2009; Barker et al., 2010). Studies involving a comprehensive assessment of overall dairy cow welfare on organic and conventional farms are very rare in the literature. One exception is from March et al. (2017), who assessed dairy cow welfare using the Welfare Quality® assessment protocol for dairy cattle (WQ®, 2009) on 46 organic farms and on 69 conventional farms in two federal states. They conducted this only during the winter period (i.e. indoor housing period) and in two federal states of Germany (North Rhine-Westphalia and Mecklenburg-Western Pomerania). The authors concluded that organic farming can have higher standards of dairy cow welfare since organic farms achieved better scores in all of the four WQ® principles (i.e. 'Good Feeding', 'Good Housing', 'Good Health', and 'Appropriate Behaviour').

In organic farming, it is mandatory to provide cattle access to pasture whenever the conditions allow this, i.e. at least during the summer period. Zero-grazing is allowed only with the extra permission of local control bodies. In a recent study of major farm types, 95 % of organic dairy farms in Germany offered pasture access for 11.9 (±6.8) hours per day on average (Ivemeyer et al., 2018). However, in conventional farming, pasture access for dairy cows is not mandatory and thus determined mainly by regional and organisational preferences. According to official census data of 2010, 42 % of all German dairy cows (organic farms included) had access to pasture (Statistisches Bundesamt, 2011). 50 % of herds between 50 and 99 cows had pasture access compared to only 30 % of herds with more than 100 cows (Lindena et al., 2017). Several reviews have highlighted potential beneficial effects of pasture on behaviour (e.g. facilitation of natural behaviour) and improved performance (Smid et al., 2020), but smaller milk yield and better health (with lower levels of lameness, hoof pathologies, hock lesions, mastitis, uterine disease, and mortality (e.g. Arnott et al., 2017). Furthermore, Armbrecht et al. (2019) showed that dairy herds with high daily pasture access were scored higher in 'comfort around resting' and 'absence of injuries' compared to farms without pasture access or with only a few hours of daily pasture access when assessed using the WQ® protocol directly after the end of the grazing season. These effects were not maintained over the winter housing period. Therefore, pasture access is a major factor in determining differences between organic and conventional farms in the outcome of WQ® assessment in behaviour and health parameters especially in the summer period.

The WQ® protocol prescribes that the assessment of the animals and of equipment is to be performed in the housed environment (called 'in the barn' in the following text) to depict the general situation under comparable conditions. However, we were also interested in a comparison of farms with and without pasture access in the actual environment of cows in the summer period. At least in most organic farms this environment is an important part of the cows' lives. To be able to show possible differences, we modified the WQ® procedure in summer: We expected the indicators 'lying behaviour', 'water provision', 'social behaviour', and 'qualitative behaviour assessment' to be different on pasture compared to the barn environment. Hence, we assessed these indicators on pasture, if offered on the farm, instead of in the barn.

The hypotheses of our study were that (1) dairy cow welfare is especially enhanced in the summer period where many farms provide pasture access, and (2) a higher level of dairy cow welfare is achieved in the organic farms compared to conventional farms in both winter and summer due to the standards of organic farming which were designed to support animal welfare.

2 Materials and methods

This study was carried out within the framework of the project entitled 'Increasing Resource Efficiency by Optimizing Crop and Milk Production on Whole Farm Level under Consideration of Animal Welfare Quality Aspects' (www.pilotbetriebe.de). This project developed from another project that ran between 2008 and 2014 and dealt with greenhouse gas emissions in agricultural systems. A total number of 80 farms in various climatic and soil regions in Germany (Bavarian Tertiary Hill Country and Allgaeu, the North Sea and Baltic Sea coastal areas, the Rhine basin, the Westphalian basin and low mountain areas, and the East German inland area) were analysed. 44 of the farms were dairy farms. These regions correspond with the typical structure and management on German dairy farms, as for example, described by Ivemeyer et al. (2018) for the organic sector, Lindena et al. (2017), and DLQ (2017). These authors characterise the dairy farms in the regions as follows: South Germany with high farm numbers, small herds, low milk yield and, in conventional farms, low pasturage; West Germany with medium to low farm numbers, medium herd size, high milk yield and, in conventional farms, frequent pasturage; North Germany with medium farm numbers, medium to large herds, high milk yields and, in conventional farms, frequent pasturage; and East Germany with low farm numbers, large herds, high milk yield and, in conventional farms, low pasturage.

In addition to representing regional aspects, selected farms were run full-time, each was twinned with a comparative farm (organic paired with conventional; however, since 2008, some twins stopped participating in the farm network, e.g. because of stopping farming altogether), and each passed a test for data availability and willingness to cooperate in the longer term. In addition, all organic farms had to have practiced organic farming for at least seven years before the start of the farm network to avoid interference from the effects of conversion. According to the expert knowledge of the project group and in comparison with agro-structural data, the farms represented typical organic and conventional management in German dairy and arable production. The main characteristics of the farms are presented in *Table 1*.

TABLE 1
Main characteristics of the analysed farm sample

Region	Organic farms				Conventional farms			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
South:	5	5883	34	4 (10)	5	7626	52	0 (0)
West:	6	7185	91	2 (8)	4	9074	134	3 (7)
North:	4	6559	68	4 (13)	3	8712	148	2 (8)
East:	3	6248	85	2 (6)	4	9375	501	0 (0)

(1) numbers of farms in the sample [n]; (2) average milk yield [kg cow^{-1} year^{-1}]; (3) herd size [n]; (4) number of farms with pasturage [n] and, in brackets, hours per day with pasture access on these farms in the summer period [h day^{-1}]

In this paper, dairy cow welfare based on the WQ® protocol (2009) was analysed for the 34 (19 organic, 15 conventional farms) of the farms that were still in the network and offered loose housing systems.

We also assessed the resting environment and lying conditions (i.e. type of lying area, litter, lying surface and softness of bedding) in the winter period. Softness was determined by the knee test (according to McFarland and Graves (1995), with the scale (1=hard, 2=medium/intermediate, 3=soft) on five randomly chosen places in the lying areas. This information together with details of the disbudding procedures in the dairy farms are presented in the results section to allow a deeper discussion on the possible role of these factors for the outcome of WQ® assessment. The data on milk yield per cow and year were generated from data from the milk recording scheme (MLP) or from farm records.

The farms were neither randomly selected from all farms in Germany nor within the regions. The results of this study therefore cannot be regarded as representing Germany or its regions. But they can be used to draw attention to and explain differences in the results of dairy cow welfare assessment between summer and winter in typical German farming situations and to discuss the effects of general management in organic and conventional farming systems on dairy cow welfare.

2.1 Assessment of animal welfare

Assessment of dairy cow welfare was done by applying the WQ® protocol (2009). It is based mainly on animal-related measures (i.e. measures that are taken directly from the animal). It uses a 'bottom-up' approach (*Table 2*). About 30 indicators (so-called measures) were assessed on a representative number of animals. The results were aggregated to define a score value for 12 criteria, which in turn were aggregated into scores for four principles (*Table 2*). The 'overall welfare score' is not presented in this study because it does not add information needed for dealing with our hypotheses.

