European
Historical
Economics
Society

EHES Working Paper | No. 257 | April 2024

Of the bovine ilk: Quantifying the welfare of dairy cattle in history, 1750-1900

Markus Lampe,
Vienna University of Economics & Business, CEPR

Paul Sharp,
University of Southern Denmark, CAGE, CEPR

EHES Working Paper | No. 257 | April 2024

Of the bovine ilk: Quantifying the welfare of dairy cattle in history, 1750-1900*

Markus Lampe,
Vienna University of Economics & Business, CEPR

Paul Sharp[1],
University of Southern Denmark, CAGE, CEPR

Abstract

We seek to understand the welfare of dairy cattle in Denmark from 1750 to 1900, a period marked by significant agricultural development and industrialization. By applying contemporary animal welfare metrics to historical data, we uncover a detailed picture of how bovine welfare evolved. Our findings reveal a complex pattern of both improvements and declines in welfare over time, influenced by changes in farming practices such as feeding, housing, and health management. Our work contributes to a deeper understanding of the nexus of economic progress and animal welfare, highlighting the historical complexities of agricultural practices and their impact on animal welfare.

JEL Codes: Animal welfare, cattle, dairying, Denmark

Keywords: N53, N54, Q18

[1]Corresponding Author: Paul Sharp (pauls@sam.sdu.dk)
* We would like to thank everyone on Videncenter for Dyrevelfærd's [Knowledge Centre for Animal Welfare] "Hånd-i-Hånd" project, and particularly Mette Vaarst, for inspiring this work.

"The cow is of the bovine ilk; one end is moo, the other milk." – Ogden Nash

1. Introduction

Despite the words of Ogden Nash, there is more to a cow than "moo" and "milk". At least since the Enlightenment, there has been a debate about whether animals are simply biological machines, whether their productivity should be maximized so as to produce the greatest returns for humans, or whether we should consider their well-being alongside our own (see e.g. Turner 1980). Animal welfare is today, together with environmental sustainability, species diversity and more at the centre of heated discussions about the future of agriculture. Historians and social scientists have increasingly debated the relationship between "human animals" and "non-human animals"[2], and as the boundaries have become blurred, animal rights have come to the forefront. Christensen et al. (2023) argue that economists can help improve animal welfare by defining priorities and setting up incentives, but economic history has been notably silent on this topic – and this despite impressive work documenting long-run human welfare (see e.g. Broadberry et al, 2015).

Economic history is of course concerned with the history of humans, but there are multiple reasons why we should also consider animals. First, the welfare of animals enters our utility functions, i.e. we care about them, their pain and suffering; second, it is important for consumers when deciding what to consume; and third, it ties into concerns about sustainability and climate. Finally, understanding the history of animal welfare also helps us to understand how we got to where we are today. Now, we have the most efficient animal industry ever, but also a record number of people in richer countries turning to vegetarianism/veganism. Nevertheless, consumption of meat is expected to continue to increase (OECD/FAO, 2021). The history of Danish agriculture is, until recently, an example of efficiency at the expense of the welfare of animals.

Thus, we ask: how can we quantify animal welfare over the long run? We summarize the recent literature and tease out indicators of animal welfare from history through the case of Denmark, where modern, industrialized dairying was invented (Lampe and Sharp, 2015a; Boberg-Fazlic et al., 2023) and from where it spread to the rest of the world (Korchmina and Sharp, 2020; Boberg-Fazlic and Sharp, 2024). We take inspiration from contemporary animal welfare science. We adopt an empirical approach to assess the

[2] See e.g. Deb Roy (2017) on human/animal relations in British India and Samanta (2021) on colonial Bengal. Govindrajan (2019) studies the same based on surveys in mountain villages in India's Central Himalayas, and Walther (2021) discusses relations between humans and non-human animals in literature. Fjalland (2022) argues that gastronomy should be understood together with animal welfare.

welfare of dairy cattle in Denmark from 1750 to 1900, a period characterized by significant agricultural evolution. This approach hinges on the innovative application of contemporary animal welfare standards to historical agricultural data. We meticulously gather and analyse archival records detailing feeding, housing, health care, and general treatment of dairy cattle during this period. These records provide a robust basis for a comparative analysis against contemporary welfare benchmarks.

Our methodology involves several key steps. First, we establish a framework for dairy cattle welfare based on contemporary standards – the European Welfare Quality® assessment protocols – encompassing aspects like diet, living conditions, health care, and behavioural freedom. This framework is then applied to historical data, allowing us to evaluate the welfare of dairy cattle in the past using a consistent, quantifiable metric. We analyse variations in diet, including changes in feed type and availability, and assess housing conditions, particularly shifts from open grazing to confined environments. Health care practices are examined through veterinary records and farming manuals of the time, providing insights into the medical understanding and treatment of dairy cattle. We also consider broader socioeconomic factors that influenced cattle welfare, such as economic pressures on farmers, technological advancements in agriculture, and societal attitudes towards animals. By integrating these factors, we gain a holistic view of the influences shaping cattle welfare during this transformative period in agricultural history. This empirical approach enables us to chart the trajectory of cattle welfare over 150 years, highlighting periods of significant improvement or decline. Our analysis reveals how advancements in agricultural techniques and economic shifts impacted the lives of these animals, offering a unique historical perspective on the intersection of economic progress and animal welfare. This research not only sheds light on the past but also provides a foundational understanding for contemporary discussions on animal welfare in agriculture.

Our comprehensive analysis reveals a multifaceted narrative that reflects the interplay between agricultural practices, socio-economic factors, and animal welfare standards over this 150-year span. The early phase of our study period, around 1750, marked the onset of gradual enhancements in the living standards of cattle. This improvement was primarily attributed to advancements in agricultural techniques and an emerging recognition of animal health needs. Notably, we observed significant changes in feeding practices. The introduction of more diverse and nutritious forage, coupled with better feed management strategies, led to improved health and increased productivity among dairy cattle. This period also witnessed the early stages of understanding animal nutrition, which played a crucial role in enhancing the overall welfare of the dairy cattle, although it was motivated through a desire to increase yields.

However, as the nineteenth century unfolded, our findings indicate a discernible shift, particularly linked to the intensification of farming practices. This era, characterized by the industrial revolution and the shift

towards more intensive farming methods, brought about substantial changes in cattle welfare. The transition to confined housing systems, aimed at boosting milk production, often led to compromised living conditions for the dairy cattle. These conditions included limited mobility and social interaction, contributing to increased stress and a decline in overall welfare. The drive for higher productivity also led to overbreeding (itself made possible by the aforementioned improved feeding) and other practices that further compromised the welfare of dairy cattle.

In the realm of healthcare, the period saw a gradual evolution from a rudimentary understanding of bovine diseases to more advanced veterinary care. However, this progress was juxtaposed against the backdrop of intensified farming practices, which brought new challenges. The increased density of cattle populations in confined spaces led to a higher incidence of diseases. While veterinary medicine advancements provided better treatment options, they were not always sufficient to offset the negative impacts of the intensive farming systems.

Our study also highlights the significant role of economic and societal factors in shaping cattle welfare. Economic pressures to maximize productivity often conflicted with the needs of the animals, leading to compromises in their well-being. Furthermore, societal attitudes towards animals underwent a transformation during this period. Initially, dairy cattle were viewed primarily as economic assets, but over time, there was a growing recognition of their sentience and welfare needs. This shift in perception, however, was slow and often at odds with the prevailing economic imperatives of the agricultural sector.

We contribute first to the economic history of the intensification and industrialization of agriculture, often seeking to place it within a developmental perspective, see Overton (1996) on the Agricultural Revolution in England, Federico (2005) on global agricultural performance, and Olmstead and Rhode (2008) on the spectacular science-based agricultural development of the United States. Sharp (2018) presents an overview of agriculture in economic history. We also contribute to the economic history of Denmark, and particularly the development of its dairy industry (Henriksen, 1992; Kjærgaard, 1994; Lampe and Sharp, 2019b; Kærgård, 2022). These often present this is an unambiguous success story, distributional consequences notwithstanding, although see Boje (2020) for an alternative view.

Within history and sociology, Hribal (2003) explains that with the enclosure of the commons, animals were to be kept in and not out of specific areas. They became commodities, with the goal being to increase their productivity and to control their reproduction, with the result that females were kept pregnant most of the time, and mothers and children were separated. He presents a Marxian interpretation of the animal rights movement as part of the working-class movement, noting that the rights of workers and animals were often linked. Specifically on dairying, Nimmo (2008) notes that the formal measurability of milk yields acted as a

mechanism for the reshaping of dairy farming practice through ever widening circles of farmers. Tacit knowledge was replaced with measurement, and farmers became *de jure* the sole producers of milk, while dairy cattle became simply organic machines for production. Israelsson (2005, 74-5) reports similar ideas in Sweden. Although this process was mostly from 1914 in the UK and confined to the segment of large estates in Sweden before 1914, such practices were introduced much earlier and more broadly in Denmark (Lampe and Sharp, 2017, 2019a,b, Martiin 2016). There is a recent surge in research on factory farming in the European postwar period, partly based on earlier US developments, and what this has meant for raising animals in 'modernized' European agriculture (Settele 2022, Auderset and Moser 2018). We are not, however, aware of any previous quantitative approaches to the history of animal welfare.

The historical context of our findings can significantly inform current animal welfare policies, offering a perspective on the evolution of farming practices. These insights underscore the necessity for policies to balance economic productivity with animal welfare considerations. Our research also points towards the need for enhanced farming practices, advocating for better living conditions and health care for livestock. Furthermore, the importance of education and awareness about animal welfare is highlighted, suggesting that informed policies could lead to improvements in farming practices.

We would however caution careful consideration when applying our findings to current policymaking, and would argue for further research in animal welfare and agriculture. Our historical data has of course gaps and inaccuracies, and applying contemporary welfare standards to historical conditions does not encapsulate the societal norms and contexts of the time. Moreover, the geographical focus on Denmark limits the generalizability of our findings. Lastly, the methodological approach of using contemporary welfare metrics to interpret historical data poses its own set of challenges, requiring careful interpretation of qualitative historical records.

