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The domestication triangle: How humans, animals and technology shape each other – The case of automated milking systems

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ABSTRACT

This article investigates the domestication of milking robots, most often labelled automatic milking systems (AMS) into dairy farms in Norway. It shows that producers of AMS tend to represent the integration of the technology as a process where their expert systems aid and guide the farmer so that she learns how to be an 'AMS farmer'. However, farmers' AMS-stories shows us that learning to live with AMS is a process that continues even after the AMS technology seems to have been fully integrated. Furthermore, cows and fellow farmers are central actors, but machines also learn in the process. Hence, we find a extended domestication process where farmers and cows not only adapt to the machine, but indeed that the machine also need to 'learn' how to function in particular farms. As such, we target a domestication triangle of machines, animals and farmers where all elements co-evolve. From this we argue that the concept of domestication in studies of agricultural technology needs to take a posthuman turn and focus on a domestication triangle of humans, animals and machines.

'1. Introduction

Norwegian farmer, Jon, finished his milking routine earlier than usual in order to prepare a nice dinner and watch a film with his children. This was a possible option because he had a milking robot. Everyone went to bed early that night, but around twelve o'clock, the robot alarm went off, and Jon rushed into the barn to fix the problem. The same happened at a quarter past three and at six o'clock next morning. Jon was frustrated and narrated his experience as follows:

> 'Then, just then, when you are in the barn and feel really tired and see that the cow standing there is kicking the robot, you know you will have extra work. You get angry […]. There is a lot of technique. You adjust the robot […] there are only four teats on a cow, but the robot keeps searching around under there. I don't know, it is possible my programming is wrong, or it may be the cow simply does not stand still […] The robot […] puts the first cup on, the second and the third teat also go fine, but it cannot locate the fourth. It is logical where it should be, but the robot tries to put the cup on a hair instead.'

Jon's experience illustrates that robots are not idealized rationalization machines that replace human workers and produce a life of leisure or unemployment. Rather, they seem to produce new kinds of labour for their users (Holloway and Bear, 2017). Robotization is often presented as leading to increased effectivity and play a major role in visions of automated agrifood futures. Automated milking systems are said to lead to lower labour costs, more free-time, improved herd management systems and much more (Carolan, 2020). However, as we see in the quote above, robotization can definitely have unexpected consequences. Moreover, as Jon's story also demonstrates, robotization is more than a machine-human concern –it also involves animals.

Within the field of science and technology studies (STS) a large body of user-oriented research has contested the assumption that products are used in accordance with their design (Oudshoorn and Pinch, 2003; Lie and Sørensen, 1996). However, to reveal the content of change one has to study practice; in other words, in empirical studies one has to 'follow the product'. Such studies have demonstrated how users further develop products through use and how the technologies as well as everyday life routines change in the process. That is, it is not given that a product's intended use and effects will correspond to the way it is actually used or the effects it has.

In this article we follow this line of investigation with an empirical focus on how milking robots, most often labelled automatic milking systems (AMS) have been presented and integrated into a selection of

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dairy farms in Norway. As studies on farming and new technology from a social science perspective have demonstrated, the introduction of AMS in farms cannot be viewed as a straightforward process (Driessen and Heutinck 2014), but could rather be investigated through what Darnhofer (2020) calls a 'process-relational perspective' that allows us to approach farming as a 'dynamic socio-material process' where humans and animals are entangled (513). As Driessen and Heutinck have shown, the changing relationship between cows and humans during periods of technological change, does not only hold the possibility to inform ethical debate on human-cow relations, but also that of technology development (Driessen and Heutinck, 2014).

Our study leans on this body of research at the intersection between rural studies and STS and will investigate socio-material processes with a specific focus on integration and learning associated with AMS. As suggested by Bear and Holloway (2019) we do this by not only investigating how human-animal relations change in the process, but also how the robot can be said to change as cow-human-machine relations are formed and reformed. In this article then, we first look at the main features of the machines and how AMS producers anticipate their integration and use at the farm. We then follow up by providing some concrete examples of how users experience the appropriation and integration of AMS. We address the following questions: What characterizes the users' learning process? What is required from the cow and the farmer in order to automate milking routines and what happens to the machines in that process?