At the levels of criteria and principles in the WQ® protocol, a value of 0 corresponds to the worst and a value of 100 to the best of all possible values.

TABLE 2
Principles, criteria, and measures (indicators) of the Welfare Quality® assessment protocol for dairy cattle (2009)

Principles	Criteria	Measures
Good Feeding	1. Absence of prolonged hunger	Body condition score
	2. Absence of prolonged thirst	Water provision, cleanliness of water points, water flow, functioning of water points
Good Housing	3. Comfort around resting	Time needed to lie down, animals colliding with housing equipment during lying down, animals lying partly or completely outside the lying area, cleanliness of udders, flank/upper legs, and lower legs
	4. Thermal comfort	*As yet, no measure is developed*
	5. Ease of movement	Presence of tethering, access to outdoor loafing area or pasture
Good Health	6. Absence of injuries	Lameness, integument alterations
	7. Absence of disease	Coughing, nasal discharge, ocular discharge, hampered respiration, diarrhoea, vulvar discharge, milk somatic cell count, mortality, dystocia, downer cows
	8. Absence of pain induced by management procedures	Disbudding/dehorning, tail docking
Appropriate Behaviour	9. Expression of social behaviours	Agonistic behaviours (assessed by observation of head butts and displacements)
	10. Expression of other behaviours	Access to pasture
	11. Good human-animal relationship	Avoidance distance
	12. Positive emotional state	Qualitative behaviour assessment (assessed by observation of cows' 'body language')

As yet, no measure is developed to assess the criterion 'Thermal comfort', and the missing criterion-score is currently replaced by the best score among the criteria 'Comfort around resting' and 'Ease of movement' (WQ®, 2009). The criterion 'Ease of movement' has five classes according to different housing systems, with possible scores between 0 (continuously tied) and 100 (loose housing). In this study all farms provided loose housing systems and therefore had a score of 100. Thus all farms got a value of 100 in 'Thermal comfort'. Therefore the values are not further discussed or listed in the following.

The whole WQ® assessment procedure set out in the protocol was conducted twice on each farm: once during winter 2014/2015 and once during summer 2015. In accordance with the instructions, animal-related assessments were carried out at each farm in a fixed order and, except for the assessment of behavioural measures, a sample of cows was chosen at random. Number of cows chosen depended on the herd size.

Indicators relating to disease were generated from MLP data and the German central data base on identification and information on animals as well as from farmer interviews and some animal-related measures. As defined by WQ®, cows with milk somatic cell counts equal or above 400,000 were counted as cows with mastitis. The data on the parameters '% of dystocia' and '% of downer cows' as well as information regarding management routines (e.g. disbudding of calves and access to pasture) were gathered during farmer interviews.

During the winter survey, all other WQ® data were collected in the barn. During the summer survey, water supply, lying behaviour, social behaviour, and qualitative behaviour assessment (QBA; defined by 20 terms of body language) were recorded on pasture where pasture was provided on the farm. As mentioned in the introduction, this assessment procedure differs from the guidelines given in the WQ® protocol. Assessing these measures on pasture might be a double counting of advantages in the WQ® principle 'Appropriate Behaviour' because pasturing is already included in the criterion 'Expression of other behaviour' (*Table 2*). However, especially measures determining the 'Comfort around resting' were expected to be different in the barn compared to the outdoor situation on pasture and also influence parameters such as lameness and cleanliness which is supposed to other welfare principles such as 'Good Health'. As we were interested in comparing differences between dairy management systems, we decided to diverge from the WQ® protocol in these points. However, all other data of the WQ® protocol (e.g. assessment of avoidance distance) in the summer period were collected in the barn.

Thus, only the results of our assessment in the winter period are comparable to other studies following the WQ® protocol.

Three different assessors collected data. They were experienced in evaluating dairy cattle before and were trained intensively by a qualified person with many years of experience in the methodology of the WQ® protocol for dairy cattle. Multiday training courses consisted of theoretical exercises with photographs and videos as well as practical exercises on different dairy cattle farms. Inter-observer reliability testing took place after each of the training courses before data survey in the summer and winter period. To estimate inter-observer reliability in the this study, prevalence-adjusted bias-adjusted kappa (PABAK) values were calculated for all animal-related measures (e.g. scoring of body condition) based on observation of 20 animals in two practical farms with > 70 dairy cows. The PABAK values averaged 0.5 to 0.9 and, thus, indicated an adequate to very good alignment (Fleiss et al., 2003; Dippel et al., 2009) between all assessors for all animal-related measures. Regarding the assessment of lying behaviour and of social behaviour on the basis of video material, inter-observer reliability, measured as Pearson correlation coefficient, ranged from 0.4 to 0.7 and from 0.4 to 0.8 (arithmetic mean of 0.6 for both), respectively.

2.2 Statistical analysis

Statistical analyses were conducted using the software JMP® 15.0.0 (SAS Institute Inc., Cary, NC, USA). All parameters of animal welfare were evaluated at herd level. To avoid merging the results gained with the different assessment technique by diverging from the standards of the WQ® protocol in the summer period, we did not analyse and compare mean values of results for the organic and conventional farming systems over both periods.

Normal distribution of data was analysed by the Anderson-Darling test and visual analysis of QQ-Plots. Data on milk yields per year in organic and conventional farms were normally distributed. When looking at the data distribution in all groups of interest (groups are: all farms, organic farms, conventional farms in summer or winter, see groups in *Table 3*), normal distribution was only given in 42 % of cases for the different measures, in 45 % of cases for the different criteria and in 62 % of cases for the different principles. We were not able to reduce the error of the residues with any type of data transformation within the different groups when comparing to normal distribution in most of the cases, therefore the original data were used for the analyses.

Mann-Whitney U tests were conducted throughout for one-factorial comparisons of means of WQ® data obtained in the two periods of the year: for all farms and for the two farming systems (i.e. organic and conventional). Categorical data we gained for the types of the resting environment (lying area, litter, lying surface and its softness) and for procedures used for disbudding of calves were analysed with contingency tables and Chi²-tests. The Fishers exact test was used in the latter parameters when the observation numbers were low in the groups (Everitt, 1992). Effects of the farm type on the number of lactating cows kept in the farms and farming systems and in both periods were analysed with one factorial analysis of variance (F-test). Here and for differences between the average milk yields or the number of days on pasture between the periods, or farming systems in the periods, group means were compared by the Tukey test. Significance of group differences was declared at $P<0.05$ for all comparisons mentioned above. Pearson correlation coefficients between average milk yields per cow on the farms and the results in scores on 'Welfare Principles' were calculated. To visualise trends and data distributions, scattergrams with density ellipses are given.