In the following section, we present a review of the literature quantifying animal welfare. In Section 3 we provide an historical overview of the importance of dairying for Denmark, and the history of animal welfare and animal rights. Section 4 provides some quantitative indicators for Denmark, ca. 1750-1900. Section 5 concludes.

2. Measuring animal welfare

Economics and economic history have much to say about the measurement of human welfare. This might be in terms of heights, calories / consumption, housing, freedom, health, working hours and other conditions, education, and more. The economic historian is often forced to use proxies, when the exact

measures are unavailable (see e.g. Steckel, 2013; Persson and Sharp, 2015; Komlos and Batten, 2016; Allen, 2017). Estimating animal welfare in history is certainly fraught with even more challenges. We can however take inspiration from the animal welfare science literature.

An early attempt to quantify animal welfare was provided by Broom (1991), who considered reduced life expectancy, impaired growth, impaired reproduction, body damage, disease, immunosuppression, adrenal activity, behaviour anomalies, and self-narcotization. Later, writing on the history of animal welfare science, Broom (2011) explains that "Human attitudes to animals have changed as non-humans have become more widely incorporated in the category of moral agents who deserve some respect. Parallels between the functioning of humans and non-humans have been made for thousands of years but the idea that the animals that we keep can suffer has spread recently." He goes on to explain how early attempts to define welfare referred to "individuals being in harmony with nature," but that the first usable definition incorporated feelings and health. A debate ensued about whether welfare should only be about feelings, but others argued that these themselves are mechanisms which have evolved to cope with the environment, and so are not the entirety of welfare.

This meant that most recent studies now list the needs of the animal, including needs to show certain behaviours, with naturalness no longer a part of the definition, despite explaining why some needs exist. An example of this is Mandel et al. (2022) who concludes, based on opinions of experts, that "the overall likelihood of a negative welfare state (i.e. welfare risk)" is greater from dairy herds than from beef herds, and that it is important to raise awareness of this among consumers to "encourage a more sustainable and responsible food consumption." Mason and Mendi (2023) explain, however, that such measures will never be perfect and will often lead to contradictory findings because they are ultimately based on subjective judgements. There is a consensus that calves and hens experience among the worst suffering of any animals (Zuzworsky, 2001).

In Europe, the Welfare Quality Network's European Welfare Quality® project provides a simple set of criteria for assessing the welfare of animals including cattle. These are phrased around welfare questions: Are the animals properly fed and supplied with water? Are the animals properly housed? Are the animals healthy? Does the behaviour of the animals reflect optimized emotional states? These in turn result in several criteria, as summarized in Table 1.[3]

[3] See e.g. Reimert et al. (2023) for an alternative conceptualization.

Table 1: The principles and criteria that are the basis for the Welfare Quality® assessment protocols

Welfare principles	Welfare criteria	
Good feeding	1	Absence of prolonged hunger
	2	Absence of prolonged thirst
Good housing	3	Comfort around resting
	4	Thermal comfort
	5	Ease of movement
Good health	6	Absence of injuries
	7	Absence of disease
	8	Absence of pain induced by management procedures
Appropriate behaviour	9	Expression of social behaviours
	10	Expression of other behaviours
	11	Good human-animal relationship
	12	Positive emotional state

Source: www.welfarequalitynetwork.net [retrieved 04-12-2023]

These are relatively self-explanatory, and will form the basis of our empirical work below. Aubé et al. (2022) explain that for example thermal comfort has become more an issue as more animals are now at pasture, following organic practices in particular. We have information about feed, housing conditions, and some indicators of health, although clearly some aspects such as behaviour in particular are difficult or impossible to determine for historical herds.

3. Historical background

Denmark's industrialization during the latter part of the nineteenth century can be attributed significantly to the swift proliferation of butter factories and the concurrent expansion of dairy farming. Danish agricultural commodities, such as bacon and subsequently eggs, secured a substantial portion of the important British market (Lampe and Sharp, 2014, 2015b). This economic success was reliant upon peasant cooperatives, the first of which was established in 1882, and the adoption of innovative technology, particularly the steam-powered automatic cream separator.

The genesis of this can be traced back to the influx of enlightened elites from northern Germany who, from the latter half of the eighteenth century, acquired extensive estates in Denmark. These elites introduced novel agricultural methodologies, including the implementation of centralized dairy facilities (known as *hollænderier*), and played pivotal roles in instigating and participating in an extensive programme of reform (Lampe and Sharp, 2018; Boberg-Fazlic et al., 2023). Noteworthy aspects of this reform encompassed the emancipation of serfs (Gary et al., 2022) and broader agrarian restructuring, which laid the foundation for the emergence of medium-sized peasant farmers integral to the cooperative movement (Boberg-Fazlic et al., 2022).

In the nineteenth century, educational institutions and extension services dedicated to disseminating best practices, inclusive of sophisticated accounting techniques, were established (Lampe and Sharp, 2017, 2019a), and these latter involved prescriptive ways in which dairy cattle were to be controlled. As the dairy sector grew behind protectionist tariffs (Henriksen et al., 2012), the invention of the centrifugal separator in the 1870s marked a pivotal moment, as Danish peasant farmers swiftly embraced this technological innovation, enabling the centralized production model that had hitherto been the monopoly of larger producers for over a century. They were not always quick to innovate, however, and health-wise were for example slow to introduce compulsory inspections of creameries for somewhat libertarian ideological reasons (Boje, 2020). According to AHAW (2023), Denmark even today has by far the largest dairy herds in the European Union, with an average of 180, followed by the Netherlands at 97. Both are large because they are mostly supplying to dairies rather than producing on farm. Danish cows also have the highest yields, and thus Danish cows are for example able to produce the same amount of milk as Ireland, despite having just half the number of dairy cows.

A focus on animal welfare and rights was relatively slow to come to Denmark, as we discuss below, but in this connection, it is important to note that it was also a long time before many basic human rights were acknowledged, and animals were therefore not special in that sense. For example, the aforementioned serfdom was replaced only in 1800 by the servant-like status of "*tyende*", which also denied many basic rights, and was itself only replaced by a more modern Employee Law in 1921, six years after *tyender* and women were given the right to vote in 1915 (Boberg-Fazlic et al., 2024).

It seems quite likely that each society or group of individuals would like to believe it is more progressive than the last, and a publication from a conference on "Animal welfare, from Science to Law" held in Paris on 11 December 2015 supports this, writing in its introduction: "We live in a society that sees itself as more and more ethical and progressive. As an area of philosophy, ethics guide human actions towards what is right and virtuous. It pushes us towards a fairer and more respectful treatment of other human beings. It

translates, among other things, into social progress and legislations in favour of human rights. Likewise, respecting nature and its living beings must constitute a principle guiding our choices and actions." (Hild and Schweitzer, 2019, 7). But such concerns are nothing new, as the first chapter in the same volume (Duncan, 2019) reveals.

Duncan traces humanity's shifting relationship with animals from ancient Greece to today. Initially, philosophers, including Aristotle, Aquinas, Descartes, Hobbes, and Kant, posited a stark dichotomy—humans possessed rationality, bestowing them with a unique moral status, while animals were relegated to instruments devoid of such distinction.[4] This viewpoint persisted until the seventeenth century. The Enlightenment ushered in a transformative era challenging this categorical separation. Influential thinkers like Hume, Bentham, and Mill contested the primacy of rationality, emphasizing instead the moral significance of an entity's capacity to suffer. Bentham's groundbreaking assertion in 1823 – "*the question is not, Can they reason? nor, Can they talk? but, Can they suffer?*" – marked a paradigm shift. Further impetus came in the nineteenth century with Darwin's Theory of Evolution, illuminating the adaptive nature of both pleasure and suffering in animals (Turner 1980). However, the formalization of animal welfare science faced impediments in the twentieth century, notably from Behaviourism, which dismissed subjective experiences in animals.

The mid-twentieth century witnessed a resurgence of ethical considerations in the treatment of animals. Ruth Harrison's *Animal Machines* (1964) spotlighted the intensified suffering of animals in industrial agriculture during the Second World War, triggering public outcry. Concurrently, Donald Griffin's *The Question of Animal Awareness* (1976) legitimized the study of animals' subjective experiences, fostering a renewed scientific and philosophical interest. Philosophers like Peter Singer (1975) and Tom Regan (1983) played pivotal roles in shaping contemporary discourse. Singer, often deemed the father of animal rights, embraced utilitarianism, while Regan, an "abolitionist" (in the sense of ending the misuse of animals), vehemently condemned killing as the ultimate harm. The present-day conversation extends beyond direct use to include the indirect environmental impacts of human activities. The intricate evolution of perspectives on animal ethics underscores the interplay of philosophy, science, and ethics, shaping a nuanced understanding that transcends centuries. Korsgaard (2018) argues that humans are obligated to treat all sentient beings as "ends-in-themselves." She also claims that we should treat the good of every sentient creature as something of absolute importance, and that our moral nature does not make us superior to other animals. Korsgaard criticizes the "marginal cases" argument and advances a new view of

[4] Although see Grumett (2019), who argues that Aristotle's idea of telos includes the flourishing of species and a good life, which is natural and unchanging. He believed that animals have purpose and provides a useful and demanding framework for farm animal ethics that goes beyond negative theories of welfare as freedom from harm.

moral standing as attaching to the atemporal subjects of lives. She also addresses practical questions such as whether we have the right to eat animals, experiment on them, make them work for us and fight in our wars, and keep them as pets.