To answer the research questions, we investigated AMS brochures, instruction manuals and websites from producers and farmer organizations' websites. In addition, we interviewed a small group of farmers. The aim of this article is twofold. Empirically, we provide examples of how and in what way both the integration of and learning about AMS involves humans, machines and animals. Theoretically, we use the case of AMS to further the development of both user studies within STS (Oudshorn and Pinch, 2003) and more specifically domestication theory (Lie and;Sørensen, 1996; Sørensen, 2006). The main argument from a domestication perspective is that integration of technology involves changes in human behaviour as well as technology. However, in the studied case, the users are not only humans. We therefore address the question: How does the process evolve when a new user, the cow, enters the process of domestication?

1.1. Automated milking systems (AMS) in Norway

Milking robots are the 'new normal' in Norwegian dairy farming and the country now has the highest number of robotic milking machines of the Nordic countries (Denmark, Finland, Island, Norway, Sweden, Greenland and Faroe Islands) relative to the number of farms. As shown by Vik et al. (2019), more than 47% of the Norwegian milk production went through milking robots by the end of 2018. The introduction of AMS into Norwegian dairy farms has also been a rather quick process. In 1999 there were no such robots, but in 2013 there were 1400, in 2015 there were more than 1500, and by the end of 2018 there were more than 1900 farms with AMS installed. This number may seem small, but so too is the Norwegian dairy farming sector. However, although the agriculture sector in Norway is relatively small compared with in many other European countries, it is quite high-tech (Statistics Norway).

Several factors have been used to explain the fast adoption of AMS in Norway. For example, automation strategies are attractive because (human) labour is expensive, there is a well-developed R&D and informational system in relation to the agricultural sector, and national policies have long been directed towards increasing yields (new productivism). Also, animal welfare policy has been a factor in the adoption of new technology. In 2003, a new regulation was introduced, the regulation regarding the keep of cattle, according to which all Norwegian animal farms had to be based on the loose housing principle (Landbruks-og matdepartementet, 2004). This transition from stalls to loose housing was estimated to cost a total of 13 billion Norwegian kroner and has meant that farmers have had to modernize. The use of robotic milking machines, included in this development, led to the need for rebuilding on farms. Also, increasing milk quotas meant that farmers could have bigger farms. On the individual level, farmers reported that more free time and a specific interest in technology were important reasons for installing AMS on their farms (Hansen, 2015; Vik et al., 2019).

1.2. Socio-material perspectives on AMS

AMS is part of a long history of digitalisation in farming and new milking technologies (Driessen, C. and Heutinck, 2014; Holloway and Bear 2017, 2019; Klerkx et al., 2019). These processes, often named smart farming, precision agriculture, digital agriculture, are often linked to expectations that new digital farm technologies will lead to technical optimization of farming practices.

Much social science research on AMS has focused on consequences in terms of economics and labour and researchers have tried to explain either why AMS has been introduced into the dairy farming or why not. For instance, Stræte et al. (2017) argue that Norwegian farmers' motives for investing in AMS were connected to wishes for flexibility, reduced physical work and to their wishes to adhere to images of future standards in dairy farming. However, such motives have often been evaluated against the high investment costs in the technology and in remodelling animal housing to accommodate it (Armstrong and Daugherty, 1997; Meijering et al., 2004). Also, researchers have reviewed the adoption rate of AMS or the impacts of AMS, for example on cows' behaviour and welfare, herd health, milk quality, and hygiene, management. The goal of this literature is to shed light on the consequences of AMS, but also on what promotes or inhibits the adoption of such technologies (Klerkx et al., 2019; Jacobs and Siegford, 2012; Hansen et al., 2019). In this AMS literature, authors seek answers as to why or why not AMS is adopted in certain areas or countries and they tend to focus on quantitative and structural aspects. Hence, these studies provide little information about the process whereby individual farmers establish practices relating to AMS.

