AUTHOR Taija Kaarlenkaski

TITLE Cows and Humans as Technology Users: Multispecies Agency and Gender in Automated Milking Systems in Finland

YEAR 2023

DOI https://doi.org/10.1353/tech.2023.a910996

VERSION Author accepted manuscript

CITATION Kaarlenkaski, T. (2023). Cows and Humans as Technology Users: Multispecies Agency and Gender in Automated Milking Systems in Finland. Technology and Culture 64(4), 1093-1119. https://doi.org/10.1353/tech.2023.a910996.

Cows and Humans as Technology Users: Multispecies Agency and Gender in Automated Milking Systems in Finland

Taija Kaarlenkaski

Abstract

Automatization has changed the interactions between cows and humans in subtle ways. In dairy husbandry, technologies like automated milking systems (AMSs) have been used commercially since the early 1990s, first in the Netherlands and then elsewhere in Western Europe and North America. Finland saw its first AMS in the early twenty-first century. By 2021, nearly 27 percent of Finnish dairy farms had adopted them. Based on fieldwork at AMS farms and articles in a Finnish trade journal, this article sheds light on agency and gender in dairy husbandry. The article argues that as technology users, both humans and cows are engaged in agential entanglements with milking robots. It shows how both cows and farmers face challenges in learning to use the milking robot, how it impacts their working and living rhythms, and how the technologized work with AMSs is gendered among dairy farmers.

Citation: Kaarlenkaski, Taija. "Cows and Humans as Technology Users: Multispecies Agency and Gender in Automated Milking Systems in Finland." *Technology and Culture* 64, no. 4 (2023): PAGES.

Introduction

Innovative technologies have the potential to make food production more efficient.[1] Over the past fifty years, technologizing animal husbandry has accelerated all over the world.[2] Researchers have understood automation and digital tools as solutions to environmental and labor shortage problems: digitalization arguably gives farmers more

[1] This study is based on fieldwork at Finnish farms using automated milking systems, as well as articles in a Finnish cattle husbandry journal. The fieldwork followed the guidelines of multispecies research. It emphasizes the inseparability of human and other forms of life and strives to extend research beyond mere human experience, and aims to understand other species "as significant social actors rather than as objects or materials". (Piers Locke and Ursula Muenster, "Multispecies Ethnography," *Oxford Bibliographies*, https://doi.org/10.1093/obo/9780199766567-0130; Hamilton and Taylor, *Ethnography after Humanism*, 11, 69). I conducted semistructured interviews with fourteen people on nine dairy farms, most of whom were couples owning the farm—and in one case a mother and daughter. Nine of the interviewees were women, and five were men, the youngest in their twenties and the oldest in their sixties. The herd sizes ranged from 55 to 160 dairy cows, and the dairy farms had between three and sixteen years of experience with AMSs. Six farms used Lely Astronaut and three used the DeLaval Voluntary Milking System. The interviews focused on how the milking robot had changed cattle husbandry. The interviewees described their views on what constitutes a good cow and what cows should and should not do in the cowshed. The interviews concluded with a brief visit to the cowshed to discuss and observe cattle-tending practices, cows' behavior, and their material environment. These visits to the cowsheds were documented by taking notes, taking photos, and recording videos. The interviews were recorded and transcribed, and the farmers are here referred to anonymously by number.

[2] Silbergeld, *Chickenizing Farms and Food*, 2–3, 29–49.

precise information about production processes, enabling more accurate investments. Moreover, automation may save working hours, reduce the workload, and increase productivity. At the same time, scholars have pointed out that technologization can cause soil pollution, unequal accumulation of capital, and exploitation of immigrant workers. Increased technologization in breeding, aimed at maximizing production, moreover, often comes at the cost of animal health and well-being.[3] The decreasing prices farmers receive put them under pressure to increase their production, as small herds cannot provide an adequate income. The number of farms has dropped in all key areas of animal production—dairy, beef, pork, and broiler. The farms in Western countries that have survived have expanded. Given the high cost of hiring agricultural workers, larger farms have switched to mechanization to mitigate labor costs. Mechanization enables farmers to track large herds' feed intake, monitor production rates, and detect any animal health problems in a timely manner.

However, scaling up also produces greater risks on large farms. The growing number of livestock interacting daily with different technologies means that disruptions can severely damage animals' well-being and the farm's economics. New technologies also demand

[3] Kaila and Järvenpää, "Työajan säästö ja työn luonteen muutokset"; Rotz et al., "Automated Pastures and the Digital Divide," 112–13; Lonkila, "Optimoituja eläimiä"; Anthony, "Building a Sustainable Future for Animal Agriculture," 129–31; Boyd, "Making Meat." For a Finnish Työtehoseura (Society for working efficiency) project on cultivation and livestock: Työtehoseura, "Kestävää kehitystä maatalouteen uusilla teknologioilla" [Sustainable development for agriculture with novel technologies], https://www.tts.fi/tutkimus_ja_kehitys/tutkimushankkeet/maatalous/kestavaa_kehitysta_maatalouteen_uusilla_teknologioilla.

appropriate skills—and farmers must be prepared for all kinds of risks.[4] This article discusses the technologization of dairy production and automated milking in the case of Finland. On technologized farms, many animals need to learn to use feed dispensers, but cows in automated milking systems (AMSs) need the additional motivation to enter the robot voluntarily in order to get milked. AMSs provide a particularly fascinating topic of innovation because they introduce new farming practices that both humans and animals need to learn.

In recent decades, AMSs have attracted a great deal of attention from scholars in both animal and social sciences. Researchers have examined, for example, the reasons for acquiring a milking robot, the social and political aspects of this process, the ethical issues associated with the technologization of dairy farming, and the various outcomes of using AMSs for farmers and cows.[5] However, the gendered aspects of robotic milking and other

[4] Raussi, "Kotieläinten massatuotannon eettiset kysymykset" 150–58; Silbergeld, *Chickenizing Farms and Food*; Rotz et al., "Automated Pastures," 115–16; Frisvold, "The U.S. Dairy Industry in the 20th and 21st Century," 218–20; Lonkila, *Making Invisible Cows?*; Tuomivaara, "Onko suomalaisesta eläintuotannosta kerrottava tarina toisenlainen?"; Kaarlenkaski, "Eläimet ja ihmiset teknologian käyttäjinä automatisoidussa tuotantojärjestelmässä."

[5] Jacobs and Siegford, "The Impact of Automatic Milking Systems on Dairy Cow Management, Behavior, Health, and Welfare"; Stræte, Vik, and Hansen, "The Social Robot"; Driessen and Heutinck, "Cows Desiring to Be Milked?"; Millar, "Respect for Animal Autonomy in Bioethical Analysis"; Schewe and Stuart, "Diversity in Agricultural Technology Adaption"; Holloway, Bear, and Wilkinson, "Re-capturing Bovine Life"; Butler and Holloway, "Technology and Restructuring the Social Field of Dairy Farming"; Bear and

automation in agriculture have scarcely been explored, according to Christopher Bear and Lewis Holloway.[6] In this study, the focus is on agency, gender, and changing practices: How do AMSs affect the working and living rhythms of both humans and cows? How is the technologized work with AMSs gendered among dairy farmers? How are humans and cows perceived as technology users, and what sort of agential entanglements are formed in the relationships among humans, cows, and milking robots? New materialist thought, human-animal studies, and cultural technology studies have inspired this research.[7]

Gender and Mechanization in Finnish Dairy Farming

Dairy farms in Finland are both similar to and different from those in other countries. AMSs were first commercially used in the Netherlands in the early 1990s, before being adopted in other Western European countries and North America.[8] Finland saw its first AMS in 2000. The number of AMS farms has since grown steadily: by the end of 2021, nearly 27

Holloway, "Redistributing Labour in Automated Milking Systems and the More-Than-Human (Co)Production of Dairy Farming"; Holloway, "Subjecting Cows to Robots"; Calvert, "Ready for the Robot"; Deturche, "'It's No Longer the Same Job.'"

[6] Bear and Holloway, "Country Life," 9–10. For a brief discussion of the gendered division of work with AMSs and a call for more research: Stræte, Vik, and Hansen, "Social Robot," 225, 228, 230–31.

[7] Barad, *Meeting the Universe Halfway*; Coole and Frost, "Introducing New Materialisms"; Haraway, *When Species Meet*; Wilkie, *Livestock/Deadstock*; Cudworth, *Social Lives with Animals*; Oudshoorn, Rudinow Saetnan, and Lie, "On Gender and Things"; Oudshoorn and Pinch, "Introduction."