Denmark, with sporadic discussions on animal rights dating back to the late eighteenth century[5], formally established legislation in 1857 to address the humane treatment of animals, later revised in 1866. A substantial reform in 1916, despite flaws, acknowledged animals as conscious and feeling beings, entitled to humane treatment (Gjernløff, 2008). Denmark was relatively late to have a formal society for the protection of animals. The first in the world, the Royal Society for the Prevention of Cruelty to Animals, was founded in London in 1824, and others were formed in the United States (ASPCA in 1866) and Europe in the ensuing decades. Denmark had to wait until 1875 with the establishment of the Society for the Protection of Animals (Lembke, 1900; Animal Protection Denmark, 1925), led by the philanthropist J.C. Lembcke. His wife, Julie (see Lembcke, 1895), concurrently founded the Women's Association for the Protection of Animals, aiming not only for animal welfare but also societal improvement through education, targeting children and servants. The overarching mission was to instil civic virtues and combat societal issues through a moral and merciful approach, ultimately striving to secure the foundations of civilization itself. They gained support from influential figures, including their first patron, King Christian IX, and engaged in various campaigns, including those addressing slaughtering and transport conditions, scientific abuse, and the treatment of working animals. Their basis among the elite in urban areas primarily directed their attention away from farm animals, deeming economic and productive advancements as progress for these creatures. This perspective posited women as caretakers and educators, asserting that a better society was achieved through fostering empathy and moral values. Notably, the movement subtly reflected elements of enlightenment, where the perceived need to enlighten those less "civilized" justified the mission.[6] The publication *Dyrevennen* [the friend of animals] played a crucial role in disseminating the animal rights message, albeit not initially affiliated with Animal Protection Denmark. This magazine, often considered Lembcke's mouthpiece, actively encouraged teachers' subscriptions, with half of the proceeds supporting teachers' pension funds. Over the years, *Dyrevennen* evolved, gaining independent status in Norway, and eventually became the official publication of the Animal Protection Society (Degen, 1930).

[5] Noteworthy figures such as Friederich Christian Eilschov (1725-50) and Lauritz Smith (1754-1794) laid the groundwork by advocating for legal protection and recognizing animal rights, albeit without significant societal resonance (Vølver, 2000).

[6] A similar mindset and framing were visible in the work of the RSPCA in Britain and the ASPCA in the US. Samanta (2021) describes the entangled discourses involving animal rights, 'civilization', colonization, class, religion and caste in Bengal animal cruelty discourses and the Calcutta Society for the Prevention of Cruelty to Animals (CSPCA) founded in 1862.

A close reading of the leading journals of the Danish agriculture and the dairy industry (*Tidsskrift for Landøkonomi*, *Ugeskrift for Landmænd*, *Mælkeritidende*) reveals little explicit concern for animal welfare in major journals and textbooks[7]. Tesdorpf's estate administrator, Niels Peter Jensen Buus (1835-1886), published a series of guides for apprentice farmers on the "treatment of milch cows" (Buus, 1875, 1877, 1884). He emphasizes sufficient nutrition and that the cowshed should be "warm, healthy and comfortable" and "light and spacious". Berhard Bøggild's leading textbook on dairying, spanning four editions from 1891 to 1916, also primarily emphasized health, quality, and productivity, with minimal attention to animal welfare.[8] Notable exceptions, such as discussions on clean and humane conditions for dairy cattle, emerged in later editions, reflecting a shifting awareness within the industry. An early exception is an account of the Danish Royal Agricultural Society's Annual General Meeting on December 13, 1877 about Animal Protection Denmark's request for separate cubicles for live cattle sent for export to the UK and a discussion about this. Even as the movement expanded beyond urban elites in the twentieth century, it exhibited limited concern for cattle, except for a brief period in the 1980s when Danish farmers sought better prices for their calves in the Netherlands, when Dutch veal earned a premium (Vølver, 2000). Today it is very different, of course, with many and detailed aims for contemporary agriculture.[9]

4. Quantifying the welfare of dairy cattle

We begin with the four welfare principles from the Welfare Quality® assessment protocols listed in Table 1: good feeding, good housing, good health and appropriate behaviour. We start with the first.

4.1 Good feeding

Until at least the 1850s, dairying was a highly seasonable activity. Dairy cattle grazed in the spring and summer months (from March/April to September/October), depending on the weather, and spent their winter in barns, due to the cold weather. It was considered economically questionable to feed marketable produce (grain) to dairy cattle, which meant that for the most part dairy cattle spent the winter eating hay made from the farm's meadows, and were offered little additional feed. They thus had to rely on reserves from the summer, and for the most part starved through the winter (S.P. Jensen 1988, 319-20), implying

[7] See e.g. Prosch (1856) for an early Danish guide on how to care for farm animals.
[8] Note e.g. that arguments against year-round barn feeding (and lack of grazing), in Denmark were based on reputational and hygienic hazards that endangered the business of dairying, while we have not come across anyone arguing on ethical grounds that denying dairy cattle access to pasture was 'unnatural' and therefore wrong, as e.g. Victorian economist and social reformer William Thomas Thornton did (Turner, 1980, 73)
[9] https://www.dyrenesbeskyttelse.dk/artikler/maerkesager-dyr-i-produktion [retrieved 14-12-2023]

relatively low annual milk yields of between 1,000 and 2,000 litres per cow.[10] In the second half of the 1850s, a debate on modern, rational agriculture took place among elite estate-owners, who were mostly interested in maximizing manure production of cattle to generate additional fertilizer from cattle dung at a time of largely organic agriculture. Estate owners asked whether it paid off to feed the cattle through the winter, which would yield further milk (and butter and cheese) for sale and dung for increased grain production (Lampe and Sharp 2015a, 2019a, 2019b). This in part took up an older discussion on summer barn feeding, which had been going on 50 years before, when a group of Danish elites tried to establish all-year barn feeding to maximize agricultural output based on Albrecht Thaer's prescription on "rational farming." These ideas, however, never gained wide traction on Denmark and its German Duchies, because summer barn feeding contained a large hygienic and reputational risk for dairy farmers at a time which preceded modern veterinary knowledge (Bjørn 1988, 35-37; Lampe and Sharp 2019b, 67-69, cf. Goldschmidt 1888).

One of the main proponents of so-called "strong feeding" from the 1850s was the leading agricultural modernizer Edward Tesdorpf, who kept and systematized records on concentrate feeding of milch cows going back to 1841, summarized and combined with later, more representative data in Figure 1. The period since the mid-1850s was characterized by increasing use of concentrates all through the winter, combined with earlier calving times (see 4.4) and year-round milk production, leading to substantially increased yields (Figure 2). This new system of dairying, which meant substantially more feed for animals, and an end to hunger, also increased production requirements and year-round lactation, spread soon to other estates and the substantially larger medium size farming sector. Danish farmers reaped strong economic gains from this, as their fresh winter butter fetched a quality premium over other providers on the British market, which in 1861 had been opened through the liberalization of near-prohibitive tariff barriers (Henriksen and O'Rourke 2005, Lampe and Sharp 2015b).

By 1878, the leading authority on animal husbandry, Professor Victor Prosch (1878, 254-5), even warned that the enthusiasm for feeding had led to 'overfeeding' beyond the milk production capacities of many cows, leading to overweight, miscarriages and calving fever. Eventually, from the 1880s, scientific feeding experiments at a newly established special laboratory at the Royal Agricultural and Veterinary College (S.P. Jensen 1988) and systematic collection of feed and yield data from estates and smaller farms enabled

[10] Israelsson (2005), chs. 9-11, shows in detail similar practices in Sweden, where especially among smallholders – the majority of Swedish herds – insufficient winter feeding and prolonged summer grazing seem to have been more common than in Denmark even at the end of the nineteenth century. Ibid., 205-225, provides estimates of the nutritional intake of Swedish cows and concludes that those outside manorial dairies must have been undernourished, using a large share of their caloric intake for survival and not for milk production, see also Cserhalmi and Israelsson (2004).

systematic optimization of the system. In the 1880s a unified measure for feed inputs into animals, the 'feed unit', was created and refined. It was soon widely used to compare feeding practices and their results across dairy herds.

The journal of the Royal Agricultural Society of Denmark*, Tidsskrift for Landøkonomi (TfL)*, published from 1880 to 1900 a continuous survey of feed and yields of a selected, but not representative sample of farms in its annual reports on dairying in Denmark, authored by Bernard Bøggild, for almost the whole period. We have used these data elsewhere to estimate the efficiency of milk and butter production (Henriksen et al 2011, Lampe and Sharp 2015a). In Figures 1 and 2, we report yields and reported feed inputs (excl. grazing in summer) and augmented estimates (incl. summer grazing) for the upper quartile of estates with the highest milk yields, which were selected as best practice, and closely align with the Ourupgaard data in the periods when we have data for both.[11] With the rise of the cooperative movement, the sample of estates became less and less representative and was eventually abandoned in the annual dairy reports. Fortunately, from 1895 so-called Control Associations emerged among the large segment of small and medium-sized farmers. These collected data on feed, yields and other indicators in a similar fashion to the estate database, and as Figures 1 and 2 illustrate, data for the first control association in Southwest Jutland from 1895 to 1911 and for the national average of control association members from 1914 to 1944 – both likely upward biased estimates for feed and yield in all of Denmark – again blend well with the estate data.[12]

In summary, from the mid-1850s, leading estates established a model that ended winter hunger at the expense of longer lactation and production periods for cows. Until the 1880s, this model became common practice all over Denmark. For dairy cattle, the amount of feed became largely detached from traditional seasonal fluctuations. Farmers were still aware of these fluctuations, however (Jessen 1885, 28; Goldschmidt 1888, 32-35). The annual reports on animal husbandry published in *TfL* explain in the 1880s that the abundance of winter feed still depended on the abundance of grain harvests. However, the latter were increasingly replaced by imported feed, first grain, and then an increasing variety of oilcakes, from the initially local produced rapeseed and linseed cakes that Ourupgaard already used in 1865, to palm oil cakes (first used at Ourupgaard in 1871), sunflower and cotton seed cakes (introduced in the early 1890s), hemp cakes (1899), peanut cakes (in 1904), soy bean cakes (1911), as well as maize, maize flour and molasse (all from the 1890s), according to Ourupgaard's archives.

[11] Note that from 1894 the Ourupgaard records look less clean in the archives, which might indicate incomplete data, especially at a time, when almost yearly new types of oil cakes enter the feed mix.

