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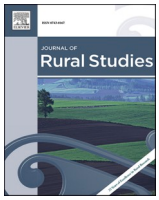

Systemic enablers and barriers to extending the productive life of dairy cows in Switzerland

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ABSTRACT

Research has shown that the economic and ecological optimum productive life of dairy cows is between six and seven lactations, but the current average length in Switzerland, and many other countries, is approximately half that figure. Reasons for culling can be unplanned, such as illness, or planned, such as to achieve breeding goals, but the reasons for the sub-optimal length of productive life are not fully understood. The aim of this study is to investigate systemic barriers to, and enablers of, the extension of the length of productive life of dairy cows in Switzerland. To address this aim, we focused on the power of actor groups in the incumbent system to induce change. We analysed the content of 29 interviews with industry experts, including practising vets, agricultural advisors, breeders' organisations, farmers' organisations, dairies and retailers, government officials, and agricultural educators. The results indicate that vets, advisors, and breeders' organisations have key resources, which could potentially be mobilized to achieve an optimal length of productive life. These resources include their relationships to farmers (human resource), their knowledge, information/data, and strategy (mental resources), and the breeding value (artefactual resource). However, the incumbent system is inflexible, which hinders individual industry actors to facilitate change. Collaborative reflection at industry level, led by breeders' associations, vets, and advisors, may create the conditions to create change and enable an optimization of the productive life of dairy cows in Switzerland.

1. Introduction

The productive life of dairy cows is commonly described in terms of either the number of completed lactations or the number of productive life days (milk production days) before a cow is replaced. From an economic, environmental, and ethical standpoint, and using full cost accounting, the optimal productive life is at least five lactations and, for most breeds, is more than six lactations (Bergeå et al., 2016; Horn et al., 2012; Leiber et al., 2019; Nor et al., 2014). However, the average productive life of dairy cows worldwide ranges from only 2.5 to 3.5 lactations, (around 4.5–5.5 years of age) (Schuster et al., 2020), which is economically and environmentally suboptimal and ethically questionable (Bergeå et al., 2016; Leiber et al., 2019). The situation in Switzerland is similarly suboptimal with the average length of productive life ranging from 3.1 lactations (5.5 years of age) for Holsteiner: a milk breed, to 3.8 lactations (5.8 years of age) for Swiss Fleckvieh: a dual-purpose breed (Hediger et al., 2021). The low average productive life, at approximately half of the optimum in terms of lactations and roughly a third of their biological life expectancy, suggests that it is in the interest of dairy farmers for cows to live longer productive lives than is currently the case. However, the current trend is rather for a decreasing productive life of dairy cows throughout Europe (Olechnowiczc et al., 2016) and in Switzerland (Leiber et al., 2017).

In terms of the economic efficiency of dairy farms, a longer productive life means that rearing costs can be amortised over longer periods (Bergeå et al., 2016). Calculations based on Swiss Herd book data showed an increase in performance, compared to the annual milk yield of the first lactation, until the ninth lactation, with a maximum between the fifth and seventh lactations (Leiber et al., 2019). The economic relevance of the length of productive life was also shown by Horn et al. (2012), who reported from Austria that cows reached their maximum annual milk yield in the fifth lactation and their highest net annual profit in the sixth lactation.

In terms of the environmental sustainability of milk production, longer productive lives reduce resource consumption and greenhouse gas (GHG) emissions per output unit (Meier et al., 2017). During the

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rearing phase, which is the life period before the future dairy cows produce milk, they consume resources, such as feed, which has an ecological footprint, and directly emit GHGs. Hence, if the resources consumed and the GHG emissions produced during the unproductive years are distributed among more years of production, the consumption and emissions, calculated per unit of milk produced, are less as the cow produces more milk. This phenomenon is known as the "dilution effect" (Leiber et al., 2019). Although older cows have been found to emit fewer GHGs than younger lactating cows, their milk production begins to diminish as they age, while they continue to consume resources and produce GHGs (Nor et al., 2014). This suggests there is an optimum, and calculable, productive life for which the overall production is the most climate-friendly (Grandl et al., 2016; Leiber et al., 2019). Based on a calculation with Swiss Herd book data of Simmental and Brown Swiss cows, Leiber et al. (2019) estimated the GHG savings potential of an extension of the length of productive life from three to five lactations to be 9–10% from the "dilution effect" for the rearing phase and the increase in performance alone. An experimental study by Grandl et al. (2016) also showed that methane emissions (per kg feed intake, per kg body weight and per kg milk yield) decrease in dairy cows from 6.5 years of age, which would amount to an additional methane reduction of about 10% if productive life was increased from three to five lactations. Zehetmeier et al. (2012) and Probst et al. (2019) showed the GHG emissions of specialised systems producing milk and beef separately is higher, per unit of product, than the GHG emissions, for the same amount of product, when meat and milk production are combined.

From an ethical perspective, a longer productive life has a strong animal welfare and animal health component (Bruijnis et al., 2013). It is proper from a purely ethical point of view to give reverence to the inherent will of animals to live by facilitating them to live long lives (Webster, 2022), while maintaining a reasonable quality of life (Fraser et al., 1997; Webster, 2022). Bruijnis et al. (2013) propose the inclusion of the natural lifespan as a fundamental aspect of animal welfare, which suggests that longevity is a constitutive element rather than merely an indicator of animal welfare. Dairy cows are biologically capable of living for approximately 20 years, with human intervention being the primary cause of shorter life-spans (Schuster et al., 2020). In this way, the goal of a long productive life implies that adequate attention is given to appropriate husbandry, such as feeding, housing, veterinary care, and management, and to the constitution and behaviour management of the cows, which would lead directly to improvements in animal welfare and therefore strengthen the ethical propriety of dairy production (Bruijnis et al., 2013).

Dairy farming requires cows to have calves to stimulate lactation, and cows are typically inseminated with semen from milk breed bulls, with traits that are strong in milk performance but poor for meat production, to maintain a supply of potential herd replacement calves (Rell et al., 2022). However, for predominantly milk breeds, such as Braunvieh/Brown Swiss, and for purely milk breeds, such as Holstein, which are the first and second most numerous cattle breeds in Switzerland (Identitas AG, 2022), this has the effect of producing unwanted calves that are considered a waste product because the calves that are not needed for herd replacement are usually not profitable for meat production (Rell et al., 2020). This issue is exacerbated by the need to produce female offspring for herd replacement, which means that herd replacement calves are bred earlier to compensate for the proportion of male calves that are born. Although the practice of using sexed semen is increasing in Switzerland (Kern, 2019), it features higher costs and lower pregnancy rates (Balzani et al., 2021), and the use is sufficiently controversial that it has been banned in organic production (Ewe, 2021). However, increasing the productive life of dairy cows offers a non-technical solution to reducing the production of unwanted calves because fewer animals are needed for herd replacement, so dairy cows can be crossbred with meat breeds, which provides an economically viable reason for raising the crossbred calf for meat production. The argument that a rapid cycle of generations may advance genetic progress via bull selection is countered by the notion that genetic improvements can still be achieved in herds with longer productive lives, and thus lower replacement rates, by advancing genetic progress through a combination of both cow and bull selection, as cows with desirable traits are allowed to produce more calves (Heikkilä et al., 2008).

The reasons for replacing a dairy cow can be classified as planned or unplanned. Planned replacement means a cow is replaced after having been on the farm for the calculated optimal productive life for the animal. Approximately one third of cow replacement in Switzerland is planned (Fuss and Burren, 2018) with variation due to breed and system effects (Bieber et al., 2019). Unplanned cow replacement is when a cow must be replaced due to non-performance, illness, or injury, which accounts for approximately two thirds of the reasons for culling of dairy cows in Switzerland (Burren and Alder, 2013; Fuss and Burren, 2018). Common causes include fertility (Gilbert, 2016), udder health (Jamali et al., 2018), and lameness (Dolecheck and Bewley, 2018), which are caused by a combination of genetic predisposition and aspects of husbandry, feeding, and management (Bielfeldt et al., 2006; Olechnowiczc et al., 2016). Although these causes for premature cow replacement are known, their relative importance is not clearly understood, which hinders the development of strategies to effectively halt and reverse the trend of decreasing length of productive life. However, the finding that the trend is consistent and ongoing (Leiber at el., 2017) suggests that the driver may be systemic.