3 Results

In the milk record year October 2014 to September 2015, the mean milk yield per cow and year was 6,513 kg for organic farms and 8,579 kg for conventional farms. The mean herd size was 125 and 115 cows at the time of the winter and the summer survey, respectively. 17 of the organic farms and only six of the conventional farms provided access to pasture. The average number of days with pasture access was 136.5 on organic and 71.5 on conventional farms. There were significant differences between all the means for the organic and conventional farming systems (*Table 3*).

The lactating cows were mostly kept in cubicle barns (13 organic and 13 conventional farms) or had free deep litter lying areas (6 organic and 2 conventional farms). Deep litter bedded cubicles were more frequent on organic farms (11 organic and 4 conventional farms). Rubber and comfort mattresses were more frequent on conventional farms (1 organic farm and 8 conventional farms). The other farms offered littered concrete lying surfaces (5 organic farms and 2 conventional farms) (*Table 4*). The softness of the lying surface was best on straw deep litter beds (in free lying areas or cubicles). The softness of straw deep litter beds (in free lying areas or cubicles) was predominantly categorised as soft, and in some cases as medium. Straw deep litter beds were found on 13 organic (68 % of farms) and 5 conventional (33 %) farms. Soft and medium soft surfaces in the lying areas were significantly more frequent in organic farms (*Table 4*).

Table 5 shows data on the practice of disbudding found in the winter and summer period and the farming systems.

TABLE 3
Comparison of average milk yields, days with pasture access and number of cows in the analysed farming systems and periods (means and extreme values; Tukey test)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farm Type:	All farms (n = 34)			Organic (n = 19)	Conventional (n = 15)		Organic (n = 19)	Conventional (n = 15)	
Number of lactating cows	125 (24–661)	115 (16–726)	0.736	65 (16–200)	178 (35–726)	**0.044**	74 (24–230)	189 (39–661)	**0.032**
Milk yield per cow kg	7425 (4303–10947)			**Both periods:** Organic: 6514 (4303–9257) Conventional: 8579 (5887–10947)					**<0.001**
Number of days on pasture per year	136.5 (0–290)			**Both periods:** Organic: 187.8 (0–290) Conventional: 71.5 (0–230)					**<0.001**

TABLE 4
Data scores for resting environment and lying conditions for dairy cows found in the analysed farming systems in the winter period (contingency table analysis, Chi²-test or Fishers exact test)

	Housing		P-value	Softness, knee test			P-value
	Organic	Conventional		hard	medium	soft	
Lying area			**0.007**				**0.046**
Free	6	2		0	1	7	
Cubicle high	2	9		5	4	2	
Cubicle deep litter bed	11	4		3	4	8	
Litter			**0.014**				0.726
No	0	4[+]		1	2	1	
Straw short	8	7		4	4	7	
Straw long	11	4		3	3	9	
Lying surface			**0.013**				**0.012**
Concrete (with straw litter)	5	2		4	2	1	
Rubber (most with straw litter)	1	8[*]		4	3	2	
Straw deep litter bed, free lying area	6	2		0	1	7	
Straw deep litter bed, cubicle	7	3		0	3	7	
Softness, knee test			**0.039**				
hard	2	6					
medium	4	5					
soft	13	4					

[+] rubber mattresses; [*] including one farm with comfort rubber mattresses

Disbudding of calves was the only horn reduction practice used. Dehorning of cows or tail docking were not reported in the interviews with the farmers. 100 % of cows on the conventional farms had been disbudded as calves whereas in the mean of organic farms only 21 or 24 % of calves (winter and summer period) had undergone this procedure (P<0.001). 13 organic farms (68 % of farms) used no disbudding of calves and had horned herds. Lots of farm managers reported that that they are increasingly introducing genetically polled (hornless) types into their dairy herds through breeding. Thermocautery was the main disbudding practice used on the farms. Use of anaesthetics, analgesics or both was much more frequent in organic farms. This practice increased in both farming systems in the summer survey.

The mean scores over all farms differed significantly in the WQ® principles 'Good Feeding' and 'Good Housing' between winter and summer (P=0.005 and P=0.034, *Table 6*). There were no significant differences between the periods for the criterion 'Absence of prolonged hunger' or for the parameter 'Percentage of very lean cows' (*Table 7*). But there were significant differences in the criterion 'Absence of prolonged thirst' with a significant lower average score apparent in the summer compared to the winter period (*Table 6*). Although means for all above mentioned parameters were higher in organic herds compared to the conventional herds in both periods, differences in means between organic and conventional farms are not significant (P>0.05, *Table 6* and *Table 7*).

The inclusion of data for 'Thermal Comfort' and 'Ease of movement' (as described above, the scores were similar in all farms) into the calculation of the scores for 'Good Housing' resulted in significant higher values over all farms in the summer period (P=0.005). This is due to differences in the data relevant to the criterion 'Comfort around resting' (*Table 7*). In the summer period the mean 'Duration of lying down movements' of cows was significantly shorter (P<0.001) and the mean 'Percentage of cows with dirty flank/upper legs' was significantly lower (P=0.002) than in the winter period. Similarly, the scores for the WQ® principle 'Good housing' and the underlying criterion 'Comfort around resting' were significantly higher on the organic farms in the summer period (P=0.017), but not in the winter period (P=0.377, *Table 6*). In summer the mean values of 'Percentage of cows colliding with housing equipment' (P=0.003) and the 'Number of cows lying outside the lying areas' (P=0.038) were significantly reduced in the mean of the organic farms compared to the conventional farms (*Table 7*).

Also, lower mean values for 'Duration of lying down movements' (P=0.036) and 'Collisions with housing equipment' (not significant) were apparent on the organic farms in winter, whereas means for the measures 'Cows lying outside the lying area' and for some parameters of 'Cleanliness' were partly but not significantly higher in this farming system (*Table 7*).

In contrast to the latter two WQ® principles, we found no significant differences between the average scores of the principle 'Good Health' and its underlying criteria over all farms between summer and winter period (*Table 6*).

However, 'Good Health' was found to be significantly enhanced in the mean of organic herds in comparison to the conventional herds in both separate periods (*Table 6*). At the level of criteria that are determining 'Good Health' (i.e. 'Absence of injuries', Absence of disease' and 'Absence of pain induced by management procedures'), all mean scores were higher on organic farms in both periods. But the differences in means were only significant for the 'Absence of pain induced by management procedures' (P<0.001, *Table 6*). Concerning the measures influencing 'Good Health' (*Table 8*), the 'Percentage of cows with at least one hairless patch but no lesion' was found to be increased in winter (P=0.008). On the other hand, 'Ocular discharge' (P=0.009) and 'Diarrhoea' (P=0.005) occurred more frequently in summer.