[12] In the 1913-14 season, milk yields of cows from herds included in Control Associations were apparently ca. 20 percent higher than the national average (De samvirkende danske Landboforeninger 1920, 74, compared to Andersen, 1945, 262). Appel (1916, 355) calculates that in 1915 19 percent of all milk cows in Denmark were part of Control Association member herds.

The reports on animal husbandry continuously discuss whether root crops, which spread in meat production, should be fed to dairy cattle (e.g., Prosch 1878, 257-8; Appel 1900, 76-77), and report on feed experiments and practical results on farms with the aforementioned and other foodstuffs. By drawing on global supplies for feed, farmers became increasingly independent of their own production of feed, and increasingly flexible in reacting to price changes. As production increased, sole reliance on natural conditions even in summer became risky and was thus loosened: while the least productive quartile of estates in the *TfL* sample gave their dairy cattle on average 153 days on grass per year, dairy cattle in the most productive quartile reduced this by 20 days. They also relied relatively more on supplementary feeding with concentrates during the summer to make up for the vagaries of nature, a practice that the annual reports on animal husbandry also describe with increasing frequency from the 1890s (e.g., Appel 1892, 69, Appel 1893, 85, Appel 1900, 76), in part in reaction to unusual "summer hunger" reported in the late 1880s (Appel 1890, 32-33), as herds might have outgrown their grazing areas.

Nevertheless, even after 1900 the annual report's author, Axel Appel (1902, 244) explains how natural conditions and market prices shaped the feeding of dairy cattle. When good weather brought abundant grass and/or grain, less commercial feed was needed. When milk and butter prices were high, the latter was more affordable. Only in exceptional circumstances, however, would farmers cut back on feeding. Such circumstances were the consequence of the outbreak of the First World War, when availability of commercial feed was reduced and had to be more locally sourced and economized upon (see the lower milk yields in 1919 and 1920, in Figure 2). In consequence, herds were downsized, not least through sale and non-replacement (e.g. Appel 1916, 338). Such short-term adjustments, however, had no long-run impact on the feeding system.

Figure 1: Feed units per cow per year, 1841-1944

Note and sources: Feed units (barley equivalent kg) calculated using standard conversion rates used in control associations given in De samvirkende Danske Landboforeninger (1920), 57-58. 'TfL top 25% estates excl. grass' uses unweighted averages of FE's for milk yield top quartile reported in the TfL sample as used in Lampe and Sharp (2015a). 'FE per cow Kontrolforeninger' uses data reported for Vejen og Omegns Kontrolforening for 1897=1895/1890, 1902=1900/05, 1907=1905/10, 1911 in De samvirkende Danske Landboforeninger (1920, 15) and for 1895 in Johansen (1896, 12) and for a weighted sample of all members of control associations in Denmark for 1914, 1920, 1925, 1930, 1935, 1938, 1940, 1942, 1944 in Andersen (1945, 262). 'FE per cow Ourupgaard excl. grass' uses archival data on feed used and cow numbers for Ourupgaard and applies the standard FE conversion rates; reports on grazing are not contained in Ourupgaard archives. 'TfL top 25% estates incl. grass' adds grass equivalents of FEs, calculated by us based on the original data and standard FE conversion rates, assuming cow weight above 450kg for Danish red (incl. mixed herds) and under 450kg for other breeds. If summer barn feeding was used, the corresponding days were deducted from grazing as indicated in the original data.

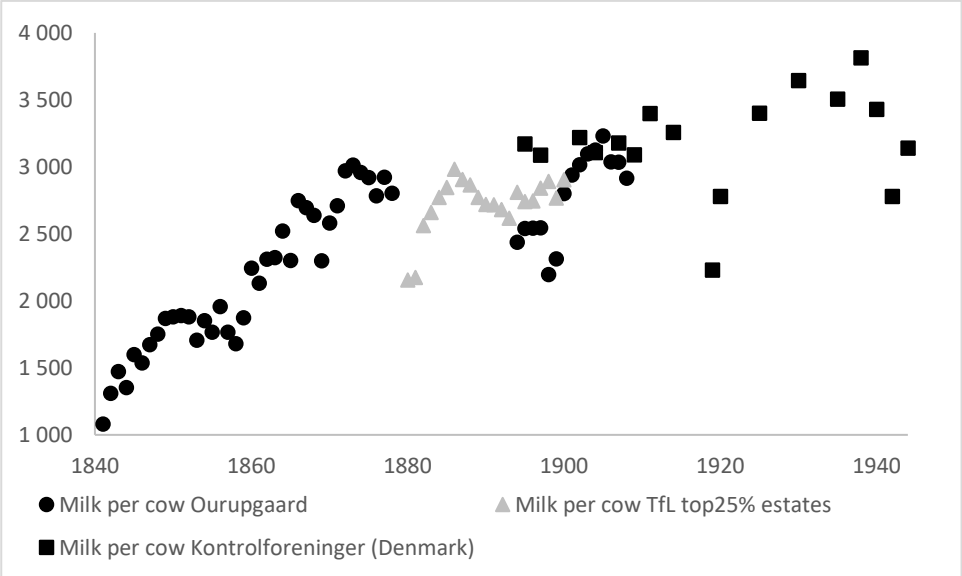

Figure 2: Milk yields per dairy cow per year, 1841-1944

Sources: See Figure 1. De samvirkende Danske Landboforeninger (1920, 15) reports yields also for 1904, 1909 and 1919, for which no feed data are reported. TfL estate sample farms are the same as in Fig. 1. For reference a typical yield in a contemporary herd is 10-15,000 kg per year. Milk yields were probably not adjusted for fat content, but average fat content varied relatively little according to historical data (Lampe and Sharp 2015, 1136).

4.2 Good housing

In Tables 2 and 3, we combine contemporary guidelines with information on the dimensions of historical cowsheds taken from a wide range of sources. A cow under 550 kg in Denmark today should be provided with a minimum cubicle of 1.1 by 2.8 meters, an increase from older rules of 1.1 by 2.25 meters. In terms of overall barn space, a cow should have between 5 and 7 square meters according to Danish law and EU guidelines, and depending on the breed. Table 2 compares this with the historical dimensions of cubicles, and Table 3 with overall cowshed dimensions. It is apparent that dimensions fall over time, before an increase in recent decades. Note, however, that the historical "width" dimensions in Table 2 are exaggerated, due to the contemporary practice of keeping two cows in each cubicle, something which is generally frowned upon today.

Table 2: The width and length of cattle cubicles in Denmark, 1873 to today

Location	Year	Width, m	Length, m	Source
Kjærsgaard, Horsens	1873	1.8843	2.5124	1
Model cowshed, two cows	1876	1.57025	1.8843	2
Model cowshed, one cow	1876	0.94215	1.8843	2
Denmark average	< 1910	0.9606	1.74605	3
Denmark average	1910-29	0.971	1.7397	3
Denmark average	1930-39	0.9911	1.76365	3
96 cowsheds on Zealand	1931	0.92		4
Denmark average	1940-49	1.0096	1.76235	3
Denmark average	1950-59	1.0752	1.7571	3
5 creamery districts on Samsø	1955	0.92		5
Islands	1953-55	0.94		6
Jutland	1953-55	0.96		6
Denmark average	1960-62	1.1313	1.7607	3
Danish “old rules”, large race (>550 kg)	< 2020	1.25	2.45	7
Danish “old rules”, small race (<550 kg)	< 2020	1.1	2.25	7
Danish “new rules”, large race	2020	1.25	3	7
Danish “new rules”, small race	2020	1.1	2.8	7

Sources: 1: Heide (1873); 2: Klein (1876); 3: Iversen (1964); 4: Hansen Larsen (1931); 5: Livoni (1955); 6: Høgsvig (1961); 7: Danish Law (BEK nr 1743 af 30/11/2020).

Table 3: The area per cow in cowsheds in Denmark, Schleswig and Mecklenburg, 1700s to today

Location	Year	Area / cow, sq m	Source
Gammelgård, Schleswig	1700s	8.0	1
Hemmelmark, Schleswig	1700s	13.8	1
Mohrberg, Schleswig	1700s	15.4	1
Ourupgaard, Falster	1843	3.8	2
Kirstineberg, Falster	ca. 1870	4.2	2
Kjærsgaard, Funen	ca. 1870	4.4	2
Nørregaard, Lolland	1879	5.1	2
Marienborg, Møn	ca. 1870	5.0	2
Mecklenburg demesne, fixed mangers	ca. 1870	5.2	2
Ourupgaard, Falster	ca. 1870	5.9	2
Gjedsergaard, Falster	ca. 1870	5.5	2
Sanderumgaard, Funen	ca. 1870	5.6	2
Ludvigsgave, Falster	ca. 1870	5.8	2
Frisenfeld, Falster	ca. 1870	6.3	2
Mecklenburg demesne, movable mangers	ca. 1870	6.1	2
Niclewe, Mecklenburg	ca. 1870	6.2	2
Altenhagen, Mecklenburg	ca. 1870	7.2	2
Russow, Mecklenburg	ca. 1870	7.3	2
Peasant cowshed, Mecklenburg	ca. 1870	7.7	2
Rockow, Mecklenburg	ca. 1870	7.8	2
Bristow, Mecklenburg	ca. 1870	7.8	2
Pannckow, Mecklenburg	ca. 1870	8.4	2
Danish “new rules”, large race	2020	6.5	3
Danish “new rules”, small race	2020	5.0	3
EU recommendations	2023	>= 7	4

Sources: 1: Iversen (1992); 2: Glahn (1880); 3: Danish Law (BEK nr 1743 af 30/11/2020); 4: AHAW (2023).