[8] Holloway, "Subjecting Cows to Robots," 1048.

percent of all dairy farms in Finland used AMSs, producing over half of the country's milk.[9] Other technologies such as automated feeding systems and manure removal increasingly regulate the cow's food system, while advanced technology observes cows' heat, calving, and udder health.[10] Consequently, the automated milking, feeding, and other observational systems create a technological complex in the barn around cows. The milking robot constantly generates information not only on the quality and quantity of milk but also on how much the cows eat, their weight, and how often they visit the milking stall. Alongside technologization, breeding practices have also changed. Molecular genomics creates animals that better fit the requirements of contemporary dairy production.[11] Technologies thus permeate throughout contemporary dairy husbandry.

Finnish dairy farms are still relatively small, with an average herd size of 49 milking cows, compared to the average of 231 on Danish farms, 183 on U.K. farms, 107 on farms in the Netherlands, and 315 on U.S. farms in 2021.[12] Still, Finnish farms using AMSs are larger than the country's average, as one milking robot unit is optimized for a herd of sixty to seventy cows. Importantly, although most Finnish cows are currently in loose-housing units, one-third are still in significantly less technologized tie-stall cowsheds.[13] Dairy husbandry in

[9] Kaj Nyman, "Yli puolet maidosta lypsetään automaattilypsyllä" [More than half of the milk is milked automatically], *Maito ja me* [Milk and us], https://www.maitojame.fi/artikkelit/yli-puolet-maidosta-lypsetaan-automaattilypsylla/.

[10] Mononen, "Valvonta- ja mittausteknologia eläinten hoidossa," 74–77.

[11] Lonkila, *Making Invisible Cows?*

[12] International Committee for Animal Recording, "Statistics," https://my.icar.org/stats/list.

[13] MTK [The Central Union of Agricultural Producers and Forest Owners], "Maidontuotanto" [Milk production], https://www.mtk.fi/-/maidontuotanto-1.

Finland is practiced industrially; however, the scale differs substantially from that in the United States, where farms with more than five hundred cows are common, and some herds have over fifteen thousand cows.[14]

In Finland, milking was mechanized late compared to many other countries. Milking machines became mainstream only in the 1960s and 1970s. In Australia, 25–50 percent of dairy farms already had a milking machine by 1930; in Britain, the proportion of machine-milked herds rose from 10 to 85 percent between 1944 and 1961; and the number of U.S. farms using milking machines increased rapidly in the 1940s and 1950s.[15] In other Nordic countries (Sweden, Denmark, and Norway), farms started to use milking machines in the 1940s and 1950s. The "bucket milker" was often the first step toward mechanization in Finnish dairy husbandry, though at first the milk was cooled and transported to dairies in milk cans. A second mechanization step involved large farm milk tanks and milking pipeline machines that transported the milk straight from the milking machine to the tank without human intervention.[16]

Technologization also meant masculinization—and in Finland it created a specific gendered outcome. The technologization of milking increased male farmers' participation in milking and other barn chores, whereas hand milking was previously regarded as women's work. In Finland and other Nordic countries, a rather strict gendered division of farm labor in

[14] Gillespie, *The Cow with Ear Tag #1389*, 18–19; Blanchette, *Porkopolis*; Boyd, "Making Meat."

[15] Henzell, *Australian Agriculture*, 138; Brassley, "Output and Technical Change in Twentieth-Century British Agriculture," 73; Gardner, *American Agriculture in the Twentieth Century*, 14–15.

[16] Kaarlenkaski, "'Octav lypsää kuin elävä vasikka.'"

animal husbandry prevailed until the mid-twentieth century.[17] Furthermore, women in Finland often continued working on family farms—even after mechanization.[18] From the 1970s, a couple owning a dairy farm usually worked together as partners in the cowshed. This was to offset the fewer family members working on the farm at a time when herd sizes were increasing.[19] On contemporary technologized dairy farms, men and women, although both working in the cowshed, have their own areas of responsibility. Men mostly deal with cultivation, forestry, and the maintenance of machinery and buildings and usually are responsible for management, including the accounts, cultivation and feed planning, agricultural subsidy applications, and tax forms. Women's responsibilities include caring for the family, and housekeeping. Thus, Finnish farmers in many cases still work according to traditional work divisions.[20]

Ethnography of Domesticated Technology

Building on the scholarship in new materialist theorization, human-animal studies, and cultural technology studies, this article examines how the meanings attached to humans,

[17] Kaarlenkaski, "'Machine Milking Is More Manly than Hand Milking'"; Thorsen, "Work and Gender"; Sommestad and McMurry, "Farm Daughters and Industrialization," 143, 150.

[18] Shortall, "In and Out of the Milking Parlour"; McMurry, "Women's Work in Agriculture."

[19] Siiskonen, "The Role of Farmers and Farmwives in Agrarian Change," 92–95.

[20] Karttunen and Tuure, *Työnjako perustuotantoa harjoittavissa ja monialaisissa maatalousyrityksissä*, 4.

technology, gender, and animals are intertwined and intra-active.[21] Technology encompasses not only the material equipment but also the requisite knowledge and skills to use it.[22] As sociologists of technology have shown, technologies may also be gendered in different ways.[23] For example, handling technology and big machines has traditionally been an important part of men's identity as farmers, while their attitudes may be more ambivalent toward using computers.[24] Technology presents the world and makes it accessible in a certain way.[25] Scholars have suggested, for example, that AMSs bring automation and the intensive use of computers together in such a way that they can change the philosophy of dairy farming.[26]

The framework of domestication of technology is useful for exploring how farmers in Finland have implemented AMSs. The concept refers to how people integrate technological objects into their everyday lives at home or at work. These processes include symbolic, practical, and cognitive work. Technology's individual users either accept or contest the

[21] Barad, *Meeting the Universe Halfway*; Coole and Frost, "Introducing New Materialisms"; Haraway, *When Species Meet*; Wilkie, *Livestock/Deadstock*; Oudshoorn, Rudinow Saetnan, and Lie, "On Gender and Things"; Oudshoorn and Pinch, "Introduction."

[22] Lie, "Technology and Masculinity," 392; Anthony, "Building a Sustainable Future," 124.

[23] Lie, "Technology and Masculinity"; Oudshoorn, Rudinow Saetnan, and Lie, "On Gender and Things."

[24] Saugeres, "Of Tractors and Men," 149–56; Brandth, "Rural Masculinity in Transition," 128–130; Lie, "Technology and Masculinity," 386, 390.

[25] Holloway, Bear, and Wilkinson, "Robotic Milking Technologies and Renegotiating Situated Ethical Relationships on UK Dairy Farms," 189; Wolfe, *Before the Law*, 3–4.

[26] Holloway, Bear, and Wilkinson, "Robotic Milking Technologies," 186.

symbolic meanings attached to a particular innovation, whereas at the practical level the artefact and its operation are assimilated in daily practices. Cognitive work refers to learning about the artefacts used. Social science scholars of domestication approaches to technology emphasize the users' points of view and the complicated cultural dynamics in their workplace.[27] They have shown how a range of cultural, social, and personal aspects impact domestication processes: for instance, gender and age frame the circumstances for acquiring and applying technologies.[28] While gendered relationships shape and give meaning to the use of technology, they also emerge as a result of new technologies bringing about new situations.[29] Furthermore, as cows must also learn to use the milking robot, they play a role in the domestication of technology.[30]

My understanding of agency is based on a relational approach discussed in new materialist theorization and human-animal studies: agency is always constructed in relationships that can include more-than-human actors.[31] Agency is thus not seen as an intrinsic feature of some individuals but shaped in material-discursive and biosocial

[27] Lie and Sørensen, "Making Technology Our Own?," 10; Oudshoorn and Pinch, "Introduction," 14–15; Lehtonen, "The Domestication of New Technologies as a Set of Trials."

[28] Talsi, "Technologies Entering the Home," 5.

[29] Cockburn and Ormrod, *Gender and Technology in the Making*, 129.

[30] Bear and Holloway, "Redistributing Labour," 988; Finstad, Aune, and Egseth, "Domestication Triangle."