Most of the previous investigations of productive life of dairy cows have quantified the environmental and economic outcomes and discussed the ethical implications of different productive life lengths, and many have examined the technical reasons for cow replacement. However, fewer studies have addressed the human factor by examining the drivers of farmer behaviour as an influence on the length of the productive life of dairy cows. Notable exceptions include Alvåsen et al. (2018) who investigated relationships between herd management and longevity in Sweden to identify predictors for cow longevity, and Bergeå et al. (2016) who investigated whether lack of awareness of the benefits of longevity might explain falling longevity in Swedish dairy cows. Alvåsen et al. (2018) found that Swedish farmers with a strong interest in breeding are often younger and commonly have culling strategies to improve the genetic potential in their herd, which leads to lower length of productive life in their herds. Furthermore, they reported that preventive herd health offered by vets or other professions were not well accepted by farmers in Sweden (Alvåsen et al., 2018). Bergeå et al.'s (2016) study found that Swedish dairy farmers blame the established dairy system as preventing them from putting the longevity of their cows in the foreground of their decision-making. These studies notwithstanding, there has been insufficient research from a systemic perspective to identify systemic barriers to, and promoters of, extending the length of productive life of dairy cows.

The aim of this contribution is to identify systemic factors that enable or hinder an extended productive life of dairy cows in Switzerland. To address this aim, we investigate the power, and perceived lock-ins, from the perspective of key industry stakeholders to understand better why the on-farm decisions appear to be against the interests of the farmers making the decisions. We focus on the power of relevant actor groups in the Swiss dairy system, and the resources they can mobilize, to achieve change to increase the average length of productive life of dairy cows.

2. Theoretical framework

The findings of scholars such as Bergeå et al. (2016), Leiber et al. (2019), and Nor et al. (2014) support the starting position of this paper that a longer productive life for dairy cows is ethically proper and contributes to the environmental and economic sustainability of dairy farms. To evaluate the extent to which the stakeholder groups perceive themselves to have the ability to increase the average length of productive life of dairy cows in Switzerland, we draw on the concept of power.

Giddens (1984, p. 14) defined power as "[…] the capability […] to 'make a difference' […]" and as the capacity to transform. It is the ability to intervene or not to intervene, and thereby cause an effect (Giddens, 1984). A definition of power more adapted to transition contexts is "the capacity of actors to mobilize resources to achieve a certain goal" (Avelino and Rotmans, 2011, p. 798). While having resources is the first condition to exert power, another condition is to have strategies to mobilize the resources. Moreover, skills to apply the strategies are needed, and finally, the willingness to use the resources in order to achieve a goal is necessary to exert power (Avelino and Rotmans, 2011). Resources can be categorized as mental, human, artefactual, natural, and financial (Avelino and Rotmans, 2009). In Table 1, we have listed the resource types with explanations relevant to our study context.

In relation to this study, we apply the definition of power for individuals to groups, as we are focussing on power of actor groups. We focus on power as the perceived capability to act differently to the dominant dairy farming practice in the system; more specifically, the perceived capability of actors to have an influence so that herds are managed for a longer productive life, i.e., for more lactations, than is currently the case. In the system of dairy farming, actors can have the capability to exert power through different resources, strategies, skills and willingness with an effect on the planned decision of farmers to cull dairy cows (vs. unplanned culling due to sudden severe illness or accidents).

However, systems are stable, up to a certain degree, due to reasons such as an equilibrium state of driving forces (Grin et al., 2010) or path dependency, which is the state when one of several technologies is adopted due to initial conditions, such as choices of individuals, technological or social development, or even historical accident, that facilitate the use of this technology (Unruh, 2000; Vanloqueren and Baret, 2009) and becomes sufficiently dominant that the costs for switching to another technology are high (Cecere et al., 2014). The technology is then locked in: even though disadvantageous long-term outcomes, such as technologies that emit high levels of carbon dioxide or fine particulate matter that is harmful to human health may appear (Cowan and Gunby, 1996; Garud and Karnøe, 2012; Unruh, 2000). For our study, we have adopted the concept of path dependency from the field of transition studies and translate it to our study context by assuming that the dominant practice in dairy farming can be locked-in due to path dependency, in a similar manner to the processes of path dependency for technology.

Table 1
Resource types for the exertion of power (adapted from Avelino and Rotmans, 2009, 2011).

Resource types	Definition	Examples of what is mobilized
Mental	Resources rising from the mind of humans	Such as *ideas*, e.g., for improving the health and length of productive life of dairy cows
	Resources that are processed in human minds	Such as *information*, for example on the performance (e.g., milk, fertility) and culling reasons of dairy cows
	Resources that are stored in human minds	Such as *knowledge*, e.g., on how to manage a herd for longer productive lives, either gained through experience or association
Human	Human support or manpower	Such as employees at a veterinary practice or at an agricultural consultancy organisation, members of a breeders' organisation, clients of vets or agricultural consultancy services
Artefact	Human-made objects	Such as *infrastructure*, here for example, the infrastructure for the commercialisation of milk and dairy products; *products*, e.g., information products to support management decisions of dairy farmers
Natural	Non-human-made resources	Such as *land*, for example for grazing the dairy cows; or *organic life*, i.e., the dairy cows
Financial	Monetary resources	such as *cash*, e.g., to pay for veterinary services; *funds*, e.g., to employ agricultural advisors

3. Material and methods

Data were collected by means of qualitative interviews with respondents who were considered to have expertise, and the potential to exert power to influence the system, in the Swiss dairy industry and who were identified using local knowledge of the industry and the Swiss agricultural knowledge and innovation system (AKIS). Given the relatively small size of the pool of potential respondents with expertise, anonymity was promised prior to participation and respondents were informed of their rights under both the European General Data Protection Regulations and Swiss law. Informed consent was gained verbally in accordance with both the European General Data Protection Regulations and Swiss law. Appropriate approval was gained prior to data collection. The number of dairy sector experts in Switzerland is reasonably small, so it is not appropriate to identify the specific respondent type for each citation in the results section as this could lead to the identification of the respondent and thereby betray the anonymity that was promised during data collection. Respondents were selected in a purposive sampling strategy (Patton, 1990) to represent a broad range of different stakeholder groups with an interest in the Swiss dairy system. The respondents included representatives of farmer's/breeder's associations (6), vets (11), retailers (3), agronomists (1), NGOs (3), government representatives (5), and farm advisors (5). The total number of respondents by stakeholder group (34) exceeds the total number of respondents (29) as some respondents belong to more than one stakeholder group.

In contrast to quantitative research, a small number of cases, in combination with theoretical contemplation, will enhance the validity of fine-grained, in-depth inquiry in naturalistic settings (Crouch and McKenzie, 2006). Mason (2010) points out that saturation, meaning the point when all of the relevant themes have been mentioned during a study, can be achieved with a comparatively low number of qualitative interviews. Guest et al. (2006, p.78) found, with their study that involved 60 interviews, that data saturation had occurred at a very early stage after 12 interviews and concluded that, for studies with a high level of homogeneity among the population, "a sample of six interviews may [be] sufficient to enable development of meaningful themes and useful interpretations". The number of participants in this study exceeds the number of interviews usually considered adequate for qualitative research because the complexity of the system meant that it would have taken considerably longer that the normal acceptable interview duration for them to describe the whole system. Furthermore, most of the respondents held expertise in specific parts of the system, so their responses were focussed on the part of the system they were most familiar with. Conducting a larger number of interviews ensured that the whole system was covered and that saturation was reached.

The interviews were conducted individually by the authors in 2021 in Switzerland, with four conducted face-to-face and the remaining 25 conducted via video-telephony due to restriction in Switzerland associated with the covid-19 pandemic. During the interview, respondents could insert comments directly onto a pre-prepared online whiteboard platform that was secured with password protection. Responses were anonymised immediately following each interview and the comments collected on a secure internal server. The interviews were recorded using MP3 Skype Recorder software and transcribed using Sonix.ai software that was corrected manually. Both the audio files and the transcripts were stored on the same secure internal server as the responses given as inserted comments.