Another important study is a Scientific Opinion (AHAW, 2023) published by the European Union’s Panel on Animal Health and Welfare (AHAW), as requested by the European Commission. They were asked to assess first, the prevalent housing systems in the EU; second, measures of the welfare consequences for dairy cattle[13]; and third to identify farm characteristics which might be used to classify on-farm welfare. They found that cubicle housing is the most prevalent system, followed by open-bedded systems and tie-stalls. Each has differing impacts on animal welfare, but permanently tying cows in stalls is considered to have the greatest negative implications, for example because it fails to allow for self-grooming. They thus conclude that dairy cattle should not be permanently housed in tie-stalls, comfortable indoor surfaces should be

[13] Locomotory disorders (including lameness), mastitis (udder infection), restriction of movement and resting problems, inability to perform comfort behaviour and metabolic disorders.

provided, and that access to pasture should be provided. They then provide five farm welfare characteristics, arguing that if one or more is present, then there should be a detailed welfare assessment of the farm in question. In order of importance, these are: "1) more than one cow per cubicle; 2) a limited total space for housed cows (<7 m²/cow); 3) cubicle dimensions are inappropriate for the size of the cows; 4) high annual on-farm mortality (that is, more than 8 percent including emergency slaughter) rates; 5) cows have access to pasture less than 2 months per year." Their conclusions explain how housing relates to health and appropriate behaviour criteria.

Iversen (1992) provides some of the earliest evidence we could find on the historical dimensions of cow sheds. It is a survey of *hollænderier* in Southern Jutland (Schleswig) in eighteenth century. Since these formed the model for the introduction of modern dairying to Denmark (Lampe and Sharp, 2019b), they provide a reasonable approximation of the situation in Danish dairying until the last decades of the nineteenth century. It is explained that their size had to be adapted to the number of dairy cattle and the building style. Far to the north in Schleswig, there were large, wide cowsheds built according to the Saxon or Holstein pattern with high roofs, whereby, in addition to having plenty of space for many dairy cattle, there was also room for large stores of hay and straw. There were posts between the cubicles to which the dairy cattle were tied. In general, it was left to the peasants and clothiers who were obliged to plait the binding sieves from straw. If they were reluctant to deliver, other material, such as iron chains could be used. In cowsheds with lower rooves, the low height and the tight binding of the many cows meant that there was a need for ventilation. The large gates, hatches and hatches therefore often had to be opened during the day. As there were no mangers in the stables, the dairy cattle had to be turned loose daily and driven out to water in the large ponds that were found at every farm of this type. Heide (1873) gives dimensions of cowshed and cubicles in a plan for Kjærsgaard, Horsens, as well as information about the room for calves, collection of manure, and more. Klein (1876) provides plans for model farm buildings, including a detailed explanation of how different types of cowsheds should be constructed. Glahn (1880), who won a prize from the Danish Royal Agricultural Society in a competition on agricultural buildings, makes a comparison between Danish and Mecklenburg (under the Danish king from 1814-64) cowsheds. He notes that the Danish cowsheds provide much less space, although noting that e.g. Tesdorpf's cowshed at Ourupgaard, considered large and extremely modern in 1843, appears small compared to that present in the 1870s.[14]

By the early twentieth century there was more focus on the quality of cowsheds. Appel (1907, 413) notes that this is needed "not only out of consideration for the animals' health, well-being and thus good working

[14] Israelsson (2005, 151-55, 161) provides some evidence for Sweden in the late nineteenth century, stressing the difference between cowsheds and barns at large estates vs. ordinary farms and smallholders.

ability, but also out of consideration to be able to promote the production and delivery of fresh and tasty milk." As a result of this he explains how so-called "exhibition stables" had been constructed by the Association of Jutland Farmers' Associations' Dairy Committees to show "how with relatively small funds an old barn can be improved, so that it becomes brighter, better ventilated and easier to keep clean".

A more thorough investigation could use the national survey of peasant farm buildings which the National Museum conducted between 1944 and 1960, see e.g. Nielsen et al. (1993). Fortunately, Ipsen (1962, 1964) provides dimensions for various years, together with other details such as how the cows were milked, how they get access to water, what type of water, fireproof ceiling, dimension of cubicle separation area. Note, however, that these are dimensions for buildings still existing at the time of writing. It is not clear whether earlier decades might thus be biased downwards (due e.g. to the most progressive farmers rebuilding smaller cowsheds) or upwards (if the best-specified cowsheds lasted longer).

In any case, the conclusion from the data we collected is clear: cowsheds became smaller over time, but as concerns about animal welfare increased, they became larger again. They are now probably comparable to the dimensions of the early nineteenth century, but of course for larger breeds of dairy cattle.

4.3 Good health

Bøggild (1891) devoted considerable parts of his textbook to feeding, ensuring good supplies of water, ventilation, and the various ways in which illness could impact on the milk. Likewise, Prosch (1878, 255-6) highlighted the "simple natural path" to healthy and productive dairying with cows delivering high quality milk, consisting of summers spent outside and spacious, well-ventilated barns for the winter. He highlighted barn ventilation and skin care as key weaknesses of Danish dairying, but saw an upward trend. Agricultural journals had active discussions on how to ensure animal health, in particular when there were outbreaks of disease such as foot and mouth or bovine pleuroneumonia (*lungesyge*, eradicated in 1886). As noted above, Denmark was relatively slow to introduce compulsory inspections and the like, but farmers had an obvious incentive to ensure the good health of their animals, although it is not obvious that this was due to any particular concern for their welfare. In most cases, the first motivation came from (impending) foreign import bans for live cattle, which triggered most severe containment measures (Jessen 1881, 24; Jessen 1882, 43-45).

Beyond the containment of epidemics, bovine tuberculosis (*Mycobacterium bovis*) and spontaneous abortions by cows, as well as fevers that caused the death of newborn calves were the main concern of farmers, not least because of their effect on lactation periods and milk production. A figure regularly

reported was that of "*Kastere og Overløbere*" [those that have spontaneously aborted, *kastere*, and those who have not become pregnant, *overløbere*], which indicated dairy cattle with no or severely reduced productivity, for which pathogens, feeding practices and unhealthy conditions were generally given as explanations. In the late 1870s, at Ourupgaard between 9 and 20 percent of all cows were reported under this condition, and similarly, at Gjedsergaard in 1875-77, on average 15 percent of cows were reported as such. Table 4 shows an almost trendless series, indicating that abortions and infertility remained an issue into the twentieth century.

Table 4: *Kastere og Overløbere* at estates, 1880-1900

Year	Average share	Share of herds with more than 25%
1880	16.5	10.0
1881	12.4	8.3
1882	14.0	9.5
1883	12.1	10.0
1884	11.8	0.0
1885	14.9	11.1
1886	13.5	7.7
1887	14.4	6.7
1888	11.3	5.6
1889	11.1	0.0
1890	14.0	8.7
1891	13.6	3.7
1892	14.2	8.7
1893	16.0	9.1
1894	13.4	5.3
1895	13.3	5.3
1896	14.3	11.8
1897	11.1	0.0
1898	14.3	13.3
1899	15.4	7.1
1900	11.2	0.0

Source: *TfL* estate sample, as in Lampe and Sharp (2015a).

However, significant efforts were dedicated to tackle these problems. Since the 1880s, Bernard Bang investigated pathogens responsible for tuberculosis, cattle dysentery, and abortions at a dedicated laboratory at the Royal Agricultural and Veterinary College (Bruun-Pedersen 1886, 46-7, Jensen 2002), and

an increasing awareness campaign was launched to make farmers aware of the risks of concealing diseases in their herds, as well as for favourable general conditions of ventilation and summers outside (Goldschmidt 1888, Appel 1889, Appel 1893). From the early 1890s, large farms started regular veterinary inspections of their dairy cattle, and the use of tuberculin to diagnose bovine tuberculosis was established as best practice (Appel 1892, 93-4). Use of boiled milk (and, later, pasteurization) for calves was promoted as a way to eliminate intergenerational transmission (Appel 1893, 112-5, Appel 1897, 69-70). From 1894, government subsidies for the tuberculin diagnosis were introduced (Appel 1895, 89), and eventually discussions regarding bovine tuberculosis disappear from the annual reports on dairy husbandry shortly before the turn of the century, although bovine tuberculosis continued to exist in the 1910s and 1920s, and was not eradicated until 1952, when Denmark as the first country in the world declared itself free of bovine TB (Jensen 2002). Bang's discovery of *Brucella abortus bang*, a bacteria which causes pregnant cattle to abort, in 1897 was another milestone. Routine checks of milk meant that Denmark was also the first country in the world to eradicate this (Jensen 2002). In 1926, Denmark's State Serum Institute established a department for epidemics, which was to be responsible for the surveillance and registration of infectious diseases. One of its first tasks was to combat the great milk epidemics which continued to affect the country, in particular of streptococcal and scarlet fever, but also typhoid, paratyphoid and dysentery (Jensen 2002).

While disease prevention and housing conditions improved with the year-round production system through better feeding, and subsequently improved ventilation of cowsheds and knowledge about the cause of infectious diseases, unlike for human populations, such improvements did not lead to increases in life expectancy. The natural life expectancy of a cow was estimated as 15-20 years, with a maximum of 25 in the nineteenth century (Nathorst, 1877, 31, cited in Israelsson 2005, 124), but as dairying modernized, lifespans became shorter and shorter.

We have early archival information for Ourugaard's sister-estate Gjedsergaard from 1855 to 1865, i.e., the period when the modern feeding and production regime unfolded. In 1855, the *average* milk cow was 7.6 years old; the largest group of cows at that time was 3 years old, but had the lowest average yields. Of these 16 cows, 12 were still alive in 1861, then 9 years old. In 1862, nine of them were left, in 1864, seven, and by 1865, the four remaining cows of this cohort were still producing 3,353 litres of milk each – there were three even older cows. However, by 1865, the average age of the herd had declined to 6.2. Table 4 shows the change in age distribution over time – despite idiosyncratic fluctuations and near-constant herd-size the number of younger cows increases significantly, while the number of cows with an age above 10 decreases, although there is (still) no reduction in the maximum age.