TABLE 5

Data on the practice of disbudding of calves and the methods of pain relief used in winter and the following summer period on the analysed organic and conventional dairy farms (Mann-Whitney U test, contingency table analysis, Chi^2-test, Fishers exact test)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farm Type:	All farms (n = 34)			Organic (n = 19)	Conventional (n = 15)		Organic (n = 19)	Conventional (n = 15)	
Disbudded cows in herd (%)	54.4 (0–100)	57.5 (0–100)	0.8	21.1 (0–100)	96.7 (50–100)	**<0.001**	24.0 (0–100)	100 (100–100)	**<0.001**
Number of farms not disbudding calves and if, method used:			1.000			**<0.001**			**<0.001**
No disbudding	13	13		13	0		13	0	
Thermocautery calves	20	20		6	14		6	14	
Caustic paste calves	1	1		0	1		0	1	
Number of farms with the use of: Anaesthetics	6	17	**0.002**	5	1	**0.002**	6	11	0.281
Analgesics	8	16	**0.028**	5	3	**0.014**	6	10	0.262
Both	4	15	**0.002**	4	0	**0.003**	6	9	0.123

TABLE 6

Scores (mean (min–max)) for the four Welfare Quality® principles with the underlying twelve criteria in winter and summer period on all farms and comparison of the scores on organic and conventional farms (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Periods:	Winter	Summer	P–value	Winter		P–value	Summer		P–value
Farm Type:	All farms			Organic	Conventional		Organic	Conventional	
Good Feeding	46.5 (5.9–99.9)	33.50 (6.3–99.9)	**0.034**	51.7 (11–99.9)	39.8 (5.9–99.9)	0.298	36.2 (6.6–99.9)	30 (6.3–99.9)	0.282
1. Absence of prolonged hunger	70.2 (23.4–99.9)	65.7 (30.9–99.9)	0.479	73.2 (30.9–99.9)	66.4 (27.3–99.9)	0.384	68.7 (33.1–99.9)	61.9 (30.9–99.9)	0.273
2. Absence of prolonged thirst	50.6 (3.0–100)	32.9 (3.0–100)	**0.041**	58.1 (3.0–100)	41 (3.0–100)	0.216	36.4 (3.0–100)	28.5 (3.0–100)	0.57
Good Housing	61.6 (42.4–72.1)	67.9 (37–86.3)	**0.005**	63.1 (42.4–70.9)	59.7 (42.4–72.1)	0.377	72.7 (47.3–86.2)	61.8 (37–86.3)	**0.017**
3. Comfort around resting	39.1 (8.6–55.7)	49.1 (0–78.2)	**0.005**	41.5 (8.6–53.8)	36 (8.6–55.7)	0.377	56.7 (16.4–78.2)	39.4 (0–78.2)	**0.017**
Good Health	44.1 (27.6–70.6)	48.4 (27.6–83.9)	0.098	49.3 (35.9–70.6)	37.6 (27.6–51.7)	**<0.001**	52.3 (33.2–83.9)	43.5 (27.6–59.5)	**0.043**
6. Absence of injuries	65.5 (28.6–90.3)	67.1 (29.8–98.1)	0.816	68 (45.4–84.4)	62.3 (28.6–90.3)	0.218	71.6 (54.7–95.2)	61.4 (29.8–98.1)	0.08
7. Absence of disease	40.6 (22.2–64.6)	41.9 (17.8–86.0)	0.716	40 (22.3–64.6)	41.3 (27.4–64.6)	0.780	43.9 (17.8–86.0)	39.4 (20–56.6)	0.561
8. Absence of pain induced by management procedures	64.7 (20.0–100)	78.1 (28.0–100)	0.108	89.5 (49.0–100)	33.3 (20.0–52.0)	**<0.001**	92.1 (75.0–100)	60.3 (28.0–75.0)	**<0.001**
Appropriate Behaviour	52.7 (26.7–83. 9)	52.4 (23.4–86.5)	0.980	64.8 (33.5–83.9)	37.3 (26.7–71)	**<0.001**	64.8 (35.8–86.5)	36.6 (23.4–66)	**<0.001**
9. Expression of social behaviours	69.2 (13.3–97)	72.9 (2.3–100)	0.202	74.8 (40.7–97)	62.1 (13.3–91.4)	0.067	79.2 (29.6–100)	64.9 (2.3–91.7)	0.15
10. Expression of other behaviours	47.5 (0–89.9)	47.5 (0–89.9)	1.000	66.1 (0–89.9)	23.9 (0–82.4)	**0.001**	66.1 (0–89.9)	23.9 (0–82.4)	**0.001**
11. Good human–animal relationship	58.3 (31.7–87.9)	56.7 (28.5–89.6)	0.699	66.8 (34.7–87.9)	47.6 (31.7–71)	**0.002**	65.1 (31.4–89.6)	46 (28.5–66.3)	**0.004**
12. Positive emotional state	84 (57.6–97.3)	83.5 (40.4–97.3)	0.581	85.8 (57.6–97.3)	81.6 (62.7–94.6)	0.150	86.1 (40.4–96.6)	80.2 (44.2–97.3)	0.306

Table 8 shows that the mean 'Percentage of moderately lame cows' in the organic herds was significantly lower in both periods compared to the conventional herds (summer: 3.2 % vs. 9.0 % of cows, P=0.008; winter: 3.6 % vs. 8.5 % of cows, P=0.014, respectively). In the measures that were quantified to characterise the 'Absence of injuries' or the 'Absence of disease', significant differences between the two farming systems in the two periods were not revealed (*Table 7*). But the scores of the criterion 'Absence of pain induced by management procedures' were significantly higher on organic farms compared to conventional farms in both periods (P<0.001, *Table 6*).

For 'Appropriate Behaviour', the mean scores for this WQ® principle and the scores in the underlying criteria (i.e. 'Expression of social behaviours' or 'of other behaviours', 'Good human-animal relationship' and 'Positive emotional state') did not differ significantly between the summer and winter period over all farms (*Table 6*). But the mean scores for the principle 'Appropriate Behaviour' were significantly higher on organic farms in both periods (P<0.001 each, *Table 6*, *Table 9*). The scores of the criteria 'Expression of other behaviour' (both seasons P<0.001) and 'Good human-animal relationship' (summer P=0.004, winter P=0.002) were higher in this farming system throughout.

These enhanced scores were influenced by the measures of 'Frequency of head butts per cow per hour', which were significantly lower in organic than in conventional herds in summer and winter (P=0.012 and P=0.018 respectively, *Table 9*). The average scores for 'Good human-animal relationship' were significantly higher in organic herds in both periods (P=0.004 and P=0.002, *Table 6*). This is attributed to lower avoidance distances at the feeding rack in the organic herds. Significantly more cows could be touched (P=0.017 and P=0.005) and fewer cows showed early signs of withdrawal or an avoidance distance greater than 100 cm in summer and winter (P=0.006 and P=0.007, respectively).

Finally, the WQ® principle scores were only weakly but slightly negatively correlated with the annual milk yield of cows across both farming systems (*Figure 1*). The correlations for the separate groups of organic and conventional farms did not differ substantially.