Respondents were provided with a diagram of the Swiss dairy system that was formulated according to van Mierlo et al.'s (2010) System Analysis Matrix to facilitate mapping of their responses to the relevant part of the system. The System Analysis Matrix was originally designed

to be a tool for guiding workshops but is also useful as a tool for enabling participants in individual interviews to orient themselves within complex systems (van Mierlo et al., 2010). The interviewers were experienced and familiar with both the topic and the System Analysis Matrix so no pilot interviews were deemed necessary.

Respondents were invited to describe their understanding of the dairy system in Switzerland, identify what they saw as enablers or barriers to extending the productive life of dairy cows in Switzerland, propose leverage points that might lead to system change, and nominate the actors within the system who could potentially use these leverage points. Overall, 29 potential respondents were approached and all agreed to participate in the study interviews, which were conducted with a duration between 45 and 70 min.

A further data source was the collated written responses to a public consultation. The aim of public consultations in general is to allow "the cantons, political parties and interested groups to participate in the shaping of opinion and the decision-making process of the Confederation" (The Federal Assembly of the Swiss Confederation, 2005; Art. 2). The consultation was carried out by an organisation of the Swiss parliament regarding a proposal for a decree by the Swiss parliament for a legislation package that included a direct payment for a longer length of productive life of cows. The public consultation took place from 28.04.2021 until 18.08.2021. The respondents were invited to insert their comments in a Microsoft Word template and send it digitally back to the organisation. The responses to the public consultation were made available to the authors after request in form of a table including a column with abbreviated respondent name and a column containing quotes of the respondents. Due to the abbreviations of the respondent names, it was not possible to identify respondents. Hence, the exact number of respondents per actor group cannot be given but, since many abbreviations were known to the authors or were easy to assign to actor groups by internet search, we can confidently assert that there was a high degree of diversity in the actor groups. Actor groups that responded to the consultation included cantons, political parties, not-for-profit organisations (such as environmental non-governmental organisations), and different organisations from the agricultural sector: from industry, trade, and services (including also advisory, education, and science organisations). A total of 112 actor groups commented on the proposal for a subsidy as an incentive for keeping dairy cows for longer.

The data from the two sources were aggregated and an inductive content analysis was conducted by the authors according to the methodology described by Mayring (2014) using MaxQDA software. Qualitative content analysis is a systematic and rule-bound procedure which enables a structured analysis of manifest and descriptive content as well as latent and interpretative content. It is based on building a multi-level framework of different categories which identify and define groups of statements or mentioned aspects with common characteristics (Graneheim et al., 2017). Statements referring to technological challenges that were outside the power of industry actors were classified as macroeconomic conditions. Statements were classified according to actor groups who were identified as having the power to create change and then into subcategories according to how their power can be leveraged. Finally, statements about on-farm technological challenges and generalizations about farmers, were classified as farm level factors. Throughout the results section, direct quotes (translated into English) that are illustrative of the points being made are shown in italics.

4. Results

4.1. Macroeconomic conditions

The respondents nominated three main macroeconomic conditions of the Swiss dairy system related to the length of productive life of cows: prices, breeding technology, and politics. Regarding prices, several respondents pointed out that *"the proportion of prices of milk and meat are important. Now, milk is cheap and meat is expensive."* This factor is exacerbated by high, and "*increasing veterinary costs*" in Switzerland as practices seek to attract vets in an under-supplied market: "*Vet costs are increasing while milk prices are falling, which makes it less (financially) attractive to treat sick cows"*. If meat prices are high, and vet costs are expensive, there is an incentive to cull a cow with health problems rather than treat it so that it can produce more milk.

Breeding technologies have enabled an upward trend in milk yield since nearly all sires on the semen market have a genetic potential to increase milk yield: "*Neutral sires are very rare on the market and it is impossible to find negative milk yield semen, so it is not possible to go back in milk yield"*. The genetic traits for high milk yields, are however, negatively correlated to some fitness traits that can enable a longer productive life. Furthermore, the technological developments of sexed semen allow farmers to decide from which cows s/he wants to breed for dairy herd replacement and which for meat. Since young bulls from milk-emphasised breeds yield less meat, the price is better for offspring from dual-purpose or meat-emphasised breeds.

Another breeding technology is the prediction of breeding values based on genetics, which means that the breeding value is known early. As the parents pass on the genotype, the selection can be made based on the genetic predisposition and not on the observed performance or traits. This can lead to cows being culled based on the genetic analysis (SNP based) suggesting that milk yield will be low.

On the landscape level, there is also pressure to react to climate change. The respondents noted the need for the dairy sector to react to the global trend of climate change: *"It must be made clear to milk producers that milk must become more sustainable so that sales do not fall. For example, emissions can be reduced by extending the length of productive life (in conjunction with milk yield)."*

4.2. Government officials

The respondents perceived that there is awareness and funding of research on the extension of the length of productive life of dairy cows already present from the side of political actors. However, there is a potential for more action by government organisations. *"The Federal Office of Agriculture (BLW) […] has the knowledge and could take a motivational role."* Moreover, they give "*talks to industry about production vs. costs",* which can be used to inform industry stakeholders, including farmers, about the possibilities to optimize the length of productive life of dairy cows. On the other hand, the animal database, which includes every animal, is in the hands of the federal government and several key factors are published based on this database, but length of productive life is not yet included. A further barrier for government officials is the Swiss national strategy to reduce antibiotic use in agriculture. Treatments with antibiotics have to be reported to federal and cantonal agencies, and farms with lower antibiotic use receive fewer inspections. Therefore, the strategy to reduce antibiotic use might work as an incentive to cull, rather than treat, a cow. If the Swiss Government were to adopt a strategy to increase the productive life of dairy cows, it would come into conflict with the Swiss strategy for the reduction of antibiotic use in agriculture. Although, the government officials have a degree of freedom to influence the dairy farming system, they are also limited in their ability to motivate change through their actions. "*Sometimes what the officials want to do is not permitted in light of the political environment."* Regulation and policy are, after all, in the hands of the political actors who provide the framing conditions for what the officials must and must not do.

4.3. Agricultural educators

While the respondents rated the quality of the education of farmers in Switzerland as high, they also pointed to a lack of attention to length of productive life: *"Agricultural schools do not teach about the benefits of a longer productive life. But they do teach about the herd replacement rate"*. Furthermore, the respondents identified a lack of education on "*whole*

farm economics" and on how farmers can *"make a profit while looking after the animals."* The focus on herd replacement rate by the education institutions means that premature culling is accepted and does not harm the self-image of being a good farmer. Farming students learn that a high herd replacement rate, with rapid generation cycles and information driven bull selection, will lead to genetic progress and herd improvement, so is a contribution to the wellbeing of both farmer and society. Agricultural education institutions, in turn, point out that they are restricted in their power to make broad changes to the syllabus by the political environment and by industry norms.

4.4. Practising vets

The respondents identified practising vets as the advisory group with the most direct influence on length of productive life. Vets interact with most of the actors within the system and therefore have an influential role in the length of productive life of dairy cows. The strong influence of the vets is, on the one hand, a result of their high level of education, their role offering a service for the farmers with a focus on animal health, and their sometimes-long-term relationship with the farmers; all of which contribute to building trust. Vets were perceived as *"[…] supporters of the farmers and can give advice for the benefit of farmers. There is no conflicting interest."* Moreover, if vets are skilled in communication, they can *"[…] convince farmers to consider new ways of doing things."* On the other hand, vets have managed to create a collaborative environment with the breeding organisations and give advice. It means that information is shared, although there is potential for more effort to be made to elaborate joint goals and strategies with the breeders' organisations.

The vets give information and advice to farmers regarding the treatment of cows. Moreover, vets have the competency to give advice that could lead to a longer productive life. *"Consultation in the area of length of productive life could be expanded to show the real costs of rearing; and the true costs of high-performance breeding."* However, vets *"[…] are mostly called out to treat animals on an individual basis. […] there is generally not enough time to analyse a farm's system to give a holistic evaluation during a normal visit."* An extra visit would be needed to give herd health advice, but due to the expected costs, it *"[…] is only demanded by farmers when they feel that it will add value."*

For veterinary practices to include herd health advice as preventive medicine in their service, they would need to become larger because it would be an additional service. However, the respondents perceived the vets to be reluctant to hire additional personnel because they carry an economic risk in case that the offer of herd health advice is not made use of by farmers. *"Vets will perceive this as a risk […] So, herd management is a difficult service to offer*."