Table 5: Age distribution of (producing) cows at Gjedsergaard, 1855 to 1865

age	1855	1860	1865
2	0	5	20
3	16	15	13
4	13	17	3
5	8	12	13
6	12	7	7
7	6	15	14
8	12	11	5
9	0	9	7
10	1	3	3
11	14	5	4
12	9	2	5
13	11	6	4
14	2	0	3
total	104	107	101

Source: Notes in Notebook 'Statistik over Höst, Meieridrift og Faarehold oaa Ourupgaards og Gjedsergaards Godser', in: Rigsarkivet, Orupgård Gods, box Statistik over høst, mejeridrift og fårehold (1849-1904).

In a wider perspective, DST (1911, 118) writes that "since the census in 1876 there has been a profound change in the age composition of Denmark's horned cattle population. This change is related to the fact that the herds of dairy cows are now renewed much faster than before; modern, rationally managed dairy farming requires a closer control of the milking cows, so that those of these that could not meet the bill are discarded." Thus, in 1898 there were 891,421 cows between 1-10 years, and 175,844 over 10 years – a ratio of roughly 1 to 5. By 1909 there were 700,557 between 1-6 years, 484,343 between 6-10 years, and just 97,074 over 10 years, giving a corresponding ratio of 1:12, with most cows in the younger category being below 6 (DST, 1911, 117). This was the result of the increasing understanding of the peak productivity of cows. Thus, in 1896 the first Control Association in Vejen found that cows should be at least 5 to be at peak productivity (Johansen 1896). They are slaughtered at roughly the same age today.[15]

[15] https://maelken.dk/dyrevelfaerd/artikler-om-dyrevelfaerd/hvor-gammel-bliver-en-malkeko/ [retrieved 12-12-2023]. For a Swedish estate, Krusenberg south of Uppsala, Israelsson (2005, 123) reports cows living 12-13 years on average around 1890, with a maximum age of around 16, down from 19-22 years in the mid-nineteenth century.

4.4 Appropriate behaviour

Appropriate behaviour relates to the other three criteria. Poor health and housing will lead to poor emotional states. We cannot of course easily assess behaviour for historical dairy cattle, but we note a few points. The practice of winter production, i.e. promoting calving during winter so that dairy cattle could produce all year, came early to Denmark, and gave its producers enormous quality and quantity advantages over their rivals, especially the Irish (Henriksen and O'Rourke, 2005). It also meant the rise of systematic insemination, and dairy cattle that spent even larger parts of their (short) lives either pregnant or lactating. It also involved less and less time outside, something we can measure, or at least approximate.

The *TfL* estate sample includes data on days on grass, summer barn feeding, and the share of cows calving before the first of January (as an indicator for year-round production). In section 4.1, we mentioned that the most productive herds (in terms of milk yields), used 20 days less per year on grass. They also had 20 percent less grazing area per cow, and used substantially more supplementary feed (grains, etc.) per cow in summers, thus taking the separation of feeding from agriculture a step further. While this implied more feed for dairy cattle and higher milk yields for their owners, in the context of appropriate behaviour, less time spent outside is generally assumed to be detrimental. While in the TfL sample the number of days on grass was trending downwards and the share of herds that received supplementary feed in summer trended upwards, it was only under two months for a minority of herds only in the late 1880s and early 1890s. In the dairy and animal husbandry reports, these instances are often related to bad natural grazing conditions, but there seems to have been a short-lived and limited tendency to attempt to introduce something similar to Thaer's "rational" approach to agriculture (see 4.1), which was severely criticized by the expert press in the context of tuberculosis spreading and increasing international awareness for epizootics (Appel 1889, 30). In the early 1890s, there seems to have been a short-lived tendency to bring even herds of 70-80 cows into barns overnight in times of bad weather in summer (Appel 1892, 68-9; id., 1893, 85).

Table 6: Access to pasture, 1880-1900

Year	Grass days in summer	Supplementary feeding in summer (%)	Share with less than 62 grass days (%)
1880	158	20.0	0.0
1881	155	16.7	0.0
1882	167	14.3	0.0
1883	151	30.0	0.0
1884	163	50.0	0.0
1885	147	66.7	0.0
1886	136	69.2	7.7
1887	128	66.7	13.3
1888	133	22.2	11.1
1889	129	52.6	10.5
1890	142	73.9	4.3
1891	138	37.0	3.7
1892	135	39.1	4.3
1893	133	59.1	4.5
1894	147	42.1	0.0
1895	138	47.4	0.0
1896	142	41.2	0.0
1897	141	58.8	0.0
1898	139	46.7	0.0
1899	133	57.1	0.0
1900	137	76.9	0.0

Source: TfL dairy reports, as in Lampe and Sharp (2015a).

As stated, the aim of maximizing milk production also led to year-round lactation, caused by early impregnation and calving in late fall, not a "natural" period for calving. In the *TfL* estate sample, this practice is widespread already in 1880, with on average 48 percent of all cows calving before January 1st, a value that remains roughly stable over the following years. From the archives, we have detailed data for Ourupgaard from 1875 to 1878 by month of calving, which indicates that the share of cows (incl. *Kastere og Overløbere)* calving in October, November and December rose from 26 to 36 percent over this period, while an additional 8 to 13 percent of cows calved in January. Those calving between October and January were clearly the ones with the highest milk yields. Interestingly, the share of cows calving between April and June, the traditional spring grazing period, was beyond 17 percent at Ourupgaard in 1875. Overall, farmers still had to leave some agency in the production process to nature. Artificial insemination seems not to have been widely used until after the Second World War (Ombelet and Robays 2015). In addition to year-round

lactation, another dimension is the age at which heifers were supposed to convert into cows. In section 4.3 we have shown that the age distribution of cows decreased over time. By the late 1880s, it had become common sense that cows should be producing from the age of 2 to 2.5 years, but not earlier, as tenant Ingo Marius Friis of Lindersvold estate put it: "It must be considered most advantageous to delay calving until 2 to 2 ½ years of age, […] there is no danger associated with feeding heifers generously in this way, so that their physical development becomes sufficiently strong and suitable to withstand the weakening influence of milking." (Goldschmidt 1888, 45).

Maximizing milk production also meant both that male calves were often slaughtered early, but also that calves were taken away from their dam almost immediately. In his guide, Buus (1875) explained that although meat producers, especially those in England and Scotland, allowed calves to stay with their mothers, since it meant they grew faster and were ready for slaughtering earlier, in Danish dairying it was already common that the young calf should be immediately removed, and placed somewhere where preferably the mother could not see it (Buus, 1875, 1877, 1884). This has become increasingly controversial (Lehmann et al., 2020). In today's Denmark calves are usually taken from their dam at 12 hours, or at least 24 hours for organic herds.[16] Weaning from milk occurs around either 8 weeks (conventional) or 12 weeks (organic). Consumers increasingly question this practice, and there is a growing interest among Danish dairy farmers in developing alternative methods. The reasons for early separation are financial profits, for example, but also welfare considerations such as the idea that the mother will be less stressed if it happens earlier, mirroring Buus' advice 150 years ago.

5. Conclusion

Animal welfare is the subject of intense debate, and its measurement is problematic. We have collected the available indicators for Danish dairying before, during and after its period of rapid modernization and industrialization. We relate these to the Welfare Quality® assessment protocols, and find that dairy cattle experienced welfare improvements along some dimensions, but also declines along others. Moreover, these developments were not linear.

Concerns about animal welfare and modern agriculture in general are not likely to decline any time soon. As the economy has grown, so has the demand for animal products (Whitnall and Pitts, 2019), and as productivity has increased, including through factory farming, this has led to even greater consumption, as

[16] https://maelken.dk/dyrevelfaerd/artikler-om-dyrevelfaerd/er-det-synd-at-tage-den-nyfodte-kalv-fra-koen/ [retrieved 12-12-2023]

products become cheaper and more widely available (Allievi et al., 2015). Hedonistic values, tastes, customs, traditions and more, mean that there is little interest in abandoning the consumption of animal products, despite an increase in vegetarianism and veganism in developed countries (Steward, 1998; Aaltola, 2019). This latter point implies that, as exemplified by the city elites who first campaigned for animal welfare, perhaps we only consider this when we ourselves have a welfare surplus. Attitudes and norms change of course over time, and perhaps in the future people animal agriculture will be considered as abhorrent as the trade in enslaved peoples. Or perhaps veganism will remain a niche cause.

And yet the pressure for change continues to increase, and even selfishly society might at some point desire to decrease the consumption of animal products. Singer (1980) argued long ago that by cutting the land used for animal agriculture, we might be able to eliminate hunger. More recently, concerns have been expressed about its impact on climate and the environment (Gjerris et al., 2011; Chapman et al., 2018), where even a return to grass-fed cattle appears not to be the solution (Turner, 2017). Danish dairying became an early consumer of large amounts of imported concentrates produced using land and fertilizer abroad, and of imported fossil fuels (Henriques and Sharp, 2016). Environmentalists today are concerned about the lack of diversity in the countryside brought about by industrialized agriculture, as exemplified by the rapid switch to the unipurpose (i.e. just for milk production) Danish red cow, designated for the first time in 1878, which dominated Danish dairying by the First World War (Andersen et al., 2003; Lampe and Sharp, 2015a). Other concerns are its association with the rise of antibiotic resistant bacteria (O'Brien, 2001), or the health hazards associated with eating red meat (Richi et al., 2015). We hope that our work will inspire other economic historians to consider the economic history of non-human animals, so that our field can provide the insights which only the long run historical perspective can give.

References

Aaltola, E. (2019). The meat paradox, omnivore's akrasia, and animal ethics. *Animals*, 9(12), 1125.

Allievi, F., Vinnari, M., & Luukkanen, J. (2015). Meat consumption and production–analysis of efficiency, sufficiency and consistency of global trends. *Journal of Cleaner Production*, 92, 142-151.

Allen, R. C. (2017). Absolute poverty: When necessity displaces desire. *American Economic Review*, 107(12), 3690-3721.

Andersen, B. B., Jensen, B., Nielsen, A., & Liboriussen, T. (2003). *Rød dansk malkerace: avlsmæssigt og kulturhistorisk belyst.* Danmarks JordbrugsForskning.

Andersen, Tage (1945). I 50-Aaret for de første Kontrolforeningers Oprettelse. Tidsskrift for Landøkonomi 127, 259-264.