[31] Barad, *Meeting the Universe Halfway*, 33, 178; Coole and Frost, "Introducing New Materialisms," 8–10, 20–21; Haraway, *When Species Meet*; Despret, "From Secret Agents to Interagency"; Nimmo, "Apiculture in the Anthropocene," 179.

networks. Human intentions are only one component in these networks, and they are significantly affected by more-than-human beings and objects, often resulting in contingencies and inadvertent corollaries.[32] Building on this, I am also interested in the agencies associated with milking robots. Technology possesses a certain agency, as it can shape, control, and facilitate human activities.[33] The concept of interagency, developed by philosopher of science Vinciane Despret, is especially useful here: various parties are interlinked, instigating and stimulating each other to become agents in their reciprocal relationships.[34]

Human voices dominate the data gathered by fieldwork on AMS farms, yet the cows importantly influence both the farmers' and my understanding.[35] Though we cannot ask cows how they experience AMSs, their behavior makes them participants in the production of knowledge.[36] As animal studies researcher Kathryn Gillespie explains, the commodification of cattle in current industrial dairy production frames the knowledge and interpretations of their experiences. A researcher can only see fragments of cows' lives. Still, it is important to view them not only as commodities but also as commodified beings whose lives are

[32] Nimmo, "Apiculture in the Anthropocene," 180.

[33] Anthony, "Building a Sustainable Future," 124. For the use of Actor-Network-Theory for understanding nonhuman entities as important agents in social practices: Callon, "Some Elements of a Sociology of Translation"; Latour, *Reassembling the Social*; and Law, "Actor-Network-Theory and Material Semiotics."

[34] Despret, "From Secret Agents," 38–41, 44.

[35] See footnote 1 for a more detailed description of the fieldwork.

[36] Callon, "Some Elements"; Bastian et al., "Introduction," 5–6.

determined by industry practices.[37] The photos and videos taken in the cowsheds help in understanding cows as individuals and thinking about potential bovine viewpoints. Another source of data comes from articles on AMSs in trade journal *Nauta* (Bovine) between 2000 and 2018.[38]

Changing Agencies in AMS Domestication

AMSs mean different kinds of agencies and rhythms for humans and cows than tie-stall cowsheds or conventional milking parlor systems, where cows are brought from the loose-housing area to be milked.[39] AMSs change the nature of dairy work profoundly: farmers do not need to milk recurrently two or three times a day. Instead of physical milking, humans monitor and control the technology while observing the animals' behavior and

[37] Gillespie, *Cow with Eartag #1389*, 22–26. On ethics in multispecies research spaces: Lonkila, *Making Invisible Cows?*, 91–95. On bovine agency modes in Finnish dairy husbandry: Kaarlenkaski and Lonkila, "In Search of Invisible Cows."

[38] Published by Finland's market leader breeding cooperative, *Nauta* targets dairy and beef farmers and other professionals in cattle husbandry. In 2020, it had a circulation of 5,800 (Mediakortti [Media card] 2020, *Nauta—eläimistä ja ihmisistä* [Bovine—of animals and humans], https://nauta.fi/wp-content/uploads/sites/2/2019/11/mediakortti2020.pdf). This study covered eighty-one articles related to milking robots and other automation technology. These articles and the fieldwork materials underwent data-driven thematic analysis to generate the most prevalent themes, followed by a more in-depth and theoretically informed analysis (Braun and Clarke, "Using Thematic Analysis in Psychology," 83–84).

[39] Butler and Holloway, "Technology and Restructuring," 518; Driessen and Heutinck, "Cows Desiring," 11–14.

welfare. Interviewees agreed that their working hours had become more flexible, as they no longer needed to be in the cowshed at precise times. However, they still routinely worked in the cowshed in the morning and late afternoon or evening, and many interviewees stated that their time spent working had not necessarily been reduced but was physically less strenuous. A farmer's typical cowshed "shift" was two to four hours twice a day. As the interviewees emphasized, however, this was only possible if everything was in order and nothing unexpected happened. On some days, their working hours could be significantly longer. Moreover, someone on the farm must be prepared to respond to the milking robot's alarms twenty-four hours a day. Interviewees were relieved when fewer alarms sounded than they anticipated.

An AMS expects the cows to be self-directed, active agents, moving independently from the resting area to the feeding area and to the milking robot, unlike tie-stall systems, where cows are rather passive, especially indoors in winter. When asked to describe a good cow, most interviewees said she should be unobtrusive, visit the milking stall regularly, stay healthy, calve with ease, and have no fertility problems—and she should produce a lot of milk. Some interviewees went so far as to describe a good cow as invisible, or, as one farmer stated, "It takes care of itself."[40] Modern breeding programs in Finland and other Nordic countries also emphasize "invisibility" as the main breeding goal.[41] *Nauta* articles similarly summarized that cows should be active, curious, and bold, because besides visiting the

[40] Farmer 9. In Finnish language, animals are usually referred to as "it," regardless of their sex, and there is only one gender-neutral pronoun for humans, "hän." Following the trend in international human-animal studies, this article refers to animals as "she" or "he."

[41] Lonkila, *Making Invisible Cows*, 19–20; Kaarlenkaski and Lonkila, "In Search of Invisible Cows."

milking stall, where they should be calm and behave well, they are supposed to make their way autonomously to the feeding area. A dairy farmer interviewed in a journal article stated, "Even if the cow milks super well, there won't be very much milk in the tank, if it constantly kicks the robot unit loose."[42] There are thus limits to being active and bold.

Many researchers have contested cows' autonomy, which AMS manufacturers often describe as "freedom of choice," claiming that AMSs allow cows to move in the cowshed as they will and get milked whenever suits them.[43] The cows' behavior is monitored and regulated in various ways, and the options for individual cows always rest on other cows' actions and the barn environment. Cows that do not adapt to robotic milking in their bodily conformation or behavior are culled, as they waste precious time at the robot. Thus, the cows' freedom is "rhetorical" rather than "real," as bioethicist Kate Millar suggests.[44] This ostensible freedom of movement and spending time is tightly managed, as optimal functioning of the AMS requires that some cows are resting, others are eating, and yet others

[42] Pentti Nieminen, "Pohjanmaalla riittää yrityshenkeä" [Plenty of entrepreneurship in Ostrobothnia], *Nauta* 44, no. 1 (2014): 43.

[43] Holloway, "Subjecting Cows to Robots," 1049–50; Holloway, Bear, and Wilkinson, "Robotic Milking Technologies," 194.

[44] Millar, "Respect for Animal Autonomy"; also Holloway, "Subjecting Cows to Robots," 1050–53; Holloway, Bear, and Wilkinson, "Re-capturing Bovine Life," 136, 138; Driessen and Heutinck, "Cows Desiring," 10–11.

are being milked, night and day. Feeding automation that provides fodder regularly around the clock maintains the cows' movement through the cowshed.[45]

The common Finnish farming phrase *käydä robotilla* (visiting the robot) expresses the aspiration to optimize the use of the robot's, cows', and consequently the farmers' time. It can be interpreted as a brief stop somewhere, like "visiting the toilet." If a cow lingers longer than the milking takes, that time cannot be used to milk other cows, rendering the business unprofitable. Enter technology: the cow that stays at the robot too long receives a slight electric shock to remind her to move on. Farmers and breeding programs prefer cows that are quick to milk. Efficiency demands mean that the robot should not stand idle but use its full capacity. In this understanding of time, related to industrial capitalism, time is money, and idleness means losing money.[46]

<<Insert figure 1 about here>>

As AMSs require novel forms of human and cow behavior and thinking, both need to learn new skills to achieve the expected modes of agency. Reports in *Nauta* from Finland's first milking robot owners summarized how the farmer needs to be prepared to reside in the cowshed for the first couple of weeks. It was also claimed that it takes six months to get fully accustomed to the system. However, the interviewees' experiences varied. Most said that the implementation had been smooth. For some the introduction had been problematic owing to

[45] Controlling bovine bodies and actions by technology is also discussed by Welk-Joerger, "Maintaining Bovine"; and Beech and Novick, "Sex Panic and the Productive Infertility of the Freemartin."