4.5. Agricultural advisors

The respondents mentioned other actors, which offer on-farm advice at no cost for farmers. These actors are specialist inseminators, feed dealers, cattle and calf health services, and other agricultural advisors. Specialist inseminators are usually employed by organisations that sell semen, e.g., Swiss Genetics, but can also be practicing vets. The respondents perceive the inseminators as being *"[…] often on the farm […]"* and as having *"[…] a strong influence."* Respondents further said, the inseminators *"[…] could be potential agents to encourage longer productive life […]"* because *"some farmers leave the choice of which bull to the inseminator."* Respondents perceived that inseminators *"[…] may tend to go for performance"*.

Cost-free advice with the potential to increase the length of productive life of dairy cows is also offered by private agricultural consultants and feed dealers, who are financed by selling products, or semi-public consultancies who are financed by memberships along with government subsidies, such as the Cattle and Calf Health Service (Rindergesundheitsdienst). However, *"[…] farmers are often unaware of the services […]"* provided by the Cattle and Calf Health Service because the organisation is too small and therefore lacks the critical mass. Their small number of employees hinders their high level of expertise from becoming mainstreamed and makes it difficult for them to have sufficient long-term contact with farmers to build trust. One respondent pointed out that *"hardly any of the knowledge that is freely advised by cattle and calf health services will actually be applied. In reality, they have little influence."* Even if most advisory groups currently have a limited influence to optimize the length of productive life length of dairy cows, the respondents pointed to the potential of collaboration between vets and other advisory groups. *"[…] It's important to collaborate with vets […] and other advisory groups to solve the health problems of cows. This has potential, but is far too little communication between these groups. Everything is in place for such collaboration. "*

4.6. Breeders' associations

The breeders' associations are key actors within the Swiss dairy system. The respondents mentioned that they have a decisive influence on the length of productive life of dairy cows. *"A lot of the information comes from the breeders' associations",* and therefore they can influence farmers' decisions. Breeders' associations collaborate with geneticists to provide farmers with *"better information", so "decisions by farmers about whether to keep a cow [can be] made earlier."* To simplify decision making for farmers regarding the breeding, the breeding associations, in collaboration with geneticists, calculate and provide a 'total breeding value''as a decision support tool to give an easy overview for the farmer. The total breeding value is composed of weighted partial breeding values, such as for milk yield and for fertility.

However, the orientation of the breeders' associations is not uniformly understood by the respondents. Overall, they thought the breeders' associations have a focus on breeding for traits that are adapted to local conditions: such as fitness traits that contribute to a long productive life, but also productivity traits that shorten productive life. Some respondents perceived that breeders' associations focus more on promoting fitness traits, such as robustness, and thus "*indirectly encourage a longer productive life, which they encourage with genetic development."* "*For example, Holstein Switzerland has an annual* award *for the Master Breeder, with the title* awarded *to breeding herds that show exceptional results over a long period of time"*. Furthermore, the *"[…] breeding associations advertise the prestige of 100′000 kilo cows",* which refers to cows that achieve a lifetime milk production exceeding 100′000 kg. With their awards, the traits that are highlighted include a high milk yield as well as longevity.

On the other hand, other respondents perceived that *"[a] lot of weight is given to increasing milk production when calculating the breeding value." This "[…] creates a difficulty for farmers who wish to breed for robustness."* Here, the notion is included that farmers who wish to focus on fitness in breeding face a difficulty in choosing an optimal sire due to the weight given to milk production when calculating the total breeding value. Another aspect is that some performance-related indicators are quicker and easier to measure than fitness-related indicators. For example, "*cows are often selected to have maximal lactation in the first 60–100 days, which is achievable and measurable, while other traits, such as fitness traits, are more difficult to include in the breeding valuation. They need a lot of data that are not yet readily available in Switzerland."* Furthermore, "*sometimes there are inverse relationships between udder health and milk, but often everything can be improved by selective breeding*."

There are, however, limits to the power of breeders' associations regarding the breeding value. Firstly, to develop a well-founded advice for breeding for a longer length of productive life, data on treatments by the vets is necessary. These data are not readily available and it is a sensitive topic for farmers to provide this information: *"Breeding associations analyse the treatment journals but vet data, […] is needed for the analysis to be reliable.*" Moreover, the breeders' organisations, as representatives of their members, need to have the profitability as a focus. *"Breeding associations represent the interests of farmers, so they also have an*

implicit goal of creating financial benefits for farmers, which creates a conflict between animal welfare, which generally is associated with costs, and farm profit."

4.7. Dairies and retailers

The price of milk is linked to cell counts and older cows are perceived to be more likely to produce milk with high cell counts: *"Milk buyers demand a low cell count or they pay a lower price,"* which motivates farmers to keep a young herd to avoid higher cell counts: *"Sometimes the farmers just want to avoid the 'theatre' about cell counts. With younger cows, there is less risk of problems with the udder. So, culling just takes a potential problem away."* This also means that dairies *"encourage antibiotic use for older cows to keep the cell count down."* Due to the strategy to reduce antibiotics in agriculture, "*there's a motivation to treat less,"* since *"all antibiotic use must be declared to the cantonal vet office […]. Farms with less antibiotic use are visited less, which makes it easier for the farmer to cull the cow,"* and the objectively correct decision. However, the power of dairies to influence the system is limited by the retailers*, who "want to sell perfect products, which is important for them. Lack of flexibility leads to healthy animals being classed as ill, which leads to the unnecessary slaughter of healthy animals."* Moreover, the respondents noted that the dairies and other milk processors have a strong interest in a high supply of milk because this strengthens their negotiation power over prices. Hence, they were perceived to be supporters of high-yielding milk breeds: *"[…] they want as much milk as possible. If there is a surplus of milk, the price negotiation is easy for the processor."*

4.8. Farm level factors

The respondents evaluated Swiss farmers as being well educated with capacity to process information needed for management decisions such as in the selection of bulls to breed for highly heritable traits or deciding the insemination intervals, since *"[…] the farmer can choose which way to go, where to put the focus."* However, the farmers were also perceived to face several obstacles when changing their farming practice to increase the length of productive life of their cows. The respondents pointed to the limits of farmers' capability to gain sufficient information to make informed breeding and herd planning decisions. For example, breeding for robustness, in terms of animal health, is a known strategy for dairy farmers who breed their own future milk cows and could lead to a more optimal length of productive life due to better health. However, this requires breeding decisions based on health, which is difficult to quantify, rather than the more commonly selected traits such as productivity, further the advertised total breeding value has an emphasis on milk yield, which is readily measurable. *"A lot of weight is given to increasing milk production when calculating the breeding value, which creates a difficulty for farmers who wish to breed for robustness." T*he milk yield, in contrast to the breeding values of persistence and fertility, is a relatively simple value for farmers *"[…] to have at hand to chat with other farmers. It simplifies the complex system to a simple number that is readily communicated and understood."*

Respondents stated that the standard practice in dairy farming in Switzerland is that cows calve once every year although several respondents pointed out that there is a "*need to get away from the idea of one lactation per year.*" A lower frequency of calving, i.e., a longer inter-calving period, can potentially increase the length of productive life of dairy cows for several reasons. First, the period around calving is risky for the cows' health, so *"[…] there would be fewer health problems of older cows, and consequently a longer productive life if the frequency of calving was lower: say one calf every* 18 months*."* Furthermore, longer inter-calving periods increase the probability of success of the insemination and thereby reduce a prominent reason for culling. *"[T]here are greater chances that the cow will become pregnant. So, fertility is less a reason to slaughter."* Finally, longer inter-calving periods would lead to a decrease in the number of replacement animals. *"Then the young cows are more expensive so it's less attractive for a farmer to change the older cows out for younger."* Even if the inherent logic of the respondents' statement is not necessarily valid, the included notion that a change in the number of replacement animals could affect the length of productive life of cows is worth consideration.

Persistence refers to the rate of decline in production after peak milk production, and cows with good persistence characteristics (a slow rate of decline) are needed for longer inter-calving periods. However, the parameters of the total breeding value are usually calculated for a standard lactation of 305 days and "*it is difficult to get information about persistence (above a standard lactation).*" If there was a value taking persistence for longer lactations than 305 days into account, it could enable "*farmers to breed for cows that lactate for say 400 or even 450 days, which has a lot less risk for the cows*".