TABLE 7

Scores (mean (min–max)) for Good Feeding and Good Housing parameters as affected by farm type and timing of the assessment (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Measures / Farming system:	All farms			Organic	Conventional		Organic	Conventional	
% of very lean cows	5.9 (0.0–23.5)	6.6 (0.0–19.4)	0.479	5.3 (0.0–19.3)	6.7 (0.0–23.5)	0.384	5.8 (0.0–17.2)	7.6 (0.0–19.4)	0.273
Duration of lying down movements (s)	5.4 (3.7–9.2)	4.5 (3.1–6.5)	**<0.001**	5.0 (3.7–8.8)	5.8 (4.1–9.2)	**0.036**	4.0 (3.1–4.9)	5.1 (3.8–6.5)	**<0.001**
% of cows colliding with housing equipment during lying down	22.1 (0.0–71.4)	15.6 (0.0–80.0)	0.133	16.3 (0.0–66.6)	29.4 (0–66.7)	0.109	3.6 (0.0–36.8)	30.7 (0–80.0)	**0.003**
% of cows lying partly or completely outside the lying area	2.5 (0.0–33.3)	3.9 (0.0–41.9)	0.536	3.7 (0.0–33.3)	0.9 (0.0–12.6)	0.339	3.0 (0.0–41.9)	5.1 (0.0–36.3)	**0.038**
% of cows with dirty udder	34.0 (3.8–92.5)	25.4 (0.0–80.6)	**0.064**	33.8 (3.8–76.4)	34.2 (6.6–92.5)	0.755	24.6 (0.0–73.9)	26.6 (0.0–80.6)	0.627
% of cows with dirty flank or upper legs	60.6 (8.6–100)	41.4 (8.5–95.7)	**0.002**	63.4 (11.5–100)	57.1 (8.6–100)	0.51	42.2 (9.4–95.7)	40.3 (8.6–80.5)	0.64
% of cows with dirty lower legs	89.1 (54.3–100)	84.1 (12.9–100)	0.782	92.3 (60.0–100)	85.0 (54.3–100)	**0.056**	82.2 (12.9–100)	86.6 (57.5–100)	0.393

TABLE 8

Scores (mean (min–max)) for Good Health parameters as affected by farm type and timing of the assessment (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Measures / Farming system:	All farms			Organic	Conventional		Organic	Conventional	
% of moderately lame cows	5.8 (0.0–17.8)	5.8 (0.0–31.1)	0.956	3.6 (0.0–12.9)	8.5 (0.0–22.4)	**0.014**	3.2 (0.0–8.8)	9 (0.0–31.1)	**0.008**
% of severely lame cows	1.3 (0.0–10.2)	1.2 (0.0–6.7)	0.922	1.0 (0.0–4.0)	1.8 (0.0–10.2)	0.463	0.8 (0.0–4.3)	1.7 (0.0–6.7)	0.268
% of cows with at least one hairless patch, no lesion	46.6 (13.3–70.0)	35.4 (2.9–76.5)	**0.008**	49.3 (20.5–70.0)	43.3 (13.3–69.6)	0.155	30 (2.9–59.6)	42.3 (8.6–76.5)	0.069
% of cows with at least one lesion	20.2 (3.3–40.0)	21.5 (0.0–63.3)	0.864	20.1 (3.2–38.4)	20.3 (3.3–40.0)	0.959	20.6 (0.0–51.4)	22.6 (0.0–63.3)	0.69
Frequency of coughing per cow per 15 min	0.8 (0.0–2.3)	0.8 (0.1–3.6)	0.668	0.7 (0.0–2.2)	0.9 (0.1–2.3)	0.340	0.7 (0.1–2.2)	1 (0.2–3.6)	0.08
% of cows with nasal discharge	10.5 (0.0–34.6)	11.5 (0.0–44.4)	0.547	8.1 (0.0–15.7)	13.5 (2.2–34.5)	0.089	8.3 (0.0–31.3)	15.6 (0.0–44.4)	0.07
% of cows with ocular discharge	1.6 (0.0–9.2)	4.4 (0.0–17.3)	**0.009**	1.4 (0.0–7.6)	1.9 (0.0–9.2)	0.627	3.4 (0.0–17.3)	5.8 (0.0–14.6)	0.089
% of cows with hampered respiration	0.0 (0.0–0.0)	0.1 (0.0–2.2)	0.317	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.000	0.0 (0.0–0.0)	0.1 (0.0–2.2)	0.261
% of cows with diarrhoea	0.5 (0.0–18.1)	2.3 (0.0–13.7)	**0.005**	0.7 (0.0–8.8)	0.2 (0.0–3.0)	0.439	2.8 (0.0–13.7)	1.8 (0.0–7.3)	0.698
% of cows with vulvar discharge	0.8 (0.0–6.6)	0.3 (0.0–3.2)	0.091	1.1 (0.0–6.6)	0.5 (0.0–2.4)	0.348	0.4 (0.0–3.2)	0.3 (0.0–2.4)	0.888
% of cows with mastitis	15.5 (0.0–62.5)	13.7 (0.0–34.3)	0.893	15.9 (0.0–40.0)	14.9 (0.0–62.5)	0.267	14.2 (0.0–30.0)	13.1 (0.0–34.3)	0.51
% of mortality	2.8 (0.0–14.4)	2.9 (0.0–16.6)	0.658	3.4 (0.0–14.4)	2.0 (0.0–6.1)	0.382	3.0 (0.0–16.6)	2.7 (0.0–6.8)	0.930
% of dystocia	4.0 (0.0–17.1)	5.8 (0.0–23.8)	0.576	3.5 (0.0–17.1)	4.5 (0.0–10)	0.234	7.2 (0.0–23.8)	4.0 (0.0–16.7)	0.459
% of downer cows	5.6 (0.0–18.6)	4.3 (0.0–17.1)	0.05	5.3 (0.0–9.6)	6.0 (1.0–18.6)	0.972	3.5 (0.0–16.7)	5.3 (0.0–17.1)	0.143

TABLE 9

Scores (mean (min–max)) for Appropriate Behaviour parameters as affected by farm type and timing of the assessment (Mann-Whitney U test, n: 19 organic farms, 15 conventional farms)

Period:	Winter	Summer	P-value	Winter		P-value	Summer		P-value
Farming system: / Measures	All farms			Organic	Conventional		Organic	Conventional	
Frequency of head butts per cow per hour	0.6 (0.0–3.1)	0.7 (0.0–4)	0.769	0.4 (0.0–1.0)	0.9 (0.1–3.1)	**0.018**	0.4 (0.0–1.6)	1.1 (0.2–4.0)	**0.012**
Frequency of displacements per cow per hour	0.3 (0.0–1.9)	0.3 (0.0–2.3)	0.051	0.4 (0.0–0.8)	0.5 (0.0–1.9)	0.358	0.3 (0.0–1.2)	0.5 (0.0–2.3)	0.591
% of cows that can be touched	30.8 (2.9–76.6)	26.1 (2.2–75.8)	0.262	40.4 (9.0–76.6)	18.7 (2.9–33.3)	**0.005**	34.5 (6.0–75.8)	15.5 (2.2–35.7)	**0.017**
% of cows that can be approached up to 50 cm, but not touched	49.4 (20.0–78.5)	52.8 (24.2–83.6)	0.394	46.8 (20.0–78.5)	52.6 (32.3–72.2)	0.26	53.1 (24.2–83.6)	52.3 (28.6–81.3)	0.849
% of cows that can be approached to between 50 and 100 cm	14.8 (0.0–50.0)	14.8 (0.0–47.6)	0.830	10.3 (0.0–50.0)	20.6 (3.3–38.4)	**0.002**	9.0 (0.0–32.0)	22.2 (4.8–47.6)	**0.004**
% of cows with an avoidance distance greater than 100 cm	5.0 (0.0–23.5)	6.3 (0.0–24.2)	0.686	2.5 (0.0–9.5)	8.1 (0.0–23.5)	**0.007**	3.4 (0.0–20.0)	10 (0.0–24.2)	**0.006**