Appel, Axel (1889). Husdyrbruget i Danmark 1888, Tidsskrift for Landøkonomi 5/VIII, 26-44.

Appel, Axel (1890). Husdyrbruget 1889, Tidsskrift for Landøkonomi 5/IX, 30-49.

Appel, Axel (1892). Husdyrbruget 1891, Tidsskrift for Landøkonomi 5/XI, 67-94.

Appel, Axel (1893). Husdyrbruget 1892, Tidsskrift for Landøkonomi 5/XII, 80-116.

Appel, Axel (1895). Husdyrbruget 1894, Tidsskrift for Landøkonomi, 5/XIV, 77-97.

Appel, Axel (1897). Husdyrbruget 1896, Tidsskrift for Landøkonomi, 5/XVI, 53-70.

Appel, Axel (1900). Husdyrbruget 1899 med særligt Henblik paa Kvægavlen og Kvægbruget. Tidsskrift for Landøkonomi, 82, 75-99.

Appel, Axel (1902). Husdyrbruget i 1901 med særligt Henblik paa Kvægavlen og Kvægbruget. Tidsskrift for Landøkonomi, 84, 211-233.

Appel, Axel (1907). Husdyrbruget i 1906 med særligt Henblik paa Kvægavlen og Kvægbruget. *Tidsskrift for Landøkonomi* 89, 401-417.

Appel, Axel (1916) Husdyrbruget 1915 med særligt Henblik paa Kvægavlen og Kvægbruget. Tidsskrift for Landøkonomi, 98, 337-361.

Aubé, L., Mialon, M. M., Mollaret, E., Mounier, L., Veissier, I., & des Roches, A. D. B. (2022). Assessment of dairy cow welfare at pasture: measures available, gaps to address, and pathways to development of ad-hoc protocols. animal, 16(8), 100597.

Auderset, J., Moser, P. (2018). *Die Agrarfrage in der Industriegesellschaft: Wissenskulturen, Machtverhältnisse und natürliche Ressourcen in der agrarisch-industriellen Wissensgesellschaft (1850-1950)*, Cologne: Böhlau.

Bjørn, C. (1988). 1810-60, in: C. Bjørn (ed.). Det danske landbrugs historie III: 1810-1914, Odense: Landbohistorisk Selskab, 7-192.

Boberg-Fazlić, N., Lampe, M., Lasheras, P. M., & Sharp, P. (2022). Winners and losers from agrarian reform: Evidence from Danish land inequality 1682–1895. Journal of Development Economics, 155, 102813.

Boberg-Fazlic, N., Jensen, P. S., Lampe, M., Sharp, P., & Skovsgaard, C. V. (2023). 'Getting to Denmark': the role of agricultural elites for development. Journal of Economic Growth 28, 525–569.

Boberg-Fazlić, N., Lampe, M., & Sharp, P. (2024). The sleeping giant who left for America: Danish land inequality and emigration during the age of mass migration. Explorations in Economic History 91, 101525.

Boberg-Fazlic, N., Sharp, P. (2024). "Immigrant Communities and Knowledge Spillovers". *American Economic Journal: Macroeconomics* 16:1, 102-146.

Boje, P. (2020). Vejen til velstand: Marked, stat og utopi, Tiden 1850-1930. Hvorfor blev Danmark rigt – og ikke rigere? University of Southern Denmark Press.

Broadberry, S., Campbell, B. M., Klein, A., Overton, M., & Van Leeuwen, B. (2015). British economic growth, 1270–1870. Cambridge University Press.

Broom, D. M. (1991). Animal welfare: concepts and measurement. Journal of animal science, 69(10), 4167-4175.

Broom, D. M. (2011). A history of animal welfare science. Acta biotheoretica, 59, 121-137.

Bruun-Pedersen, N. (1886). Husdyrbruget i Danmark 1885, *Tidsskrift for Landøkonomi* 5/V, 30-47.

Buus, N.P.J. (1875). *Malkekøernes Behandling Sommer og Vinter.* Copenhagen, Denmark: Danish Royal Agricultural Society.

Buus, N.P.J. (1877). *Malkekøernes Behandling Sommer og Vinter.* 2nd edition. Copenhagen, Denmark: Danish Royal Agricultural Society.

Buus, N.P.J. (1884). *Malkekøernes Behandling Sommer og Vinter.* 3rd edition. Copenhagen, Denmark: Danish Royal Agricultural Society.

Chapman, J., Power, A., Chandra, S., & Cozzolino, D. (2019). Meat consumption and green gas emissions: A chemometrics analysis. *Food Analytical Methods*, 12, 469-474.

Christensen, T., Lawrence, A., Lund, M., Stott, A., & Sandøe, P. (2012). How can economists help to improve animal welfare?. Animal Welfare, 21(S1), 1-10.

Cserhalmi, N., Israelsson, C. (2004). "Sommarfet och vintersvulten?" *Bebyggelsehistorisk tidsskrift* 47, 73–84. De samvirkende danske Landboforeninger (1920). *1895-1920. Kontrolforeningerne og deres Arbejde gennem fem og tyve Aar*. Copenhagen: De samvirkende danske Landboforeninger.

Deb Roy, R. (2017). Malarial subjects: Empire, medicine and nonhumans in British India, 1820–1909. Cambridge University Press.

Degen, A. (1930). "Dyrevennen 1880 – Januar – 1930". *Dyrevennen* 51:1, 1-7.

Duncan, I.J.H. (2019). "Animal Welfare: A Brief History". Chapter I in Hild and Schweitzer (2019).

EFA Panel on Animal Health and Animal Welfare (AHAW) (2023). *Welfare of dairy cows*. EFSA Journal. doi: 10.2903/j.efsa.2023.7993.

EFSA Panel on Animal Health and Animal Welfare (AHAW), Nielsen, S. S., Alvarez, J., Bicout, D. J., Calistri, P., Canali, E., ... & Winckler, C. (2023). Welfare of dairy cows. EFSA Journal, 21(5), e07993.

Federico, G. (2010). Feeding the world: an economic history of agriculture, 1800-2000. Princeton University Press.

Fjalland, E. L. P. (2022). Høns som gastronomiske socialiteter. Forskning og forandring, 5(2).

Gary, K., Jensen, P. S., Olsson, M., Radu, C. V., Severgnini, B., & Sharp, P. (2022). Monopsony power and wages: Evidence from the introduction of serfdom in Denmark. The Economic Journal, 132(648), 2835-2872.

Gjerris, M., Gamborg, C., Röcklinsberg, H., & Anthony, R. (2011). The price of responsibility: Ethics of animal husbandry in a time of climate change. *Journal of Agricultural and Environmental Ethics*, 24, 331-350.

Gjerløff, A.K. (2008). "Kvinder, børn og andre dyr". *1066: Tidsskrift for Historie* 38:2, 13-25.

Glahn, H.C. (1880). Om landbrugsbygninger med særligt hensyn til de mecklenborgske: foredrag i det kgl. Landhusholdningsselskab den 12te marts 1879. Hoffensberg & Traps Etab.

Goldschmidt, Harald (1888). Husdyrbruget i Danmark 1887. *Tidsskrift for Landøkonomie* 5/VII, 30-49.

Govindrajan, R. (2019). Animal intimacies: Interspecies relatedness in India's central Himalayas. University of Chicago Press.

Griffin, D.R. (1982). The Question of Animal Awareness: Evolutionary Continuity of Mental Experience. The Rockefeller University Press.

Grumett, D. (2019). Aristotle's ethics and farm animal welfare. *Journal of Agricultural and Environmental Ethics*, 32(2), 321-333.

Hansen Larsen, L . (1931). Kostaldens Hygiejne. *Nordisk Hygiejnisk Tidsskrift*.

Harrison, R. (1964). Animal Machines: The New Factory Farming Industry. London: Vincent Stuart Ltd.

Heide, H.P. (1873). Avlsbygninger paa Kjærsgaard. *Tidsskrift for Landøkonomi* 55, 462-467.

Henriksen, I. (2006). An economic history of Denmark. EH.net.

Henriksen, I., & O'Rourke, K. H. (2005). Incentives, technology and the shift to year-round dairying in late nineteenth-century Denmark. *The Economic History Review*, 58(3), 520-554.

Henriksen, I., Lampe, M., & Sharp, P. (2012). The strange birth of liberal Denmark: Danish trade protection and the growth of the dairy industry since the mid-nineteenth century 1. The Economic History Review, 65(2), 770-788.

Henriques, S. T., & Sharp, P. (2016). The Danish agricultural revolution in an energy perspective: A case of development with few domestic energy sources. The Economic History Review, 69(3), 844-869.

Hild, S. and L. Schweitzer (2019, eds.). *Animal Welfare: from Science to Law.* Paris, France: La Fondation Droit Animal, Éthique et Sciences.

Høgsvig, B. (1961). *Landbrugets byggeblade: Isolering af stalde 1.* Copenhagen, Denmark: SBI forlag.

Hribal, J. (2003). "Animals are part of the working class": a challenge to labor history. *Labor History*, 44(4), 435-453.

Ipsen, E.J. (1962). *En undersøgelse vedrørende danske kostalde.* Særtryk af *Tidsskrift for Landøkonomi* 7, 1962. Frederiksberg Bogtrykkeri.

Ipsen, E.J. (1964). *Malke- og staldforhold i 5.000 ydelseskontrollerede besætninger med særligt henblik på disse forholds indflydelse på ydelsesniveauet.* Særtryk af *Tidsskrift for Landøkonomi* 5, 1964. Frederiksberg Bogtrykkeri.

Israelsson, C. (2005). *Kor och människor. Nötkreatursskötsel och besättningsstorlekar på torp och herrgårdar 1850-1914*, Möklinta: Gidlunds förlag.

Iversen, P. K. (1992). Hollænderier i Sønderjylland i 1600-og 1700-årene. *Sønderjydske Årbøger*, 104(1), 73-112.