Higgins et al. (2017) however, shows how rice farmers tinker with technologies to handle diverging technological set-ups and difficult bio-physical condition, and by so doing adapt precision agriculture technologies to their circumstances. Furthermore, Eastwood et al. (2017) state that complex agricultural innovation require collaboration between a range of actors in order for successful diffusion, and adoption, to take place. Such collaborations span the distinctions between public, industry and private, farm-level and national and even global. The collaborations vary as to when they are needed and the scales at which they are necessary within the technological innovation system. Furthering such insights, Higgins and Bryant (2020) show how farm advisors play a central role in technology adoption, but that the relation between agricultural industries and farm advisors can also hinder smart farming implementation. These studies shed light on the networks, or assemblies, connected to agricultural technology, and demonstrate that while structural elements matter in their adoption, we need to investigate them through concrete adoption processes.

Studies with a socio-material and constructivist perspective have shown that in the adoption of AMS, a range of factors affect the adoption process and the outcomes vary both for farmers, animals and the farm (Klerkx et al., 2019). Legun and Henry for instance, argue for a post-human turn in agri-food studies and show how perspectives from science and technology studies (STS) can be useful in studies of materiality in agriculture. They suggest that non-humans participate in food systems 'dialogically in ongoing ways' and influence what is seen as possible and inspire particular forms of action (Legun and Henry, 2017: 79).

Following along similar lines, Holloway and Bear analyse practical use and ethical implications of AMS and argue that 'what it is to be a cow or human is co-produced with technological change' (Holloway and

Bear 2017: 20). They further argue that there is no direct link between the introduction of the robots and improvements in bovine health or herd productivity and that 'only when the right people and other circumstances are in place' could such effects be traced (Holloway and Bear 2017: 19). Thus, they point to the situatedness of AMS and its effects.

Similar concerns are voiced by Driessen and Hautinck (2014) who use STS perspectives as they analyse how ethical concerns in farming are dependent on the co-evolution of producers, farmers and cows. They show how ethical standards have to be understood and evaluated in the socio-material context of the milking practice: 'Thus, the moral ideas that changed with the use of a robot can actually be found to feed back into how the robotic system is used and laid out, leading to ongoing techno-moral co-evolution' (Driessen and Hautinck 2014: 4). Additionally, Butler et al. (2012) found that the stockperson was vital in the establishment of new milking- and working routines when AMS was introduced, although the main implication of the technology was changes in workload, not less work.

Butler and Holloway (2016: 527) argue that AMS 'is part of an entangled hierarchy of machine-cow-stock-keeper, where each component is reliant on the other for the hierarchy to function efficiently'. They developed the concept of 'hybrid capital' to explain how the components of the hierarchy define each other. The important factor is whether the farmer is able to learn to utilize the information generated by the use of AMS. Thus, learning becomes a vital aspect of the integration and functioning of AMS. This points to what we term a 'multi-species turn' in understanding the integration of AMS.

Bear and Holloway (2019) takes such insights one step further in an article where they develop the concept of 'divergent conduct' to explore how heterogeneous entities co-produce activity which is likely to differ from accounts of trouble free introductions of technologies and practices. They suggest scholars 'engage with the lively nature of machines' and argue that technologies are 'more than tools through which (techno) biopower emerges and affects humans and animals; they are active within heterogeneous, hybrid (technobiosocial) collectivities. It is thus too simplistic to say that any cow merely resists human intentions and desires; these intentions and desires, and divergent conducts, are themselves co-produced in unsettled and problematic more-than-human relations between farmers, their milking robots and the wider technological system' (Bear and Holloway, 2019: 217). Here then, cow-farmer relations are seen as ongoing and, in the making, but they go one step further in highlighting that even technologies can be seen as 'unreliable accomplices in regimes of biopower' whose interventions will not necessarily accord with human intentions (217).

The above-mentioned studies clearly demonstrate a kind of co-production of robots, cattle and humans accompanying technological change, which we explore further empirically in this article. Also, several of the articles presented above show, at least implicitly, that a kind of relational learning processes goes on in the adoption, integration and use of AMS. One way of labelling this process is through the concept of domestication (Lie and Sørensen, 1996), which Hansen (2015) used in a study of AMS in Norwegian farms. He argues that the farmers needed to actively engage in the use of the technology in order to adapt it to their special, local needs, but states that detailed studies are required in order to understand the concrete processes of domestication (Hansen, 2015: 115).