4 Discussion

With regard to our first hypothesis that dairy cow welfare is especially enhanced in the summer period, we observed improved animal welfare at the level of principles and criteria in the area of 'Good Housing'. Contrary to our hypothesis, the opposite was confirmed in the area of 'Good Feeding', where a lower score was achieved for the summer compared to the winter period. This was strongly influenced by the criterion 'Absence of prolonged thirst'. In the other principles and criteria, no differences between summer and winter were found.

Concerning our second hypothesis that a higher level of animal welfare is achieved on the organic farms compared to conventional farms in both winter and summer period, we found a better rating in the principles of 'Good Housing', 'Good Health' and 'Appropriate Behaviour' for the organic farms especially in summer. A detailed discussion about these findings will follow for each principle at all levels.

In this study, average scores in the WQ® principle 'Good Feeding' were generally lower in summer than in winter. Obviously, this value was mainly influenced by suboptimal water provision in the grazing season wherein both farming systems reached lower values (*Table 6*). Especially on pasture, the number of water points and its accessibility were found frequently low on the farms (detailed assessment data are not listed). This situation may have been influenced by the additional efforts farmers have to make to provide more watering options on pasture due to technical difficulties under outdoor conditions, long distances and additional time they would need for maintenance and control.

The differences in the means for 'Absence of prolonged hunger' and 'thirst' suggest better water and feed supply on organic farms in both periods, but these differences were not significant. The results on sufficient feeding are in line with the findings in other studies of March et al. (2017) in Germany, Roesch et al. (2005) in Switzerland and Bergman et al. (2014) in the United States where body condition of cows in organic and conventional dairy herds did not differ significantly.

Looking at the water provision, March et al. (2017) reported that organic farms achieved a better score for the WQ® principle 'Good Feeding'. This was due to a higher score for the WQ® criterion 'Absence of prolonged thirst'. In contrast, Langford et al. (2009) observed no differences in the water supply (i.e. number of troughs per group of cows, height of troughs, and surface area of troughs per 10 cows) in lactating cow housing on organic and conventional farms in the United Kingdom. However, the lowest score values for 'Absence of thirst' were observed in the summer period in our study (all farms: 32.9, organic farms: 36.4 and conventional farms: 28.5). These are all below the threshold level of 40 suggested by Kirchner et al. (2014) for the identification of on-farm welfare problems. Also, a high proportion of animal groups had no sufficient access to drinking water in the winter period (i.e. in the barn, mean score values of 58.1 on organic and 41.0 on conventional farms, *Table 6*). Therefore, there is potential for improvement of dairy cow welfare with regard to sufficient water supply, particularly during the grazing period. But it must also be considered that water provision is a resource-based measure and actual water intake is not only determined by numbers of water points and dimensions of troughs and their cleanliness, but also by climate and the available feedstuffs. Therefore water provision according to WQ® should not determine the final outcome of WQ® assessment by masking animal based measures that are more relevant to characterise the actual welfare situation of cows (de Vries et al., 2013). Especially on grassland it has to be considered that water-rich feedstuff is consumed by the cows. This influences their water demand.

In our study, the percentage of cows with low body condition scores did not differ significantly between summer and winter or between farm types (*Table 6*). This shows that the interrelations of resource-based measures (such as water provision) and animal-based ones (body condition score) are not so clear in multifaceted livestock systems. But low scores reached in resource-based measures should be used to check the actual situation of animals without bias and evaluate possibilities for improvements.

The distribution of data (*Figure 1*) showed that low scores for 'Good feeding' occurred at the full range of milk productivity and in both farming systems. The wide range of data for 'Good Feeding' in both periods and farming systems reveals the potential for improvement on farm individual level.

Organic farms scored higher in the WQ® principle 'Good Housing' and in the criterion 'Comfort around resting' in the summer period (*Table 6*). The observation of more lying comfort in summer was surely due to the greater access to pasture that was provided to cows on the organic farms (89 % vs. 40 % of farms). Over all farms, the lying down movements were shorter in summer and cows were cleaner. Also, when grouping the data on grazing time from zero to high in an extended dataset (Wagner et al., 2018) the WQ® criterion 'Comfort around resting' was positively influenced by increased time spent on pasture. Several other studies show evidence of improved lying behaviour at pasture compared to housing conditions (O'Connell et al., 1989; Olmos et al., 2009; Corazzin et al., 2010).

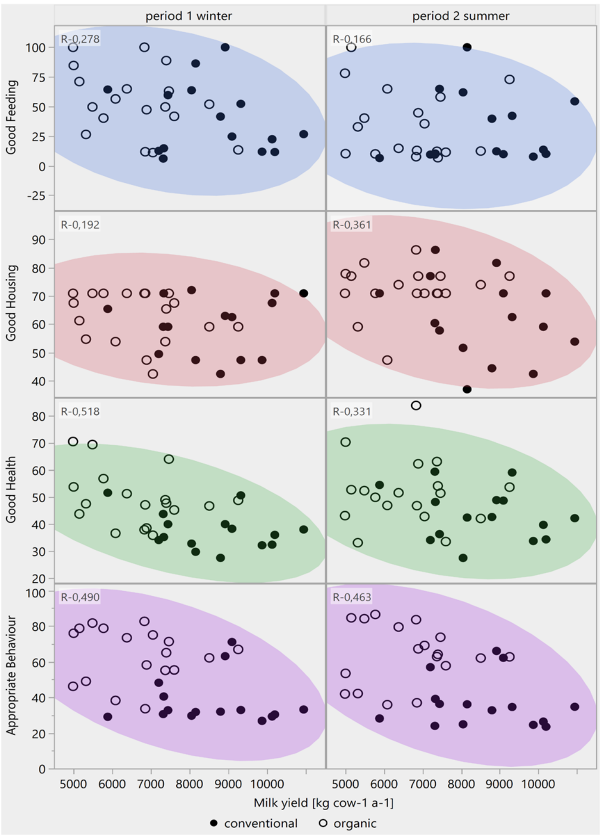

FIGURE 1
The score values for the welfare principles on the monitored farms (org: n=19; conv: n=15) in the summer and winter period plotted in relation to the average annual milk yield per cow for each farm (density ellipses are covering 95 % of data, R values are correlation coefficients of data with the following P-values in the summer period: Milk yield and: 'Good Feeding' 0.348, 'Good Housing' 0.036, 'Good Health' 0.056, 'Appropriate Behaviour' 0.006, and in the winter period of P=0.112, 0.277, 0.002 and 0.003, respectively.)