The respondents pointed out, that while breeding decisions are important regarding an optimal length of productive life of dairy cows, *"[…] management is at least as important, if not more important, than genetics."* However, farmers' management and culling decisions are constrained by financial considerations and there is limited room for manoeuvre within the system in which "*the farmer has no control over the prices for milk and meat*." For example, herd health advice from vets could possibly lead to an extended length of productive life, but farmers *"don't want to pay for a vet to come and give advice when there is not a sick animal to treat."* They may be unwilling to seek herd health advice since they cannot pass on the costs to the buyers: *"In a functioning market, the added costs of veterinary services would be added to the price of the products when sold."* Nonetheless, some respondents thought that farmers are more ready to pay for herd health advice than in the past: "*Farmers see the economic benefits to them of improved herd health, so are increasingly prepared to pay for high quality herd health advice."* There is also free of charge advisory service, which farmers can obtain.

5. Discussion

Although it is in the interests of farmers to keep problem-free, high-performing, long-lived dairy cows, the trend of a declining length of productive life identified by Olechnowiczc et al. (2016) throughout Europe and by Leiber et al. (2017) in Switzerland is persisting. The results of this study explain this persistence in the Swiss system by suggesting that the transformational power of actor groups is not sufficient to enable innovations that can have a positive effect on the incumbent system. The finding that actors feel powerless to change within the incumbent dairy system reflects the results of Bergeå et al.'s (2016) study of the attitudes of Swedish dairy farmers to the longevity of their cows, which found that farmers cannot put longevity in the foreground of their decisions due to external forces. They reported as well that requirements by dairy and slaughter companies, expectations of high milk yield, pressure on fertility of cows, and demands for low somatic cell counts are relevant reasons for short lengths of productive life (Bergeå et al., 2016).

Messner et al.'s (2021, p. 3) warning that, "in agrifood systems […] resistance to change (i.e., lock-in), may come in the form of existing infrastructure design, sunk investments and regulatory standards perpetuating and reinforcing 'business as usual', which in turn contours how the problem[s] […] are […] understood and addressed", appears to apply to the length of productive life of dairy cows in Switzerland. Within the Swiss dairy system, individual actors within their system realm, possess the power for learning and experimenting that Avelino and Rotmans (2009) suggest they need, so have the power to incubate what Geels (2004) would describe as radical novelties. However, the system is sufficiently stable and the path dependency and lock-ins (Cecere et al., 2014) are sufficiently strong, that is very difficult for an individual farmer to apply them and extend the length of productive life of their cows. Furthermore, the pressure of societal demand was reported by the respondents to be so abstract that it is not perceived by industry actors to be an imperative that demands urgent action. This

leads to the uncomfortable situation that farmers are locked into behaving against their own interests, which has negative effects on animal welfare.

The key question then, is what can be done at the system level in which actors similarly perceive that they have insufficient power to affect change? To further explore these perceptions of insufficient power, we discuss the types of key resources available and the perceived capability of actors to mobilize them to induce changes that could lead to an optimal length of productive life of dairy cows in the Swiss dairy system.

5.1. Political actors, dairies and retailers

Political actors set the regulations for hygiene in milk production that contain the thresholds for cell counts (Federal Department of Home Affairs, 2005) and for antibiotic use (The Federal Council, 2004), and dairies and retailers have a strong negotiation power over milk prices (Logatcheva et al., 2019). High somatic cell counts lead to significantly reduced cheese yields, texture, and taste, and are commonly the results of poor cow (udder) hygiene, insufficient cleaning of milking equipment, or inadequate refrigeration, so are penalised within the existing system by lower prices (Meier, 2023). However, high cell counts can also be the result of udder infections, with older cows more likely to produce milk with high cell counts. The rear quarters of older cows tend to be closer to the floor due to slackening of the connective tissue in the udder, which increases exposure to potential pathogens that cause infections, and which tend to last longer and cause greater tissue damage in older cows (Sumon et al., 2020). Furthermore, older cows have higher time-on-risk, which refers to a greater length of time for exposure to mastitis pathogens resulting in an increase in the number of infected quarters (Reneau, 1986). The price penalty is applied regardless of whether the high cell counts are the result of poor practice or are due to keeping older cows and following guidelines on antibiotic use.

Both political actors and dairies/retailers thereby set structural conditions, which manifest as strong barriers to the farmers to an extension of the length of productive life of dairy cows. It appears that both actor groups have the capability to mobilize their resources, i.e., financial resources and the regulatory power. However, as strong players in the system, they defend their interests and are understandably reluctant to change. Political actors could potentially mobilize their regulatory power to facilitate the flow of innovations to the system by bringing antibiotic regulations in line with cell count price penalties, which would give more consistent signals to farmers regarding the culling or treatment of dairy cows.

5.2. Agricultural educators

The agricultural education institutions in Switzerland have the possibility to mobilize mental resources (see Table 2), such as knowledge, in farmers for an optimized length of productive life of dairy cows. The education institutions have the knowledge on herd management and breeding, and they have human resources. The human resource is their range of influence since the majority of farmers receive agricultural education. Therefore, if the length of productive life was addressed here, a high number of farmers could potentially be aware of it. Similarly, Burns et al. (2020) and Just et al. (2018) showed that farmer education is related to the breeding decisions, such as whether traits are selected to rather improve efficiency or resilience.

5.3. Practicing vets

Practicing vets were reported to have mental and human resources (see Table 2), such as their knowledge and their clients, although with a limited capability to mobilize them to motivate change towards an optimal length of productive life of dairy cows. Their mental resources comprise of their knowledge about herd health and about the origin of the diseases they treat, which is in some cases related to management and breeding. Their human resources are the personal relationships with the farmers, which were characterised by the respondents by a rather high degree of trust. A trustful relationship between farmers and vets in Switzerland was also found by Gerber et al. (2020). This combination of trustful relationships and knowledge about herd/animal health could potentially initiate breeding and management decisions in farmers that lead to an optimized length of productive life. The results, however, show that respondents perceived the capability of vets to mobilize these resources as limited because the farmers call the vets to treat individual

Table 2
Resources of actor groups based on results.

Actor group	Resources category	Resources	Factors hindering resource mobilization
Government officials	Financial	• Direct payments, subsidies, other price mechanisms	Restrictions due to the political environment and to framing conditions of duties
	Artefact	• Regulations, e.g. cell count thresholds, antibiotic use; • Animal data base	
Agricultural educators	Mental	• Knowledge on herd management and breeding	Restrictions to make broad changes to the syllabus by the political environment and by industry norms
	Human	• Pupils	
Practising vets	Mental	• Knowledge about herd health	Restrictions due to farmers' low willingness to pay for an extra appointment for a consultation on herd health; risk on the vets' side to hire specialised staff for herd health advise
	Human	• Clients, trust • Collaboration with breeders' associations	
Agricultural advisors	Mental	• Cattle and Calf Health Service: knowledge on cow and calf health	Specialist inseminators: bias towards performance traits; Cattle and Calf Health Service: small number of employees
	Human	• Specialist inseminators: clients, frequent contact to farmers	
Breeders' associations	Mental	• Information on breeding • Data on cows • Strategy for breed development (weights given to traits/ characteristics)	Lack of data from vets on treatments; necessity to have profitability as a focus
	Human	• Members • Collaboration with geneticists and vets	
	Artefact	• Breeding value • Awards	
Dairies and retailers	Financial	• Milk prices (related to cell counts)	Dairies: high quality requests from retailers restrict relaxation of price penalties for cell counts; strong interest in a high supply of milk to strengthen their negotiation power over prices
Farmers	Mental	• Knowledge on dairy farming	Not sufficient information to make informed breeding and herd planning decisions; management and culling decisions are constrained by financial considerations (no control over prices)

cows and have a low willingness to pay for an extra appointment for a consultation on herd health. Swiss farmers' low willingness to pay for farm-adapted consulting by vets was also revealed by Gerber et al. (2020). The stability of the system hinders the ability of the vets to realise large-scale herd health advice. This finding reflects the results of Alvåsen et al. (2018) who reported that preventive herd health offers by vets or other professions are not widely used by farmers in Sweden. Nonetheless, in our study, as well as in the study by Gerber et al. (2020), vets were identified by respondents as one key actor group to extend the productive life of dairy cows.