Jensen, K. (2002). *Bekæmpelse af infektionssygdomme – Statens Serum Institut 1902-2002.* Statens Serum Institut.

Jensen, S.P. (1988). Husdyrbruget, 1860-1914, in: C. Bjørn (ed.). Det danske landbrugs historie III: 1810-1914, Odense: Landbohistorisk Selskab, 313-350.

Jessen, P. (1881), Husdyrbruget 1880. *Tidsskrift for Landøkonomi* 4/XV, 22-27.

Jessen, P. (1882). Husdyrbruget 1881. *Tidsskrift for Landøkonomi* 5/I, 39-52.

Johansen, J. (1896). *Kontrolforeningen for Vejen og Omegn.* Særtryk af *Mælkeritidende*. Odense: Milo'ske Bogtrykkeri.

Kærgård, N. (2022). The economic history of Denmark, 1784–2019. In Oxford Research Encyclopedia of Economics and Finance.

Kjærgaard, T. (1994). The Danish Revolution, 1500-1800: An Ecohistorical Interpretation. Cambridge University Press.

Klein, A. (1876). *Tegninger til Landbrugsbygninger.* Copenhagen: Forlaget af Rudolph Klein.

Komlos, J., and Baten, J. (2004). Looking backward and looking forward: anthropometric research and the development of social science history. *Social Science History*, 28(2), 191-210.

Korchmina, E. and P. Sharp (2020). "Denmark and Russia: What can we learn from the historical comparison of two great Arctic agricultural empires?". *Russian Journal of Economics* 7, 105.

Korsgaard, C. M. (2018). *Fellow creatures: Our obligations to the other animals.* Oxford University Press.

Lampe, M., & Sharp, P. (2014). Greasing the wheels of rural transformation? Margarine and the competition for the British butter market. The Economic History Review, 67(3), 769-792.

Lampe, M., & Sharp, P. (2015a). Just add milk: a productivity analysis of the revolutionary changes in nineteenth-century Danish dairying. *The Economic History Review*, 68(4), 1132-1153.

Lampe, M., & Sharp, P. (2015b). How the Danes discovered Britain: the international integration of the Danish dairy industry before 1880. European Review of Economic History, 19(4), 432-453.

Lampe, M., & Sharp, P. (2017). A quest for useful knowledge: The early development of agricultural accounting in Denmark and Northern Germany. Accounting History Review, 27(1), 73-99.

Lampe, M., & Sharp, P. (2019a). Accounting for the wealth of Denmark: A case study of Smithian growth using the emergence of modern accounting in Danish dairying. The European Journal of the History of Economic Thought, 26(4), 659-697.

Lampe, M., & Sharp, P. (2019b). A land of milk and butter: how elites created the modern Danish dairy industry. University of Chicago Press.

Lehmann, J. O., Vaarst, M., & Mogensen, L. (2020). Dam-reared calves: Lessons from pioneer farmers for Danish dairy producers. In *Book of Abstracts of the 71st Annual Meeting of the European Federation of Animal Science* (Vol. 26). Wageningen Academic Publishers.

Lembcke, J.A.A. (1895). *Nogle Kvinder i Dyrebeskyttelsens Tjeneste.* Copenhagen, Denmark: Lehmann & Stage.

Lembcke, J.C. (1900). *Foreningen til Dyrernes Beskyttelse i Danmark: Et tilbageblik paa 25 aars virksomhed 1875-1900.* Copenhagen, Denmark: J.H. Schultz Universitetsbogtrykkeri.

Livoni, P. (1955). *Mastitisbekæmpelse: eksperimentelle undersøgelser specielt med henblik på gennemførelse af kollektive bekæmpelsesforanstaltninger.* Doctoral thesis, Royal Veterinary and Agricultural Colleges.

Mandel, R., Bracke, M. B., Nicol, C. J., Webster, J. A., & Gygax, L. (2022). Dairy vs beef production–expert views on welfare of cattle in common food production systems. *Animal*, 16(9), 100622.

Martiin, C. (2016). "Specialisation in dairying: a rapid transformation in Denmark and a drawn-out process in Sweden", in: A. Antoine, ed., *Agricultural specialisation and rural patterns of development*, Turnhout: Brepols, 213-232.

Mason, G., & Mendi, M. (1993). Why is there no simple way of measuring animal welfare?. *Animal welfare*, 2(4), 301-319.

Nathorst, H. (1887). *Husdjursskötsel*, 2. upp., Del 2, Stockholm: Beijer.

Nielsen, J. H., Skougaard, M., & Vorre, B. (1993). Gårde i Djursland og Salling: en genoptagelse af Nationalmuseets Bondegårdsundersøgelser. *Bol og By: Landbohistorisk Tidsskrift*, 9(1), 58-111.

Nimmo, R. (2008). Auditing nature, enacting culture: Rationalisation as disciplinary purification in early twentieth-century British dairy farming. *Journal of Historical Sociology*, 21(2-3), 272-302.

O'Brien, T. (2001). Factory farming and human health. *The Ecologist*, 31(5), S30-S30.

OECD/FAO (2021). *OECD-FAO Agricultural Outlook 2021-2030.* Paris: OECD Publishing, https://doi.org/10.1787/19428846-en.

Olmstead, A. L., & Rhode, P. W. (2008). Creating abundance. Cambridge University Press.

Ombelet, W., Van Robays, J. (2015). Artificial insemination history: hurdles and milestones. *Facts Views Vis Obgyn.* 7(2), 137-143.

Overton, M. (1996). Agricultural revolution in England: the transformation of the agrarian economy 1500-1850 (No. 23). Cambridge University Press.

Persson, K. G., & Sharp, P. (2015). An Economic History of Europe: Knowledge, Institutions and Growth, 600 to the Present. Cambridge University Press.

Prosch, V. (1856). *Grundtræk af Huusdyrenes almindelige Sundhedspleje, udarb. nærmest til brug for Veterinærer og Landmand.* Copenhagen, Denmark: Forlaget af C.A. Reitzels Bo og Arvinger.

Prosch, V. (1878). Husdyrbruget i Danmark, Tidsskrift for Landøkonomi 4/XII, 239-258.

Regan, T. (1983). The Case for Animal Rights. University of California Press.

Reimert, I., Webb, L. E., van Marwijk, M. A., & Bolhuis, J. E. (2023). Towards an integrated concept of animal welfare. *animal*, 100838.

Richi, E. B., Baumer, B., Conrad, B., Darioli, R., Schmid, A., & Keller, U. (2015). Health risks associated with meat consumption: a review of epidemiological studies. *Int. J. Vitam. Nutr. Res*, 85(1-2), 70-78.

Samanta, S. (2021). Meat, Mercy, Morality: Animals and Humanitarianism in Colonial Bengal 1850-1920. New Delhi, OUP.

Settele, V. (2022). *Deutsche Fleischarbeit: Geschichte der Massentierhaltung von den Anfängen bis heute.* Munich: C.H. Beck.

Sharp, P. (2018). Agriculture and Rural Development. In M. Blum, C. L. Colvin (eds.), An Economist's Guide to Economic History, Palgrave Studies in Economic History, 231-237.

Singer, P. (1975). Animal Liberation: A New Ethics for Our Treatment of Animals. HarperCollins.

Singer, P. (1980). Utilitarianism and vegetarianism. *Philosophy & Public Affairs*, 325-337.

Statistics Denmark (1911. *Landbrugsforhold i Danmark siden midten af de 19. aarhundrede.* Statistisk Tabelværk V C.4.

Steckel, R. H. (2013). Biological measures of economic history. *Annual Review of Economics*, 5(1), 401-423.

Turner, J. (1980). *Reckoning with the Beast Animals, Pain, and Humanity in the Victorian Mind.* Baltimore: Johns Hopkins University Press.

Turner, J. (2017). Grass-fed cows won't save the climate, report finds. *Science*. doi: 10.1126/science.aaq1116

Vølver, G. (2000, ed.). *I dyrernes tjeneste: Dyrernes Beskyttelse i 125 år.* Frederiksberg, Denmark: Animal Protection Denmark.

Walther, S. (2021). Multispecies modernity: Disorderly life in postcolonial literature. Wilfrid Laurier Univ. Press.

Whitnall, T., & Pitts, N. (2019). Global trends in meat consumption. *Agricultural Commodities*, 9(1), 96-99.

Zuzworsky, R. (2001). From the marketplace to the dinner plate: The economy, theology, and factory farming. *Journal of Business Ethics*, 29, 177-188.

European Historical Economics Society

EHES Working Paper Series

Recent EHES Working Papers

2024

EHES 256 Retaining population with water? Irrigation policies and depopulation in Spain over the long term
Ignacio Cazcarro, Miguel Martín-Retortillo, Guillermo Rodríguez-López, Ana Serrano, Javier Silvestre

EHES 255 Breaking the HISCO Barrier: Automatic Occupational Standardization with OccCANINE
Christian Møller Dahl, Torben Johansen, Christian Vedel

EHES 254 Birth Order and Social Outcomes, England, 1680-2024
Gregory Clark, Neil Cummins

EHES 253 Assimilate for God: The Impact of Religious Divisions on Danish American Communities
Jeanet Sinding Bentzen, Nina Boberg-Fazlić, Paul Sharp, Christian Volmar Skovsgaard, Christian Vedel

EHES 252 Where are the Female Composers? Evidence on the Extent and Causes of Gender Inequality in Music History
Karol Jan Borowiecki, Martin Hørlyk Kristensen, Marc T. Law

EHES 251 Multigenerational Effects of Smallpox Vaccination
Volha Lazuka, Peter Sandholt Jensen

EHES 250 Revealing the Diversity and Complexity Behind Long-term Income Inequality in Latin America, 1920-2011
Pablo Astorga

EHES 249 The Returns to Education: A Meta-Study
Gregory Clark, Christian Alexander Abildgaard Nielsen

EHES 248 Matriline versus Patriline: Social Mobility in England, 1754-2023
Gregory Clark, Neil Cummins

EHES 247 The Global Sanitary Revolution in Historical Perspective
Daniel Gallardo-Albarrán