Cows prefer clean, dry and soft surfaces for lying down and resting (Rushen et al., 2007). In more technical detail, cows prefer deep-bedded free stalls compared to mattresses topped with minimal bedding (Tucker et al., 2003). Our observations on type and comfort of lying areas, as well as the results of the knee-test we performed in all lying areas in the barns (*Table 4*), reflect the organic farming practice of littered bedding as required in the organic standards of the European Community (Commission Regulation (EC) No 889/2008 and Regulation (EU) 2018/848). Within a scale of 1 to 3 (from hard to soft bedding) significantly more organic farms offered soft lying areas for the cows in lactation. But in the winter period the overall score for 'Good Housing' and 'Comfort around resting' were not significantly elevated in organic farms as should be expected (*Table 6*). In the outcome of WQ® assessment for 'Good Housing' only the shorter 'Lying down behaviour' and lower means for 'Percentage of cows colliding with housing equipment during lying down' hint to more lying comfort for the mean of organic cows in the winter period.

Figure 1 indicates that high milk yields are not associated with 'Good Housing' scores, especially in winter, whereas in summer the values for 'Good Housing' seemed to decrease with increasing milk yield. Mainly conventional herds were found in the lower right quarter of data where low scores for 'Good Housing' and higher milk yields coincide. It is interesting to note that the four lowest scores for 'Good Housing' in summer (see *Figure 1*) occurred on farms without or with only short grazing access (0, 0, 5 or 2.5 hours per day, the latter value was found on an organic farm). The three highest producing herds (milk yield >10,000 kg cow^{-1} a^{-1} were all conventionally managed without pasturing in summer) had high 'Good Housing' scores of around 70 in winter and were among the best farms for this parameter in this period.

Higher 'Comfort around resting' seemed to manifest in parameters determining the data for the WQ® principle 'Good Health'. Here organic farms had better scores compared to the conventional farms in both periods, whereas significant differences over all farms between summer and winter were not found. This indicated more general differences between the farming systems probably driven by legal standards and orientation towards higher welfare management in organic farming. The described differences in the use of disbudding, pain and sedation management were obvious (*Table 5*) and influenced the results. They were also in line with those observed by March et al. (2017). The new legal requirements on pain regulation which were enforced for all farming systems in the summer period of this study drastically increased the use of anaesthetics and analgesics especially in conventional herds, showing the power of legal regulations to change agricultural management. However, some remaining conventional farms performed disbudding by administering only anaesthetics or analgesics in that summer period. Some used neither.

Lower percentages of moderately lame cows were found on the organic farms, both in winter and in summer (*Table 8*).

These results were in line with other studies on lameness prevalence in dairy herds in Germany (March et al., 2017), England and Wales (Barker et al., 2010), and in the United Kingdom (Weller and Cooper, 1996; Rutherford et al., 2009). Housing and feeding are major risk factors associated with the development of claw and leg disorders and, thus, more preferable conditions by demands of the organic standards might benefit hoof and limb health in organic in comparison to conventional dairy farming. In more detail, the Commission Regulation (EC) No 889/2008 and Regulation (EU) 2018/848 on organic farming demand (i) the provision of a bedded lying area, (ii) the maximum use of grazing at pasture, or (iii) the requirement of a minimum forage proportion in daily rations of herbivores, consequently restricting the use and the dietary proportion of concentrates. Several studies have highlighted the importance of lying comfort with respect to claw lesions (Barker et al., 2009) and lameness in dairy cows (Dippel et al., 2009; Solano et al., 2015). Also, access to pasture has been shown to be beneficial in terms of reducing lameness (Hernandez-Mendo et al., 2007; Rutherford et al., 2009; Burow et al., 2013; Sjöström et al., 2018). Manson and Leaver (1988) and Livesey et al. (1998) reported that feeding a higher forage-to-concentrate ratio was associated with lower lameness prevalence in lactating dairy cows and lower lameness incidence in heifers, respectively.

The reduced 'Percentage of cows with at least one hairless patch and no lesion' found in the summer period also hints to better conditions for cows during the grazing season. But the maximal values we found for the measures of injuries show risks in both farming systems (*Table 8*). Other expectations, like significant negative correlations between 'Percentage of cows with no lesions' and the presence of horned cows in the herd were analysed but could not be verified by the data obtained in this study (correlation matrices are not presented). More cows found with 'ocular discharge' and 'diarrhoea' in the summer period over all farms might reflect the more windy and chilly conditions outside the stable and the increased intake of fresh green fodder. Means and range differences between the farming systems in the two analysed periods of the year were not obvious and would also lack explanation for most other measures influencing the WQ® criterion 'Absence of disease' (e.g. for mortality). However, the averages found in both farming systems and in both periods for 'Percentage of cows with nasal discharge' were well above the warning threshold given in the WQ® protocol (2009) (i.e. 5 % of cows) in the organic herds and were overriding the alarm value (i.e. > 8 % of cows) on the conventional farms. This justifies careful consideration as follows. A view on the data shows (*Table 8*) that the mean values found on organic farms are lower than in the mean of all farms in both periods, although not significant at the 5 % level. The means and maximum values seemed to be lower on the organic farms in both periods (P=0.07, P=0.089). Reports of investigation of bovine respiratory disorders in adult cows are rare in the literature. Richert et al. (2013) reported that dairy herds on organic and conventional farms with access to grazing had four-fold decreased rates in pneumonia compared with non-grazing conventional herds in the United States. Access to pasture was more common on organic farms than on conventional farms within our study (89 vs. 40 %). However, the percentage of cows with nasal discharge was found not to differ significantly between the periods, suggesting that the farming system might be the important explanatory factor. Coignard et al. (2013) have found that the overall health score in French dairy cattle herds, measured through the WQ® protocol, was significantly better in herds equipped with straw yards (no more details are given in this study) than in herds housed in cubicles, which was, inter alia, due to a lower frequency of nasal discharge. Although cubicles were the dominant housing system in both of the farming systems within our study (57 and 80 % on organic and conventional farms, respectively), free deep litter lying areas were more common on the organic farms compared to the conventional farms (43 vs. 20 %). In addition, the total space allowance per cow in the barn on the organic farms was, on average, higher (8.3 vs. 7.1 m² per cow) than on the conventional. Also access to an outdoor loafing area (excluding pasture) was more often provided on organic farms (74 vs. 33 % of farms; data not presented), which might have ensured better ventilation and air quality for the cows in the barn.