5.4. Breeders' associations

The breeders' associations were found to be an important actor group within the Swiss dairy system, with multiple key resources, such as members, knowledge, data, collaboration, breeding value, and awards (see Table 2). The results suggested that they have a range of options to act differently regarding the optimization of the length of productive life of dairy cows. Indeed, they were reported have a key power position with their definition of parameters and weighting within the total breeding value, which could enable other actors, such as inseminators, vets and farmers, who use the total breeding value to make decision more targeted to optimizing the length of productive life.

Their capability to mobilize their resources appears to be rather high, even though it is limited by expectations of their members. The length of productive life is competing with many other interlinked aspects of cattle breeding, such as milk and meat performance, and overall costs and earnings from dairy production. It can be assumed that the breeders' organisations would mobilize their resources stronger if the importance given to the length of productive life was higher compared to the other aspects. Magne and Quénon (2021) reported in their study on crossbreeding of cows conducted in France that the breeders' associations were not interested in promoting crossbreeding despite its advantages over pure breeding. The reason for breeders' associations' resistance was that crossbreeding would challenge their main activities and would raise questions concerning economics, and the possibility to have an index for crossbred cows, among others. Also, Paakala et al. (2020) stated that the traits in indexes, such as the total breeding value, are weighted based on their economic importance in the respective production system. The extension of the length of productive life of dairy cows in Switzerland may also be perceived to challenge the activities of the breeders' associations.

5.5. Other advisors

The resources of semen sellers that were identified by the respondents were of human and mental nature (see Table 2) but were limited regarding their mobilization for an optimized length of productive life of dairy cows. The human resources of the semen sellers consist of their relationships to the farmers, which were characterised by frequent contacts. Their mental resources are comprised of their knowledge about the genetic potentials of the semen they sell, which enables them to give breeding advice. However, the weighting and parameters of the breeding value are perceived as improvable regarding its use for breeding for an optimized length of productive life. Hence, the semen sellers, who base their advice on the breeding value, are also limited in the advice they can give for increasing length of productive life through breeding by the inflexibility of the regime. This finding is comparable to the finding of Magne and Quénon (2021) on French inseminators' capability of promoting crossbreeding which is limited by the breeding indexes.

Private agricultural consultancy organisations and the cattle and calf health service have information as mental resources, which can be used to increase the length of productive life of dairy cows and which is provided free of charge. However, the respondents assessed their influence as small, with their human resources being too small to mobilize their mental resources effectively for an optimized length of productive life of dairy cows. Reasons for the limited influence could be a question of critical mass, with the small organisation having too few staff to gain sufficient visibility for the services to become part of the mindset of farmers. The lack of visibility leads to lack of demand, which makes it difficult for the service to expand their human resources.

5.6. Farmers

Farmers have mental resources in the form of knowledge about dairy farming. They might also have, or mobilize, financial resources, for example through sales and direct payments. The results suggest that mental resources about an optimal length of productive life are a key resource that dairy farmers may mobilize to be able to change their herd management and breeding decisions. However, despite these resources, the respondents perceived farmers' power to increase the length of productive life of their dairy cows as limited: mainly due to the market structures, but also by standard practice within the dairy system regime in calculating breeding values. This result reflects the findings of Bergeå et al. (2016) who reported that Swedish dairy farmers feel unable to put the longevity of their cows in the foreground of their decision-making due to the inflexibility of the established dairy system. The market structures lead to a risk of a lower income, for instance due to higher costs for veterinary herd-health advice or lower prices for milk with higher cell counts. These are external barriers to the extension of the length of productive life of cows for farmers, over which they have little influence.

6. Conclusions

The starting point for this research was the realisation that complex modelling, which accounts for all of the variables, demonstrates that the optimum productive life of dairy cows is longer than the industry practice. Efforts to increase the length of productive life of dairy cows in Europe, which started in the 1960s (Bode et al., 1994) have not been successful, and the reality of dairy cattle breeding in Europe has moved away from this goal in recent decades. This suggests that the system is resistant to change and that there may be systemic factors that enable or hinder an extended productive life of dairy cows. We investigate the power and lock-ins from the perspective of the key actors: namely agricultural educators, the breeders' associations, practising vets and other advisors, including semen sellers, dairies and retailers as well as representatives of government authorities and farmers. With this approach, we better understand why the on-farm decisions appear to be against the interests of the farmers making the decisions and can identify the resources that relevant actor groups in the Swiss dairy system could potentially mobilize to achieve change.

This study has the limitations that the results are specific to Switzerland so caution should be taken when drawing conclusions in other contexts. This question of generalizability is exacerbated by the lack of comparable study in other contexts into motivations for dairy farmers to increase the longevity of their cows, so possibilities for generalization may increase as the body of knowledge grows. A further limitation is that we chose a qualitative research approach with stakeholder participants who commonly gave their opinions on the role of different system actor in changing to an extended productive life, so it is possible that there are relevant characteristics of the system that are not included in the results. Future research in Switzerland could examine the system, but from the perspective of farmers by asking them directly where they see themselves within the system. Despite these limitations, the richness of the collected data gives confidence to draw conclusions.

The results of the interviews show almost unanimous agreement that changes to extend the useful life of dairy cows are necessary and desirable. Breeding associations, educational institutions, practising vets and other advisors, as well as representatives of government authorities are the most important actors for gradual change at the system level.

However, the existing system is so entrenched that none of the actors within the system feel that they are able to bring about comprehensive change on their own and they see themselves as locked in to the systemic norms. Any actor who could initiate change in the part of the system where they have influence feels that they would then no longer be in harmony with the rest of the system. As long as all actors within the system share this view, they are committed to a behaviour that they know is not optimal. This creates the situation that system change can only take place slowly and leads to the conclusion that rapid change in the system can only occur if all actors within the system start changing at the same time.

A faster system change would be possible if it was led by a collective and organised demand from dairy farmers, but such a demand is only likely if farmers would do the complex modelling and trust that profits will increase with an extended useful life. However, there are many other relevant variables, including, but not limited to, agricultural subsidies, predicted veterinary costs for common cattle diseases, predicted milk production along with estimates of future cell counts that influence prices, current and predicted market prices for milk and meat, costs of semen from desired breeding lines, current and predicted feed costs, current and predicted energy costs, opportunity costs of rearing calves for herd replacement, costs of herd replacement heifers that are sourced externally, and estimated labour costs. Even if data to quantify these variables were readily available, several respondents expressed that farmers tend to dislike accounting tasks, and many farmers are not equipped with the advanced modelling skills needed to calculate the optimum productive life of their cows.

Bettman et al. (1991) point out that people who are faced with complex decisions tend to find mental shortcuts (heuristics) to simplify these decisions by selecting individual components that are easy to understand and for which data are readily available. However, when the calculation is reduced to fewer, and more easily measured variables, the results can be misleading so that farmers make decisions using incomplete information and inadvertently cause themselves economic loss. In the case of Swiss dairy farmers, decisions (per animal) are commonly based on milk production and estimates of future veterinary costs. These findings allow the conclusion that the responsibility for motivating change cannot be placed with the farmers but rather needs mobilization at the industry level.

Several respondents mentioned that collaboration and pooling of resources is a promising strategy to initiate industry reform. The different actor groups have different resources and capabilities to mobilize them. For example, the vets have the relationships to farmers and other advisory groups have the possibility to offer free advice to farmers. The breeders' organisations have the capability to offer different calculations for the breeding value and semen sellers could adapt their breeding advice based on a breeding value with a stronger weight on fitness or persistence. Political actors could use their regulatory power to facilitate keeping older cows: for example, by limiting the financial risk farmers face for milk with higher cell counts, such as by introducing a system to compensate farmers whose herds suffer higher cell counts due to keeping older animals and/or by enabling farmers to make use of herd health advice by vets, such as with a subsidy. Furthermore, providing sufficient state funding to the Cattle and Calf Health Service (Rindergesundheitsdienst) to allow them to expand their employee base and increase their visibility would facilitate the dissemination of the expertise held within the organisation. An interest group combining several actor groups could negotiate with dairies and retailers to change the structural conditions that pose financial risks by older cows to farmers. Activities highlighting the benefits of the use of sexed semen and financial incentives for the use of sexed semen could lead to an unfolding of the technology's potential for better-planned breeding for replacement heifers. These are some examples of how collaborations between actor groups could enable niche level innovation to become mainstream and facilitate extension of the length of productive life of dairy cows in Switzerland.