[46] Ingold, "Work, Time, and Industry," 13.

cows' udder structures and technical errors early on. Some farms had a particularly challenging start: not only did they move their cows from a tie-stall system to a free-stall system with AMSs, but they also simultaneously increased the size of their herd. The transformation from a tie-stall barn with 30–40 cows to a free-stall barn with a capacity of over 100 cows and two milking robot units significantly changed the environment and working practices. A farmer who had experienced such a situation described the early stages as "managed chaos."[47] Another declared, "During the first months it felt like, was this the right decision, as nobody knew what to do really. Neither humans nor animals."[48] In addition, one farmer claimed that the cows learned the new system faster than the humans, as people on their farm were not accustomed to computers, which made AMS use difficult at first.[49]

Expectations of the cows' learning abilities seemed quite low: articles in *Nauta* often emphasized that cows can learn or have learned to use the robot surprisingly easily and have become accustomed to new practices. One article describing the first AMS on a Finnish research farm noted that "even old cows learn new tricks."[50] Many interviewees similarly claimed that training the cows to use the robot was surprisingly trouble-free. The following exemplifies a typically positive description of the first milking:

> On the first day, […] milking all 30 cows took five hours, there were almost ten people doing it, so some were at the robot to save information about the cow; when she's there for the first time, the robot must be taught to milk that particular cow.

[47] Farmer 12.

[48] Farmer 10.

[49] Stræte, Vik, and Hansen, "Social Robot," 224–25.

[50] Sakari Alasuutari, "Ensikokemuksia automaattilypsystä" [First experiences on automatic milking], *Nauta* 31, no. 1 (2001): 56.

> And then in the cowshed, there were several people, they [the cows] had to be practically pushed, they wouldn't voluntarily walk into the box, but well, in five hours we got it done, and the next morning, when the same bunch was pushed around, it was maybe three hours, so they went there more eagerly, and of course you didn't have to teach the robot the same information, but it, well, knew a part of it. For a couple of days, they were pushed there, but then the smartest ones started to go there autonomously, and others followed. The herd seems important to them. So, no bad memories from that time.[51]

This excerpt shows the multispecies networks of teaching and learning in AMS domestication. The interviewees commonly used the word "teach" to describe the situation: humans must teach the cows to use the robot and teach the robot to milk the cows—and learn to operate the robot at the same time. Thus, both the cows and the milking robots are understood as having capacities to learn. Moreover, the farmer must learn how individual cows react to the robot, due to differences in their character and behavior. Even more challenging is finding the right settings for the robot. As an interviewee noted, the settings must be "herd-specific. What suits us does not necessarily suit another [farm]."[52] Evidently with AMSs, "technologies are not simply installed but reworked through place-specific everyday relationships," as Bear and Holloway point out.[53]

---

[51] Farmer 1.

[52] Farmer 12.

[53] Bear and Holloway, "Redistributing Labour," 988; also Finstad, Aune, and Egseth, "Domestication Triangle," 217; Oudshoorn and Pinch, "Introduction"; Lehtonen, "Domestication of New Technologies," 364.

Cows also take part in various aspects of implementing AMSs.[54] For humans, the cognitive work begins already when planning to buy and getting to know how to operate an AMS. Most interviewees mentioned they had visited several AMS barns, even abroad, before installing their own system. They also said that merely looking around in a barn does not give a realistic picture of AMS use on their own farm. Most of the learning was done in practice while assimilating an AMS into their daily routines. Usually, the representatives of the milking robot manufacturer were present at the installation for a day or two to advise and help both humans and cows—and in many cases the farmers also received help from colleagues who already had experience with AMSs.

Robotic technology and automation, however, had highly significant symbolic meanings. Some early users, or their circle of acquaintances, were slightly suspicious of the milking robot's functionality and reliability. Even a *Nauta* article in 2000 discussing milking robots was titled "A Miracle Called Milking Robot."[55] Furthermore, AMSs not only changed milking practices but also affected the dairy farm's entire management. Interviewees found being in control of their whole production system demanding, requiring changes to their mindset.[56] All the interviewees were used to working daily in the cowshed, but they also had to learn to be managers.

For cows, AMSs become domesticated through practical and cognitive work. Some cows learn faster than others to visit the robot. Although they were enticed to it by concentrate feed that only comes from the milking robot, some cows needed to be pushed or

[54] Finstad, Aune, and Egseth, "Domestication Triangle," 217–18.

[55] Pirkko Luttinen, "Ihme nimeltä lypsyrobotti" [A miracle called milking robot], *Nauta* 30, no. 1 (2000): 53.

[56] Deturche, "'It's No Longer,'" 15.

fetched for a couple of weeks before they learned to visit the robot autonomously. Moreover, cows moved from tie-stall barns to free-stall barns have difficulty understanding the new environment and its requirements: they do not know where the farmer wants them to lie down, and sometimes they stand in the resting stalls waiting for fodder instead of walking to the feeding area. Certain cows stick to the same milking times they were used to in the former tie-stall or milking parlor system; if the robot is not free at those times, they might skip the milking altogether. This behavior can also be seen as cows expressing their attitude toward changing environments and practices: they might find them confusing and want to maintain old habits. To learn all the new practices, cows have to invest their "intelligence and affects" in their work, to quote sociologists Porcher and Schmitt.[57]

<<insert figure 2 about here>>

According to the interviewees, most cows eventually learned how to perform in the AMS, which confirms other studies: adaptation takes from a few days to a month.[58] The journal *Nauta,* however, estimated (based on research) that milk yield drops for two to three months after introducing an AMS and that milk quality returns to normal within a year—rather a long time for full adaptation.[59] The interviewees mentioned that some cows failed to

[57] Porcher and Schmitt, "Dairy Cows," 55. On the conceptualization of animal work: Coulter, *Animals, Work, and the Promise of Interspecies Solidarity*, 55–95.

[58] Calvert, "Ready for the Robot," 89; Jacobs and Siegford, "Lactating Dairy Cows Adapt Quickly to Being Milked by an Automatic Milking System," 1582–83.

[59] Sanna Lohenoja, "Robottikarjan utareterveys hallintaan" [Managing the udder health of robot-milked cattle], *Nauta* 38, no. 5 (2008): 13.

adapt their behavior to robotic milking, or their udders and teats did not allow it. The economic realities of milk production mean that adapting to AMS technology is obligatory for cows. If they fail, they are culled.

Gendered Division of Labor and Agency

Division-of-labor practices vary depending on how many people work on the farms. As an agronomist explained in a *Nauta* interview, a herd of seventy cows is manageable by the people living on the farm, but a larger herd calls for someone to oversee everything and delegate responsibilities.[60] Some farms employ workers or outsource some of the work to contractors. Nearly all Finnish farms are still family farms run by a couple or an individual farmer. Some have established larger farming syndicates, providing employment for extended family members, though the business model is still rare in Finland—about 9 percent of all farms in 2021.[61] Of the visited farms, four were family farms, three were farming syndicates, one was a limited company, and another was owned by an educational consortium. Indeed, dairy husbandry is no longer an enterprise necessarily divided between the husband and wife owning the farm. It may be managed by parents together with their adult children, or by two couples working on the same farm with additional employees. Finland, like many other European countries and the United States, has a strong cultural model of patriarchal transferring of the farm to a son. There are exceptions, although a woman in charge of a farm may find her position challenged owing to traditional gendered expectations in the farming

[60] Pentti Nieminen, "Navetan rakentaminen on joukkuepeliä" [Building a cowshed is team sport], *Nauta* 42, no. 3 (2012): 69.

[61] Luke, Natural Resources Institute Finland, "Structure of Agricultural and Horticultural Enterprises," https://stat.luke.fi/en/structure-of-agricultural-and-horticultural-enterprises.

community.[62] Among the interviewees was a young woman aiming to take control of the family farm, and this possibility was discussed on another farm.

Extensive generalizations are not possible based on a small number of interviews. Still, work division practices are similar on the farms visited. Men are usually responsible for feeding, involving big machinery like loaders, and also typically in charge of repairing the milking robot and other machinery. Women take care of small calves, observe heat in cows, and make breeding decisions.[63] *Nauta* articles indicate that such practices are common on Finnish AMS farms. Thus, although many tasks in the cowshed are shared, there are traditional elements in the chores that are the most gendered: men are associated with large machinery and women with care work and reproduction. Researchers have reported similar observations: men are usually responsible for using heavy machinery and tasks involving larger animals. Duties involving care and emotionality are associated with women's roles and qualities.[64] Interviewees also referred to traditionally gendered roles when asked about the division of work on their farm. Many suggested that men are "naturally" interested in machines and women in animals.

While large agricultural machinery has been identified with men on the farm, computers are arguably no longer strictly a man's or a woman's domain, and for many men used to working with "real" machines, computers are a different matter and far less

[62] Silvasti, "Bending Borders of Gendered Labour Division on Farms"; McMillan Lequieu, "Keeping the Farm in the Family Name."