Back to the general outcome in the WQ® principle 'Good Health': When comparing the scattergram of the dataset in winter and summer (*Figure 1*), the improved situation in summer on the conventional farms by the legally forced introduction of pain relief during disbudding is evident. Concerning milk yields, the three most productive herds had only moderate scores in the WQ® principle 'Good Health' in both periods. Conventional herds with higher scores for 'Good Health' tended to have lower yields (within the conventional category), but even these did not compare favourably with the better (but mostly still moderate) scores reached on most of the organic farms.

The better scoring in organic herds in both periods for the WQ® principle 'Appropriate Behaviour' and in the underlying criteria 'Expression of other behaviours' and 'Good human-animal relationship' were in line with the findings of March et al. (2017) for the winter half-year. Better scores for the WQ® criterion 'Expression of other behaviours' on organic farms vs. conventional farms in our study were related to pasture access. In addition, it is worth noting again that organic farms offered, on average, longer grazing periods compared to the six conventional farms offering pasture access in our farm sample (i.e. on 210 vs. 179 days per year when including all farms providing access to pasture or on 214 vs. 180 days per year when including only those farms providing access to pasture for at least 6 hours per day, respectively). Under most farming conditions, farm animals interact with carers in several ways (e.g. at feeding and milking times) and human-animal relationships are of great importance, both for carers and for animals (Waiblinger et al., 2006). Waiblinger and Menke (1999) and Ebinghaus et al. (2018) found some correlation between herd size and the human-animal relationship, with herd size being correlated negatively with the percentage of cows that can be touched and positively with the percentage of cows showing an avoidance distance of greater than 100 cm, respectively. Additionally, Ebinghaus et al. (2018) reported that the percentage of dehorned cows in the herd was associated with a higher median avoidance distance. Indeed, on our organic farms, herd sizes (sum of lactating and dry cows) were, on average, lower (*Table 3*) and horned herds were only found on organic farms (10 farms). These points offer a possible explanation for the higher scores found in the WQ® criterion 'Good human-animal relationship' on the organic farms. Compared to the above-mentioned factors, the personality and attitudes of caretakers forming a basis for their behaviour and the quality of human-animal-interactions (Ebinghaus et al., 2018), seems to be of great importance for this WQ® criterion (Waiblinger and Menke, 1999; Windschnurer et al., 2009; de Boyer des Roches et al., 2016). The higher scores found on organic farms in our study and also in the study of March et al. (2017) suggest effects of technical aspects mentioned above. But the possible differences in human animal interactions which might be related with different attitudes of different farmers – or in farming systems with commitments to achieve high animal welfare in their standards – were not explored here. Although scores in the WQ® criterion 'Expression of social behaviours' were unaffected by the farming system in both periods of our study, cows on organic farms showed less agonistic behaviour. On this topic, Fregonesi and Leaver (2002) and Schütz et al. (2015) reported that agonistic interactions were less frequent with increasing space allowances for dairy cows housed in cubicles, as well as for non-lactating dairy cattle managed temporarily on rubber matting for up to 18 hours per day. In our study, the organic farms offered higher total space allowance per cow in the barn as well as in the outdoor loafing area (data not listed) compared to conventional farms. This might have enabled low ranked cows to cope with dominant cows and avoid conflicts and, thus, could represent one reason for the lower frequency of head butts observed for cows on the organic farms. In addition, the more frequent use of free lying areas in organic farms with fewer bottlenecks and dead ends than in cubicle houses could have influenced the results.

The sample sizes within the two farming systems (e.g. regarding housing system) were too small to examine some effects in detail. For this, we recommend further studies with a higher number of farms that include potential factors of interest. With increasing political interest in animal welfare status and its assessment and documentation, more routine data might be available in near future.

Conducting this study over the winter and summer period revealed differences in water provision and lying behaviour between summer and winter which would not have been disclosed by a study of only one of these periods (in summer: less drinking water availability, shorter duration of lying down movements, fewer cow collisions with housing equipment). This was particularly obvious when comparing the data of the two analysed periods on organic farms, where most of the herds had pasture access (*Table 6*, *Table 7*). In contrast, the scores for 'Social behaviour' and 'Expression of other behaviours' and the results on the underling measures showed smaller differences between the winter and summer period (*Table 6*, *Table 9*), thus supporting the view of Broom and Johnson (2019) that animal behaviour is a long term response to the complete farming system. Evaluation of the welfare status of cows on pasture have been reported by various authors (O'Connell et al., 1989; Nguyen and Kilgour, 2013). We were aware that double counting might pose a potential problem for a proper evaluation if assessing WQ® data on pasture as opposed to the barn (the latter is a requirement by the WQ® protocol). However, it seems not to make perceptible differences in the results on 'Appropriate Behaviour' and in its underlying criteria.

5 Conclusions

For our first hypothesis, we found some clear differences in dairy cow welfare performance between the summer and winter period based on measurements made for the WQ® protocol in our network of organic and conventional farms in Germany: The water provision on pasture did not meet the requirements of high welfare standards in many of the farms. The mean body condition of cows and scores for 'Good Feeding' generally decreased in summer and in both farming systems across different rates of pasture access. 'Comfort around resting' was especially enhanced in summer in the mean of organic farms (where 83 % of herds had pasture access). Scores for 'Good Health' and 'Appropriate Behaviour' responded to longer term management aspects in farming systems and did not change between the periods. Differences found in measures, i.e. in 'Percentage of cows with ocular discharge' or in 'Percentage of cows with diarrhoea', could be explained by the grazing environment and fodder resources used in summer. For our second hypothesis, we found significant differences in animal welfare between organic farms and conventional farms in our network in both winter and summer period. More generous space provision, softer lying surfaces, less painful management procedures and more access to pasture were provided to the organic dairy cows compared to conventional farms. The requirements of the organic farming standards obviously make a difference in practical farming. They affect comfort, health and behaviour in a positive way (i.e. in lying down behaviour, lameness, suffering painful procedures, agonistic behaviour, human-animal relationship).

Looking at the productivity of cows, highest milk yields (>10,000 kg cow^{-1} a^{-1}) were only achieved in the farms with conventional management. However in comparison to all farms (average milk yield 7,425 kg cow^{-1} a^{-1}) or to the two organic farms with highest milk yields (8,500 and 9,250 kg cow^{-1} a^{-1}) scores for 'Good Health' and 'Appropriate Behaviour' in these high yielding dairy herds were generally low. Also in the principles 'Good Housing' and 'Good Feeding' the values only sometimes approached those of farms with lower average milk yields.

To state it clearly: All the dairy farms we analysed in this study had the potential to improve animal welfare. In order to achieve this, interventions that are specific to the individual farm are required, as the data of this study showed very obviously: The ranges of all values were wide in both periods of the year and in both farming systems showing that the impact of farm-individual management on animal welfare can be very high. Even though EU regulations on organic farming offer great potential for good animal welfare, they cannot offer a guarantee. Therefore, we recommend the implementation of outcome-based assessments in organic standards and other legal provisions for livestock farming in general to address and improve all dimensions of animal welfare.

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