To conclude, one way to motivate a systemic change could be to create strong incentives at all levels and for all actors at the same time, so that no actor in the system would experience a period in which they did not fit into the system. Another way could be to organise the cooperation, and thus the pooling of key resources, of the relevant actors. Both these alternatives suggest that the way forward is most likely to be successful with a top-down government intervention that is designed in consultation with the relevant stakeholders.

Author statement

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Declaration of competing interest

The authors have no relevant financial or non-financial interests to disclose.

Data availability

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References

Alvåsen, K., Dohoo, I., Roth, A., Emanuelson, U., 2018. Farm characteristics and management routines related to cow longevity: a survey among Swedish dairy farmers. Acta Vet. Scand. 60 (1) https://doi.org/10.1186/s13028-018-0390-8.

Avelino, F., Rotmans, J., 2009. Power in transition an interdisciplinary framework to study power in relation to structural change [article]. Eur. J. Soc. Theor 12 (4), 543–569. https://doi.org/10.1177/1368431009349830.

Avelino, F., Rotmans, J., 2011. A dynamic conceptualization of power for sustainability research. J. Clean. Prod. 19 (8), 796–804. https://doi.org/10.1016/j.jclepro.2010.11.012.

Balzani, A., Aparacida Vaz do Amaral, C., Hanlon, A., 2021. A perspective on the use of sexed semen to reduce the number of surplus male dairy calves in Ireland: a pilot study. Front. Vet. Sci. https://doi.org/10.3389/fvets.2020.623128.

Bergeå, H., Roth, A., Emanuelson, U., Agenas, S., 2016. Farmer awareness of cow longevity and implications for decision-making at farm level. Acta Agricul. Scandinavica Sec. a-Animal Sci. 66 (1), 25–34. https://doi.org/10.1080/09064702.2016.1196726.

Bettman, J.R., Luce, M.F., Payne, J.W., 1991. Consumer Decision Making. Handbook of Consumer Psychology. https://doi.org/10.4324/9780203809570.CH23.

Bieber, A., Wallenbeck, A., Leiber, F., Fuerst-Waltl, B., Winckler, C., Gullstrand, P., Neff, A., 2019. Production level, fertility, health traits, and longevity in local and commercial dairy breeds under organic production conditions in Austria, Switzerland, Poland, and Sweden. J. Dairy Sci. 102 (6), 5330–5341. https://doi.org/10.3168/jds.2018-16147.

Bielfeldt, J.C., Tölle, K.H., Badertscher, R., Krieter, J., 2006. Longevity of Swiss Brown cattle in different housing systems in Switzerland. Livest. Sci. 101 (1), 134–141. https://doi.org/10.1016/j.livprodsci.2005.10.023.

Bode, L., Durrwald, R., Ludwig, H., 1994. Borna virus infections in cattle associated with fatal neurological disease. Vet. Rec. 135, 283–284.

Bruijnis, M., Meijboom, F., Stassen, E., 2013. Longevity as an animal welfare issue applied to the case of foot disorders in dairy cattle. J. Agric. Environ. Ethics 26, 191–205. https://doi.org/10.1007/s10806-012-9376-0.

Burns, J.G., Glenk, K., Eory, V., Simm, G., Wall, E., 2020. Preferences of European dairy stakeholders in breeding for resilient and efficient cattle: a best-worst scaling approach. J. Dairy Sci. 105 (2), 1265–1280. https://doi.org/10.3168/jds.2021-20316.