[63] On breeding as women's responsibility: Lonkila, *Making Invisible Cows*, 82.

[64] Cudworth, *Social Lives*, 132; Coulter, *Animals, Work*, 29; Wilkie, *Livestock/Deadstock*, 56–58.

interesting. Men do not necessarily regard using a computer as "real work" on the farm.[65] Accordingly, the levels of interest in the computer programs controlling AMSs and generating production information varied between men and women. On some farms, husbands delegated this work to their wives, because they were neither used to using computers nor eager to learn.[66] Given that an AMS needs to be observed and controlled several times a day, its introduction increased the time women spent on computer work.[67]

A potentially gendered negotiation took place on one farm regarding the milking robot's hardware and software. The interviewee describes the situation when the milking robot was assembled:

> INTERVIEWEE. Well, that surprised me of course that the repairman asked me to look at, right away, like that toolbox and the engine room of the robot. That it belongs to everybody who works [there]. And for me, those things are awfully unfamiliar.
>
> INTERVIEWER. Well, that computer . . .
>
> INTERVIEWEE. Yes, all those batteries and fuses and other things. Well not the computer but that . . .
>
> INTERVIEWER. The actual machine?

---

[65] Lie, "Technology and Masculinity," 386, 390; Bryant, "Gendered Bodies, Gendered Knowledges," 470–72.

[66] Stræte, Vik, and Hansen, "Social Robot," 228.

[67] The fieldwork focused on the milking robots and other technology in the cowsheds, not on computer use in general, such as accounting and writing funding applications. Karttunen and Tuure (*Työnjako perustuotantoa harjoittavissa*) show that mostly men conduct such tasks on Finnish farms—in contrast with some of the men interviewed who were reluctant to use computers.

INTERVIEWEE. Machine. That certain basic things you need to know how to do. I can't repair machines, but certain things you have to know. So, he specifically wanted to show it to us both, not just to [husband's name].[68]

As the interviewee was almost sixty, I assumed that she would not be familiar with computers. But she was trying to say that she was surprised that the repairman assembling the robot insisted that everyone working in the cowshed needed to know the basics of the robot's hardware ("engine room"). Other women also said they might be more skillful with the robot's software, but they could only do basic hardware repairs. More difficult problems the men on the farm or professional repairmen needed to solve.

Understanding AMSs as both hardware and software underlines the gendering of technology: hardware is mostly considered a man's domain, while software tends to be managed by both men and women (though some men may be hesitant). As some researchers have suggested, women tend to consider technology a "black box" whose contents and functions are difficult to understand or of little interest, while men tend to focus on and specialize in understanding machinery.[69] These attitudes were shared by many of the farmers. As repairing machines has traditionally belonged to the masculine sphere in farming, farmers may also see the milking robot's hardware as a machine that might seem unfamiliar to women and difficult to manage.

Regarding bovines, AMSs affect the lives and living conditions of female animals. Feminist research has focused on the exploitation of female animals because they usually produce the protein like milk and eggs and reproduce the next generation of farm animals that

[68] Farmer 9.

[69] Lie, "Technology and Masculinity," 388; Talsi, "Technologies Entering the Home," 7–8.

ultimately become meat. The gendering of cows also occurs on a discursive level: the ideal cow is often described as docile and collaborative, characteristics usually considered as feminine.[70] Interviewees commonly used such descriptions to emphasize that cows should be calm and even-tempered and get along with both humans and the other cows.

AMSs also affect cows' bodies because there are limitations to what kind of udders and teats a robot can milk. This puts demands on cows' udder structure and breeding.[71] Developments in milking technology have impacted breeding throughout history, subjecting diverse living beings to mechanical equipment.[72] A completely automated system, however, requires as standardized animal bodies as possible. The system also needs to reckon with several feminine bodily processes, even though AMSs are working twenty-four hours a day. For example, cows need their nightly resting time in dim lighting in order for their hormonal rhythms and reproduction to function properly. As William Boyd has pointed out, pressing biological beings into serving industry and pushing for higher production can lead to unintended consequences and vulnerabilities like fertility problems.[73]

Interagencies with the Milking Robot

[70] Cudworth, *Social Lives*, 129–32.

[71] Calvert, "Ready for the Robot," 75.

[72] Nimmo, "Biopolitics and Becoming in Animal-Technology Assemblages," 125–35; Kaarlenkaski, "'Octav lypsää kuin elävä vasikka,'" 225. Milking machines are also involved in the development of human breast pumps; Martucci, "Breast Pumping," 792.

[73] Boyd, "Making Meat," 662–63; also Lonkila, *Making Invisible Cows?*

Nauta articles convey that much is expected from milking technology: it should serve both the animal and the human being and "meet all the requirements set by biology."[74] This has been the case ever since the first milking machines were introduced in the late nineteenth century. Bovine physiology had to be taken into account in order to create workable machines that were practical for humans to use and would generate profits.[75] A properly working milking robot requires a manufacturer's maintenance services and easily available spare parts. *Nauta* also discussed the limitations of milking robots' capabilities. According to an agronomist specializing in cowshed planning, the milking "robot is a quite expensive and often fragile worker, who is able to do only one job."[76] His point was that a human worker, although expensive to employ, can do many other tasks besides milking.

Farmers anthropomorphized the machine. Some interviewees called the robot "a worker," and one called it "a maid." They compared it to a human worker and gendered it according to traditional roles. Views differed on the robot's features, some describing it as stable: "the machine doesn't give in, it just does what it can do, and it doesn't question anything."[77] Compared to humans, "the robot is always in the same mood."[78] And, according to one farmer quoted in *Nauta,* cows seemed to enjoy being milked by the robot, probably

[74] Editorial, "Automaatio lypsykarjassa" [Automation in dairy cattle], *Nauta* 30, no. 2 (2000): 3; Esa Manninen, "Sopivat nännikumit, terveet utareet" [Well-fitting teat cups, healthy udders], *Nauta* 42, no. 2 (2012): 26.

[75] Nimmo, "Biopolitics and Becoming," 125–35.

[76] Nieminen, "Navetan rakentaminen on joukkuepeliä," 69.

[77] Farmer 1.

[78] Farmer 4.

because everything is repeated the same way every time, without surprises.[79] In this context, the farmers considered the milking robot a more reliable and stable milker than humans. In addition, as the farmers stated, milking robots can "learn" and adapt to different types of udders because their computer operating system is continually updated. Interviewees who owned several robot units even pointed out different robots' capabilities to milk certain cows and that some cows prefer certain robots. The other side of the coin is the robot's vulnerability: many interviewees reported the technology's malfunctioning. Unexpected failures caused trouble and pauses in milking, and consequently misused time of the robot, the cows, and the farmers. One interviewee remarked, "You never get back the time you lose. It is, like, a brutal fact."[80]

Interviewees frequently mentioned "assisting" the robot, for example, when a cow's udder structure is problematic. In this case, farmers insert plastic slabs under the cow's back feet to elevate her, move the teats to their proper position with a stick, or even attach the teat cups manually. Such "tinkering with technology," as Butler and Holloway suggest, is how farmers try to find ways to keep their cows at work as long as possible: they make more money milking older cows than constantly rearing new heifers.[81] Cows that calve for the first time also need assistance. According to *Nauta*, Finnish AMS farms usually accustom heifers

[79] Pseudonym AL, "Helpotusta lypsytyöhön" [Relief for milking work], *Nauta* 31, no. 5 (2001): 26; Driessen and Heutinck, "Cows Desiring," 15.

[80] Farmer 2.

[81] Butler and Holloway, "Technology and Restructuring," 526.

individually to the milking robot.[82] The interviewees all agreed that human beings should be present at least for the first milking. Many use the robot's learning feature before calving. In this mode, it does not milk but moves the robotic arm under the heifer, getting the young cow accustomed to the robot's movements and sounds. Despite this feature, the interviewees agreed that it was important to have someone present to calm the heifer down during the first milking.

Other parts also require human interventions. Cows have to be reminded to be milked: some cows only need to hear the farmers call out their names to start moving toward the robot. Some cows in the herd refuse to visit the milking stall frequently on their own, prompting the farmer to fetch them and bring them to the robot. These human mediating practices create interagencies: humans assist the robot in milking and help cows visit the robot, while the robot assists humans in farm management by constantly generating information on milk quality and quantity, as well as cows' health. In the words of historian of consciousness Scout Calvert, contemporary cows are "information-generating machines."[83]

Nevertheless, the interviewees and journal articles emphasize that technology and automation are just aids—not meant to replace humans. Ultimately, human beings are responsible for the technology's operational preconditions and the animals' well-being. A *Nauta* journal article titled "Milking Robot Requires a Human Being" crystalized this argument: "it is unrealistic to expect that you would hardly need to visit the cowshed

[82] Sanna Lohenoja, "Lypsettävyys korostuu automaattilypsyssä" [Milkability is emphasized in automatic milking], *Nauta* 36, no. 1 (2006): 18. This method is also used in Norway; Finstad, Aune, and Egseth, "Domestication Triangle," 217.

[83] Calvert, "Ready for the Robot," 74.

anymore."[84] Interviewees similarly highlight that human work is still essential. They feel that AMSs are not suitable for farmers with no interest in cows or in spending time with them. Farmers have to be prepared to observe their animals in order to notice illnesses and deviant behavior in time to avoid serious problems.[85] According to one interviewee, "you should have that eye for cattle, and if you don't . . . , if you are not interested in that part, you should forget about dreaming of this [work], or you should be ready to employ a worker who is interested in it."[86] Observing and having an "eye for cattle" were important skills in traditional milking systems, but more so with milking robots because farmers do not regularly get physically near the cows.[87] Farmers also need to understand and control the AMS technology because, as one journal article summarized the sentiment, technology is a "Good Servant but a Bad Master."[88]

STS scholars have described the domestication of technology as a reciprocal process with no end point when technology is adopted in a final form.[89] This is confirmed in my research: interviewees admitted that even after using AMSs for years, they still found new features in the robot's computer programs. Evidently the agential networks in AMSs contain

[84] Manninen, "Sopivat nännikumit, terveet utareet," 20.

[85] Deturche, "'It's No Longer,'" 13; Driessen and Heutinck, "Cows Desiring," 14; Kaarlenkaski and Lonkila, "In Search of Invisible Cows," 46–47.

[86] Farmer 11.

[87] Kaarlenkaski, "Communicating with the Cow," 200–201.

[88] Jussi Savander, "Hyvä renki, huono isäntä?" [Good servant, bad master?], *Nauta* 42, no. 4 (2012): 48.

[89] Talsi, "Technologies Entering the Home," 4; Oudshoorn, Rudinow Saetnan, and Lie, "On Gender and Things," 487.

more-than-human entities. The milking robot possesses agency, as it interferes with the farmers' and the cows' lives, forcing them to act.[90] However, the robot's agency seems ambiguous: it represents state-of-the-art technology yet is vulnerable to malfunctioning and has limited capabilities. Finally, there are always new heifers with different bodies and behavior that have to be accustomed to the milking robot, making the domestication a never-ending process—also from cows' point of view.

Conclusion

Regarding the changing agencies and gendered aspects of AMS use in Finland, this article confirms Bear and Holloway's argument that the distinctions between technologies, users, and who uses what are often blurred.[91] The milking robot puts pressure on both human and bovine agencies and bodies: they all have to learn to use the robot and adapt to the new environment, rhythms, and working times.[92] At the same time, the robot and its settings are adapted to the farm's circumstances and to the characteristics of individual biological beings with mental capacities. An AMS is not merely about adopting a system that affects humans and cows. The implementation is a complicated process in which both human and nonhuman actors shape each other.[93]

---

[90] Butler and Holloway, "Technology and Restructuring," 522; Latour, *Reassembling the Social*, 70–75.

[91] Bear and Holloway, "Redistributing Labour," 987.

[92] Nimmo, "Introduction," 1.

[93] Lehtonen, "Domestication of New Technologies," 382–83; Schewe and Stuart, "Diversity," 210; Finstad, Aune, and Egseth, "Domestication Triangle."

Using AMSs involves more than learning how to use technology. The milking robot brings into focus the system's drive for profitability and for optimization of how cows, humans, and the milking robot use time. As the robot is a huge investment, farmers feel compelled to use it at full capacity all the time. This economic drive translates into requirements for cows. Their bodies and characteristics should enable short visits to the robot, and they should move in the cowshed to perform useful and productive activities like eating, resting, and milking. For humans, the AMS enables flexible working hours and lightens the physical load. It also highlights the human's obligation to respond to the robot alarm twenty-four hours a day. In addition, the AMS underlines the different gendered meanings of software and hardware, as well as computers and "real" agricultural machines—still considered a masculine domain. While the "traditional" milking machines brought male farmers to the cowsheds in the 1960s and 1970s, automatization has not affected gendered division of work in significant ways. Female farmers are still usually responsible for care work and tasks related to reproduction. It shows how traditional gendered divisions of work persist in agriculture.

Humans, cows, and milking robots alike have agency—each with their own tasks in the system, capable of making a difference and enticing others to act.[94] Still, the participants of this assembly are limited in their capabilities: nudging and interagency remain required. This imperfection makes the human-animal-machine assemblage fragile, requiring continuous surveillance, reassessment, and correction. Although there is a long tradition of understanding animals as technologies, whose bodies resemble machines, the case of AMSs shows that nonhuman animals are vital creatures that shape technologies and knowledge

[94] Despret, "From Secret Agents," 38–41, 44; Bear and Holloway, "Beyond Resistance," 219.

practices by their bodies and behaviors.[95] The voices of the cows may be silenced for the most part, but in the cowshed, they are continually making individual choices within their restricted environment. Farmers also need to consider cows' bodily processes and behaviors for the system to function. Industrial production may encourage considering cattle as an anonymous mass without identity, yet farmers must recognize cows' individual features in order to spot and treat ailments. Individual cows that stand out from the herd tend to make the human work more meaningful.[96] This insight invites humans to reflect on the agency of these commodified nonhuman subjects, given that in the future an increasing number of farm animals around the globe will be living in technologized environments.

Bio/Acknowledgments

Taija Kaarlenkaski, Ph.D., is an Academy research fellow at the University of Eastern Finland. She also holds the title of docent (associate professor) in cultural animal studies at the University of Turku. She has a background in folklore studies and human-animal studies, and she has specialized in her research in human-cattle relationships and the history and technologization of Finnish dairy husbandry, as well as the changing meanings of milk production and consumption. This study was funded by the Academy of Finland (project nos. 296488, 323756, and 347838). The author would like to thank the interviewees and reviewers.

[95] Riskin, "The Defecating Duck, or, the Ambiguous Origins of Artificial Life"; Nimmo, "Biopolitics and Becoming," 131; Boyd, "Making Meat."

[96] Kaarlenkaski and Lonkila, "In Search of Invisible Cows," 43–46; Wilkie, *Livestock/Deadstock*, 133; Kaarlenkaski, "Communicating with the Cow."

Bibliography

Interviews with Finnish farmers from November 2018 to February 2019

Farmer 1, female, and Farmer 2, male, couple. North Karelia, 60–99 dairy cows.

Farmer 3, female. North Ostrobothnia, 60–99 dairy cows.

Farmer 4, female, and Farmer 5, female, mother and daughter. North Ostrobothnia, 60–99 dairy cows.

Farmer 6, female. North Ostrobothnia, over 150 dairy cows.

Farmer 7, female. North Savonia, 20–59 dairy cows.

Farmer 8, male, and Farmer 9, female, couple. North Savonia, 60–99 dairy cows.

Farmer 10, male, and Farmer 11, female, couple. North Savonia, 100–150 dairy cows.

Farmer 12, female, and Farmer 13, male, couple. North Ostrobothnia, 100–150 dairy cows.

Farmer 14, male. North Savonia, 60–99 dairy cows.

Published Sources

Anthony, Raymond. "Building a Sustainable Future for Animal Agriculture: An Environmental Virtue Ethic of Care Approach within the Philosophy of Technology." *Journal of Agricultural and Environmental Ethics* 25, no. 2 (2012): 123–44.

Barad, Karen. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham: Duke University Press, 2007.

Bastian, Michelle, Owain Jones, Niamh Moore, and Emma Roe. "Introduction: More-Than-Human Participatory Research. Contexts, Challenges, Possibilities." In *Participatory Research in More-Than-Human Worlds*, edited by Michelle Bastian, Owain Jones, Niamh Moore, and Emma Roe, 1–15. London: Routledge, 2017.

Bear, Christopher, and Lewis Holloway. “Beyond Resistance: Geographies of Divergent More-Than-Human Conduct in Robotic Milking.” *Geoforum* 104, no. 1 (2019): 212–21.