Burren, A., Alder, S., 2013. Abgangsursachen und LBE. CHBraunvieh 3, 8–11.
Cecere, G., Corrocher, N., Gossart, C., Ozman, M., 2014. Lock-in and path dependence: an evolutionary approach to eco-innovations. J. Evol. Econ. 24 (5), 1037–1065. https://doi.org/10.1007/s00191-014-0381-5.
Cowan, R., Gunby, P., 1996. Sprayed to death: path dependence, lock-in and pest control strategies. Econ. J. 106 (436), 521–542. https://doi.org/10.2307/2235561.
Crouch, M., McKenzie, H., 2006. The logic of small samples in interview based qualitative research. Soc. Sci. Inf. 45, 483–499.
Dolecheck, K., Bewley, J., 2018. Animal board invited review: dairy cow lameness expenditures, losses and total cost. Animal 12 (7), 1462–1474. https://doi.org/10.1017/s1751731118000575.
Ewe, A., 2021. Was halten Sie vom Spermasexing-Verbot bei Bio Suisse? Bauernzeitung, Nov. 21, 2021. https://www.bauernzeitung.ch/artikel/tiere/was-halten-sie-vom-spermasexing-verbot-bei-bio-suisse-drei-delegierte-des-verbandes-machen-ihren-standpunkt-klar-391098. (Accessed 13 January 2023). Accessed.
Federal Department of Home Affairs, 2005. Verordnung des EDI über die Hygiene bei der Milchproduktion. Regulation Nr. 916.351.021.1. Web address: https://www.fedlex.admin.ch/eli/cc/2005/824/de.
Fraser, D., Weary, D.M., Pajor, E.A., Milligan, B.N., 1997. A scientific conception of animal welfare that reflects ethical concerns. Anim. Welf. 6, 187–205.
Fuss, M., Burren, A., 2018. Abgangsursachen und LBE, Holstein News, Switzerland. https://www.holstein.ch/wp-content/uploads/2018/07/holstein-news_juillet_2018_d.pdf. (Accessed 12 July 2022). Accessed.
Garud, R., Karnøe, P., 2012. In: Garud, R., Karnøe, P. (Eds.), Path Dependence and Creation. Psychology Press.
Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems. Res. Pol. 33 (6–7), 897–920. https://doi.org/10.1016/j.respol.2004.01.015.
Gerber, M., Dürr, S., Bodmer, M., 2020. Decision-making of Swiss farmers and the role of the veterinarian in reducing antimicrobial use on dairy farms. Front. Vet. Sci. 7 (565) https://doi.org/10.3389/fvets.2020.00565.
Giddens, A., 1984. The Constitution of Society Outline of the Theory of Structuration. University of California Press.
Gilbert, R.O., 2016. Management of reproductive disease in dairy cows. Vet. Clin. Food Anim. Pract. 32, 387–410.
Grandl, F., Amelchanka, S.L., Furger, M., Clauss, M., Zeitz, J.O., Kreuzer, M., Schwarm, A., 2016. Biological implications of longevity in dairy cows: 2. Changes in methane emissions and efficiency with age. J. Dairy Sci. 99 (5), 3472–3485. https://doi.org/10.3168/jds.2015-10262.
Graneheim, U., Lindgren, B., Lundman, B., 2017. Methodological challenges in qualitative content analysis: a discussion paper. Nurse Educ. Today 56, 29–34. https://doi.org/10.1016/j.nedt.2017.06.002. Epub 2017 Jun 17. PMID: 28651100.
Grin, J., Rotmans, J., Schot, J., 2010. Transitions to Sustainable Development - New Directions in the Study of Long Term Transformative Change. Routledge, Taylor & Francis.
Guest, G., Bunce, A., Johnson, L., 2006. How many interviews are enough? An experiment with data saturation and variability. Field Methods 18, 59–82.
Hediger, F., Bieber, A., Pfeiffer, C., Walkenhorst, M., 2021. Development of the Productive Life of Swiss Dairy Cows from 1990 to 2021. Research Institute of Organic Agriculture, Frick Switzerland.
Heikkilä, A.-M., Nousiainen, J.I., Jauhiainen, L., 2008. Optimal replacement policy and economic value of dairy cows with diverse health status and production capacity. J. Dairy Sci. 91 (6), 2342–2352. https://doi.org/10.3168/jds.2007-0736.
Horn, M., Knaus, W., Kirner, L., Steinwidder, A., 2012. Economic evaluation of longevity in organic dairy cows. Organic Agriculture 2 (2), 127–143. https://doi.org/10.1007/s13165-012-0027-6.
Identitas, A.G., 2022. Evolution by breed – cattle – tierstatistik. Website. https://tierstatistik.identitas.ch/en/cattle-breeds.html date of last update: 18.07.2022, date of access: 21.07.2022.
Jamali, H., Barkema, H.W., Jacques, M., Lavallée-Bourget, E.-M., Malouin, F., Saini, V., Stryhn, H., Dufour, S., 2018. Invited review: incidence, risk factors, and effects of clinical mastitis recurrence in dairy cows. J. Dairy Sci. 101 (6), 4729–4746. https://doi.org/10.3168/jds.2017-13730.
Just, A., Wellmann, R., Bennewitz, J., 2018. Estimation of relative economic weights and the marginal willingness to pay for breeding traits of Brown Swiss cattle using discrete choice experiments. J. Dairy Sci. 101 (6), 5207–5213. https://doi.org/10.3168/jds.2017-14012.
Kern, M., 2019. Spermasexing im Schweizer Biolandbau: Ökonomische Konsequenzen des Verbotes von Spermasexing im Schweizer Biolandbau. Masters thesis at Berner hochschule HAFL. https://www.bauernzeitung.ch/fileadmin/user_upload/kern-matthias-bscthesis-spremasexing-20190808.pdf. (Accessed 13 January 2023). Accessed.
Leiber, F., Muller, A., Maurer, V., Schader, C., Bieber, A., 2017. Organic dairy farming and sustainability. In: van Belsen, N. (Ed.), Achieving Sustainable Production of Milk, ume 2. Burleigh Dodds Science Publishing. https://shop.bdspublishing.com/store/bds/detail/product/3-190-9781838797645.
Leiber, F., Müller, A., Maurer, V., Schader, C., Bieber, A., 2019. Organic dairy farming: towards sustainability. In: Vaarst, Mette und Roderick, Stephen (Hrsg.) Improving organic animal farming. Burleigh Dodds Science Publishing Limited, Cambridge, UK, Kapitel 11, S, pp. 225–244.
Logatcheva, K., van Galen, M., Janssens, B., Rau, M.L., Baltussen, W., van Berkum, S., Mann, S., Ferjani, A., Cerca, M., 2019. Factors driving up prices along the food value chain in Switzerland – Case studies on bread, yoghurt, and cured ham. Schwerpunktthema: Vor- und Nachgelagerte Wertschöpfungsstufen der Landwirtschaft. Strukturberichterstattung Nr. 60/3. Study on the behalf of the State Secretariat for Economic Affairs SECO.
Magne, M.A., Quénon, J., 2021. Dairy crossbreeding challenges the French dairy cattle sociotechnical regime. Agron. Sustain. Dev. 41 (25) https://doi.org/10.1007/s13593-021-00683-2.
Mason, M., 2010. Sample size and saturation in PhD studies using qualitative interviews. Qualitative Social Research 11, 190–197.
Mayring, P., 2014. Qualitative Content Analysis: Theoretical Foundation, Basic Procedures and Software Solution.
Meier, S., 2023. 150 Franken pro Kuh und Jahr. Schweizer Bauer. Visited. https://www.schweizerbauer.ch/tiere/milchvieh/150-franken-pro-kuh-und-jahr/. (Accessed 3 May 2023).
Meier, M., Hörtenhuber, S., Schader, C., Stolze, M., 2017. Organic Framing and Sustainability: Life Cycle Assessment of Organic Foods. FiBL Facts Sheet. Research Institute of Organic Agriculture, Frick, Vienna. https://shop.fibl.org/chde/1020-life-cycle-assessments.html.
Messner, R., Johnson, H., Richards, C., 2021. From surplus-to-waste: a study of systemic overproduction, surplus and food waste in horticultural supply chains. J. Clean. Prod. 278, 123952 https://doi.org/10.1016/j.jclepro.2020.123952.
Mierlo, B. van, Regeer, B., Amstel, M. van, Arkesteijn, M., Beekman, V., Bunders, J., Cock Buning, T. de, Elzen, B., Hoes, A., Leeuwis, C., 2010. Reflexive Monitoring in Action: A Guide for Monitoring System Innovation Projects. Athena Institute, Wageningen/Amsterdam.
Nor, N., Steeneveld, W., Hogeveen, H., 2014. The average culling rate of Dutch dairy herds over the years 2007 to 2010 and its association with herd reproduction, performance and health. J. Dairy Res. 81 (1), 1–8. https://doi.org/10.1017/S0022029913000460.
Olechnowiczc, J., Kneblewski, P., Jaśkowski, J.M., Włodarek, J., 2016. Effect of selected factors on longevity in cattle: a review. The Journal of Animal & Plant Sciences 26 (6), 1533–1541.
Paakala, E., Martín-Collado, D., Mäki-Tanila, A., Juga, J., 2020. Farmers' Stated Selection Preferences Differ from Revealed AI Bull Selection in Finnish Dairy Herds, 240. Livestock Science, 104117. https://doi.org/10.1016/j.livsci.2020.104117.
Patton, M., 1990. Qualitative Evaluation and Research Methods. Sage, Newbury Park, CA.
Probst, S., Wasem, D., Kobe, D., Zehetmeier, M., Flury, C., 2019. Greenhouse gas emissions from coupled dairy-beef production in Switzerland. Agrarforschung Schweiz 10, 440–445, 2019.
Rell, J., Wunsch, N., Home, R., Kaske, M., Walkenhorst, M., Vaarst, M., 2020. Stakeholders' perceptions of the challenges to improving calf health and reducing antimicrobial use in Swiss veal production. Prev. Vet. Med. 179, 104970 https://doi.org/10.1016/j.prevetmed.2020.104970.
Rell, J., Home, R., Bähler, C., Oehen, B., Vaarst, M., Wunsch, N., Kaske, M., Walkenhorst, M., 2022. Motivations for Swiss veal farmers to adopt calf health management strategies that enable reduction in antibiotic use. Anim. Prod. Sci. 62 (5), 490–500. https://doi.org/10.1071/AN20690.
Reneau, J., 1986. Effective use of dairy herd improvement somatic cell counts in mastitis control. J. Dairy Sci. 69, 1708–1720.
Schuster, J., Barkema, H., De Vries, A., Kelton, D., Orsel, K., 2020. Invited review: academic and applied approach to evaluating longevity in dairy cows. J. Dairy Sci. 103 (12), 11008–11024. https://doi.org/10.3168/jds.2020-19043.
Sumon, S., Parvin, M., Ehsan, M., Islam, M., 2020. Dynamics of somatic cell count and intramammary infection in lactating dairy cows. J. Advan. Veterin. Animal Res. 7 (2), 314–319. https://doi.org/10.5455/javar.2020.g423.
The Federal Assembly of the Swiss Confederation, 2005. Federal Act on the Consultation Procedure (Consultation Procedure Act, CPA) of 18 March 2005 (Status as of 26 November 2018), Based on Article 147 of the Federal Constitution1, and Having Considered the Federal Council Dispatch of 21 January 2004, Nr, p. 172, 061. https://www.fedlex.admin.ch/eli/cc/2005/542/en.
The Federal Council, 2004. Verordnung über die Tierarzneimittel. Regulation Nr. 812.212.27. Web address: https://www.fedlex.admin.ch/eli/cc/2004/592/de.
Unruh, G., 2000. Understanding carbon lock-in. Energy Pol. 28 (12), 817–830. https://doi.org/10.1016/S0301-4215(00)00070-7.
Vanloqueren, G., Baret, P., 2009. How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. Res. Pol. 38 (6), 971–983. https://doi.org/10.1016/j.respol.2009.02.008.
Webster, J., 2022. The moral status of animals:Biological foundations. In: Knight, A., Phillips, C., Sparks, Paula (Eds.), Routledge Handbook of Animal Welfare. Routledge, New York, pp. 3–12.
Zehetmeier, M., Baudracco, J., Hoffmann, H., Heißenhuber, A., 2012. Does increasing milk yield per cow reduce greenhouse gas emissions? A system approach. Animal 6 (1), 154–166. https://doi.org/10.1017/S1751731111001467.