Bear, Christopher, and Lewis Holloway. “Country Life: Agricultural Technologies and the Emergence of New Rural Subjectivities.” *Geography Compass* 9, no. 6 (2015): 1–13.

Bear, Christopher, and Lewis Holloway. “Redistributing Labour in Automated Milking Systems and the More-Than-Human (Co)Production of Dairy Farming.” In *Sage Handbook of Nature*, edited by Terry Marsden, 980–98. London: Sage, 2018.

Beech, Lucy, and Tamar, Novick. “Sex Panic and the Productive Infertility of the Freemartin.” *Technology and Culture* 64, no. 4 (2023): PAGES.

Blanchette, Alex. *Porkopolis: American Animality, Standardized Life and the Factory Farm*. Durham: Duke University Press, 2020.

Boyd, William. “Making Meat: Science, Technology, and American Poultry Production.” *Technology and Culture* 42, no. 4 (2001): 631–64.

Brandth, Berit. “Rural Masculinity in Transition: Gender Images in Tractor Advertisements.” *Journal of Rural Studies* 11, no. 2 (1995): 123–33.

Brassley, Paul. “Output and Technical Change in Twentieth-Century British Agriculture.” *Agricultural History Review* 48, no. 1 (2000): 60–84.

Braun, Virginia, and Victoria Clarke. “Using Thematic Analysis in Psychology.” *Qualitative Research in Psychology* 3, no. 2 (2006): 77–101.

Bryant, Lia. “Gendered Bodies, Gendered Knowledges: Information Technology in Everyday Farming.” *Social Science Computer Review* 21, no. 4 (2003): 464–74.

Butler, Deborah, and Lewis Holloway. “Technology and Restructuring the Social Field of Dairy Farming: Hybrid Capitals, ‘Stockmanship’ and Automatic Milking Systems.” *Sociologia Ruralis* 56, no. 4 (2015): 513–30.

Callon, Michel. “Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay.” *Sociological Review* 32, no. S1 (1984): S196–233.

Calvert, Scout. “Ready for the Robot: Bovines in the Integrated Circuit.” *Humanimalia* 10, no. 1 (2018): 74–97.

Cockburn, Cynthia, and Susan Ormrod. *Gender and Technology in the Making.* London: Sage, 1993.

Coole, Diana, and Samantha Frost. “Introducing New Materialisms.” In *New Materialisms: Ontology, Agency, Politics*, edited by Diana Coole and Samantha Frost, 1–43. Durham: Duke University Press, 2010.

Coulter, Kendra. *Animals, Work, and the Promise of Interspecies Solidarity*. Houndmills: Palgrave Macmillan, 2016.

Cudworth, Erika. *Social Lives with Other Animals: Tales of Sex, Death, and Love*. Houndmills: Palgrave Macmillan, 2011.

Despret, Vinciane. “From Secret Agents to Interagency.” *History and Theory* 52, no. 4 (2013): 29–44.

Deturche, Jeremy. “‘It’s No Longer the Same Job’: Robotization among Breeders and Dairy Cows.” *Vibrant* 16, no. 1 (2019): 1–28.

Driessen, Clemens, and Leonie F. M. Heutinck. “Cows Desiring to Be Milked? Milking Robots and the Co-evolution of Ethics and Technology on Dutch Dairy Farms.” *Agriculture and Human Values* 32, no. 1 (2015): 3–20.

Finstad, Terje, Margrethe Aune, and Kine Ariela Egseth. “The Domestication Triangle: How Humans, Animals, and Technology Shape Each Other—the Case of Automated Milking Systems.” *Journal of Rural Studies* 84, no. 1 (2021): 211–20.

Frisvold, George B. “The U.S. Dairy Industry in the 20th and 21st Century.” *Journal of Food Law and Policy* 16, no. 2 (2020): 197–226.

Gardner, Bruce L. *American Agriculture in the Twentieth Century: How It Flourished and What It Cost*. Cambridge, MA: Harvard University Press, 2006.

Gillespie, Kathryn. *The Cow with Ear Tag #1389*. Chicago: University of Chicago Press, 2018.

Hamilton, Lindsay, and Nik Taylor. *Ethnography after Humanism: Power, Politics and Method in Multi-species Research*. London: Palgrave Macmillan, 2017.

Haraway, Donna. *When Species Meet*. Minneapolis: University of Minnesota Press, 2008.

Henzell, Ted. *Australian Agriculture: Its History and Challenges*. Melbourne: CSIRO, 2007.

Holloway, Lewis. “Subjecting Cows to Robots: Farming Technologies and the Making of Animal Subjects.” *Environment and Planning D: Society and Space* 25, no. 6 (2007): 1041–60.

Holloway, Lewis, Christopher Bear, and Katy Wilkinson. “Re-capturing Bovine Life: Robot–Cow Relationships, Freedom and Control in Dairy Farming.” *Journal of Rural Studies* 33, no. 1 (2014): 131–40.

Holloway, Lewis, Christopher Bear, and Katy Wilkinson. “Robotic Milking Technologies and Renegotiating Situated Ethical Relationships on UK Dairy Farms.” *Agriculture and Human Values* 31, no. 1 (2014): 185–99.

Ingold, Tim. “Work, Time, and Industry.” *Time and Society* 4, no. 1 (1995): 5–28.

Jacobs, Jacquelyn, and Janice Siegford. “The Impact of Automatic Milking Systems on Dairy Cow Management, Behavior, Health, and Welfare.” *Journal of Dairy Science* 95, no. 5 (2012): 2227–47.

Jacobs, Jacquelyn, and Janice Siegford. “Lactating Dairy Cows Adapt Quickly to Being Milked by an Automatic Milking System.” *Journal of Dairy Science* 95, no. 3 (2012): 1575–84.

Kaarlenkaski, Taija. “Communicating with the Cow: Human-Animal Interaction in Written Narratives.” In *The Semiotics of Animal Representations*, edited by Kadri Tüür and Morten Tønnesen, 191–216. Amsterdam: Rodopi, 2014.

Kaarlenkaski, Taija. “Eläimet ja ihmiset teknologian käyttäjinä automatisoidussa tuotantojärjestelmässä” [Animals and humans as technology users in automated production system]. In *Tunteva tuote. Kuinka eläimistä tuli osa teollista tuotantoa?* [Sentient commodity. How animals became part of industrial production?], edited by Taija Kaarlenkaski and Otto Latva, 205–24. Tampere: Vastapaino, 2022.

Kaarlenkaski, Taija. “‘Machine Milking Is More Manly Than Hand Milking’: Multispecies Agencies and Gendered Practices in Finnish Cattle Tending from the 1950s to the 1970s.” *Animal Studies Journal* 7, no. 2 (2018): 76–102.

Kaarlenkaski, Taija. “‘Octav lypsää kuin elävä vasikka.’ Monilajinen toimijuus ja sukupuoli lypsykoneen käyttöönotossa 1950–1970-luvuilla” [“Octav milks like a real calf.” Multispecies agency and gender in the introduction of milking machines from the 1950s to the 1970s]. In *Kanssakulkijat. Monilajisten kohtaamisten jäljillä* [Fellow beings. In search of multispecies encounters], edited by Tuomas Räsänen and Nora Schuurman, 208–33. Helsinki: Finnish Literature Society, 2020.

Kaarlenkaski, Taija, and Annika Lonkila. “In Search of Invisible Cows: Collaboration, Resistance and Affection in Human–Animal Relationships on Contemporary Dairy Farms.” *Ethnologia Fennica* 47, no. 2 (2020): 27–53.

Kaila, Eerikki, and Markku Järvenpää. “Työajan säästö ja työn luonteen muutokset” [Saving working time and the changing nature of work]. In *Teknologian hyödyntäminen*

maatilalla [Utilization of technology on farms], edited by Markku Järvenpää, Erkki Savela, and Taina Harmoinen, 8–9. Helsinki: ProAgria Keskusten Liitto, 2014.

Karttunen, Janne, and Veli-Matti Tuure. *Työnjako perustuotantoa harjoittavissa ja monialaisissa maatalousyrityksissä* [Division of work in the farm enterprises practising primary and multisectoral production]. Rajamäki: TTS Työtehoseura, 2013.

Latour, Bruno. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press, 2005.

Law, John. "Actor-Network-Theory and Material Semiotics." In *The New Blackwell Companion to Social Theory*, edited by Bryan S. Turner, 141–58. Oxford: Blackwell, 2008.

Lehtonen, Turo-Kimmo. "The Domestication of New Technologies as a Set of Trials." *Journal of Consumer Culture* 3, no. 3 (2003): 363–85.

Lie, Merete. "Technology and Masculinity: The Case of the Computer." *European Journal of Women's Studies* 2, no. 3 (1995): 379–84.

Lie, Merete, and Knut H. Sørensen. "Making Technology Our Own? Domesticating Technology into Everyday Life." In *Making Technology Our Own? Domesticating Technology into Everyday Life*, edited by Merete Lie and Knut H. Sørensen, 1–30. Oslo: Scandinavian University Press, 1996.

Lonkila, Annika. *Making Invisible Cows? Genomic Knowledge and More-Than-Human Agency in Finnish Dairy Breeding*. Joensuu: University of Eastern Finland, 2022.

Lonkila, Annika. "Optimoituja eläimiä: Eläinten jalostus teknologisena ratkaisuna ruoantuotannon kriiseihin [Optimized animals: Animal breeding as a technological solution to food production crises]." In *Tunteva tuote. Kuinka eläimistä tuli osa teollista tuotantoa?*[Sentient commodity. How animals became part of industrial

production?], edited by Taija Kaarlenkaski and Otto Latva, 185–204. Tampere: Vastapaino, 2022.

Martucci, Jessica. “Breast Pumping.” *Virtual Mentor* 15, no. 9 (2013): 791–97.

McMillan Lequieu, Amanda. “Keeping the Farm in the Family Name: Patrimonial Narratives and Negotiations among German-Heritage Farmers.” *Rural Sociology* 80, no. 1 (2015): 39–59.

McMurry, Sally. “Women’s Work in Agriculture: Divergent Trends in England and America, 1800 to 1930.” *Comparative Studies in Society and History* 34, no. 2 (1992): 249–70.

Millar, Kate. “Respect for Animal Autonomy in Bioethical Analysis: The Case of Automatic Milking Systems (AMS).” *Journal of Agricultural and Environmental Ethics* 12, no. 1 (2000): 41–50.

Mononen, Jaakko. “Valvonta- ja mittausteknologia eläinten hoidossa” [Surveillance and measuring technology in animal care]. In *Teknologian hyödyntäminen maatilalla* [Utilization of technology on farms], edited by Markku Järvenpää, Erkki Savela, and Taina Harmoinen, 73–77. Helsinki: ProAgria Keskusten Liitto, 2014.

Nimmo, Richie. “Apiculture in the Anthropocene: Between Posthumanism and Critical Animal Studies.” In *Animals in the Anthropocene: Critical Perspectives on Non-human Futures*, edited by Human Animal Research Network Editorial Collective, 177–99. Sydney: Sydney University Press, 2015.

Nimmo, Richie. “Biopolitics and Becoming in Animal-Technology Assemblages.” *HoST—Journal of History of Science and Technology* 13, no. 2 (2019): 118–36.

Nimmo, Richie. “Introduction: Taking Animals Seriously in Studies of Science and Technology.” *HoST—Journal of History of Science and Technology* 13, no. 2 (2019): 1–4.

Oudshoorn, Nelly, and Trevor Pinch. “Introduction: How Users and Non-users Matter.” In *How Users Matter: The Co-construction of Users and Technology*, edited by Nelly Oudshoorn and Trevor Pinch, 1–25. Cambridge, MA: MIT Press, 2003.

Oudshoorn, Nelly, Ann Rudinow Saetnan, and Merete Lie. “On Gender and Things: Reflections on an Exhibition on Gendered Artifacts.” *Women’s Studies International Forum* 25, no. 4 (2002): 471–83.

Porcher, Jocelyne, and Tiphaine Schmitt. “Dairy Cows: Workers in the Shadows?” *Society and Animals* 20, no. 1 (2012): 39–60.

Raussi, Satu. “Kotieläinten massatuotannon eettiset kysymykset [Ethical questions in the mass production of domestic animals].” In *Ihmisten eläinkirja. Muuttuva eläinkulttuuri* [*The animal book for human beings. Changing animal culture*], edited by Pauliina Kainulainen and Yrjö Sepänmaa, 149–63. Helsinki: Gaudeamus Helsinki University Press, 2009.

Riskin, Jessica. “The Defecating Duck, or, the Ambiguous Origins of Artificial Life.” *Critical Inquiry* 29, no. 4 (2003): 599–633.

Rotz, Sarah, et al. “Automated Pastures and the Digital Divide: How Agricultural Technologies Are Shaping Our Labour and Rural Communities.” *Journal of Rural Studies* 68, no. 1 (2019): 112–22.

Saugeres, Lise. “Of Tractors and Men: Masculinity, Technology and Power in a French Farming Community.” *Sociologia Ruralis* 42, no. 2 (2002): 143–59.

Schewe, Rebecca L., and Diana Stuart. “Diversity in Agricultural Technology Adaption: How Are Automatic Milking Systems Used and to What End?” *Agriculture and Human Values* 32, no. 2 (2015): 199–213.

Shortall, Sally. “In and Out of the Milking Parlour: A Cross-National Comparison of Gender, the Dairy Industry and the State.” *Women’s Studies International Forum* 23, no. 2 (2000): 247–57.

Siiskonen, Pirjo. “The Role of Farmers and Farmwives in Agrarian Change.” In *The Social Implications of Agrarian Change in Northern and Eastern Finland*, edited by Tim Ingold, 91–98. Helsinki: Finnish Anthropological Society, 1988.

Silbergeld, Ellen K. *Chickenizing Farms and Food: How Industrial Meat Production Endangers Workers, Animals, and Consumers*. Baltimore: Johns Hopkins University Press, 2016.

Silvasti, Tiina. “Bending Borders of Gendered Labour Division on Farms: The Case of Finland.” *Sociologia Ruralis* 43, no. 2 (2003): 154–66.

Sommestad, Lena, and Sally McMurry. “Farm Daughters and Industrialization: A Comparative Analysis of Dairying in New York and Sweden, 1860–1920.” *Journal of Women’s History* 10, no. 2 (1998): 137–64.

Stræte, Egil Petter, Jostein Vik, and Gunnar Hansen. “The Social Robot: A Study of the Social and Political Aspects of Automatic Milking Systems.” In *Proceedings in System Dynamics and Innovation in Food Networks 2017*, edited by Jivka Deiters, Ursula Rickert, and Gerhard Schiefer, 220–33. Kiel: CentMa, International Center for Management, Communication and Research, 2017.

Talsi, Noora. “Technologies Entering the Home—the Domestication of Mundane Technologies.” In *IADIS International Conference ICT, Society and Human Beings 2012*, edited by Gunilla Bradley, Diane Whitehouse, and Angela Lin, 3–10. Lisbon: IADIS.

Thorsen, Liv-Emma. “Work and Gender: The Sexual Division of Labour and Farmers’ Attitudes to Labour in Central Norway, 1920–1980.” *Ethnologia Europaea* 16, no. 2 (1986): 137–48.

Tuomivaara, Salla. “Onko suomalaisesta eläintuotannosta kerrottava tarina toisenlainen?” [Is the story about Finnish animal production different?] In *Eläinten syömisestä* [Eating animals], by Jonathan Safran Foer, 375–90. Jyväskylä: Atena, 2012.

Welk-Joerger, Nicole. “Maintaining Bovine.” *Technology and Culture* 64, no. 4 (2023): PAGES.

Wilkie, Rhoda. *Livestock/Deadstock: Working with Farm Animals from Birth to Slaughter*. Philadelphia: Temple University Press, 2010.

Wolfe, Cary. *Before the Law: Humans and Other Animals in a Biopolitical Frame*. Chicago: University of Chicago Press, 2013.

Captions

Figure 1: Next! A cow entering a milking robot. In automated milking systems, cows move independently from the resting area to the feeding area and to the milking robot. The cow’s agency to move around freely is severely curtailed. For farmers to make a profit, the cows need to visit the milking robot as briefly as possible. Photo: author

Figure 2: How to Rest, Eat, and be Milked in a 24/7 Milking System. A free-stall barn with approximately 160 milking cows. For the milking robot to function optimally in a free-stall barn, some cows rest, some eat, while others are milked, night and day. When moved from tie-stall barns, some cows find it difficult to understand the new environment and its requirements. Photo: author