In this article we aim contribute to the understanding of how new agricultural technologies are integrated into the farm by studying the concrete practices of a small group of farmers who have appropriated AMS. Additionally, we focus not only on the co-production of cattle and humans following technological development, but follow the suggestion of Bear and Holloway (2019) that we should highlight the 'lively nature' of technology and investigate how technology can be said to be subjected to change in the process where it is domesticated into the farm.

The domestication perspective represents an effort within STS, to include users and everyday life in studies of innovation and technological development (Lie and Sørensen, 1996; Oudshoorn and Pinch, 2005). The concept originated from the processes whereby humans domesticated animals (Swanson et al., 2018) and by analogy the process of domestication of an animal also changed its human owner. This perspective was later transformed in analysis of media and everyday life in media studies (Silverstone and Hirsch, 1992). Domestication as a user-turn in STS, was further developed through numerous empirical studies (c.f. Berker et al., 2006; Ask and Sørensen, 2017). According to Sørensen (2006), a domestication process should be studied along three dimensions, 'practical', 'symbolic' and 'cognitive'. Berker et al. (2006) and Ask and Sørensen (2017) emphasize the importance of studying domestication of technology 'from below' and that it requires a focus on both human actors *and* technologies.

In our study of automatic milking systems (AMS) we aim to investigate how practices developed and the role of the different actors in the process. We focus specifically on learning and integration, namely how producers and retailers present and assist in the appropriation of AMS and how the users learn to use the machinery and integrate its use into their farming practices. In theory, we need to reinstate the 'original' non-human actors in the domestication process – the animals or more specifically the cows (Lien, 2015). In accordance with Legun and Henry's suggestion and domestication theory, we also treat the technology as a non-human actor, or actant in the micro-network (Bear and Holloway, 2018). And, importantly, we approach technology not as a force coming from outside without being subjected to change, but rather as lively relational entities that might not act in accord with human intention (Bear and Holloway, 2019). This means that in addition to investigating the relational learning of farmers and cows, we are also interested in what we term 'machine learning'.

The next section gives a short description of the empirical basis of the study. Thereafter, we analyse the incorporation of AMS into farming practices in a Norwegian context, followed by a general discussion. The relevance of this discussion is not limited to the Norwegian situation, as AMS is becoming more common in dairy farms worldwide, together with a range of robots and automation technologies for other purposes. It is therefore worthwhile to expand the domestication perspective so that it can include non-human actors and be better suited for studies of the integration of technology in the agricultural sector. We do not offer a fully adapted domestication perspective for rural studies in this article, but we present a place from where to begin such an endeavour.

2. Empirical data

Since the aim of our study was to provide insights into the AMS producers' visions and ambitions, as well as to understand the lived and varied experiences of the users, both humans and animals, we chose a qualitative approach. The empirical basis was documents, websites and interviews. We examined various types of documents such as AMS user manuals and information materials concerning dairy farming. These documents were directed at farmers either interested in procuring AMS or farmers that already had installed the technology. The data gathering took place in the period 2017–2020.

When reading these documents, we were interested in how producers' 'scripted' and promoted the technology materially and symbolically (Akrich, 1994). That is, how did the producers describe the technology in these materials, how did they describe the process of appropriation and use of AMS? Asking such questions to the documents allowed us to go beyond their intended use for sales and information, and to see how the producers not only represented their technology, but also imagined its use. As we analysed these documents, it became clear that while the technology had an important role in them, we also saw that the promotion of AMS included an expert system of consultants of various types, sales representatives, informational materials and networks with other organizations. As such, we used the materials to investigate how the producers represented the technology and trace the system that worked to guide or influence the domestication of the technology (Oudshoorn and Pinch, 2005).

The descriptions of the farmers' experiences are based on four in-depth interviews with five people, as well as a study of an online farmer forum. The interviews were held at the farmers' workplaces. In order to find suitable interviewees, we contacted an advisor in dairy farming who gave us a list of farmers with AMS. We then contacted a small selection of farmers from the list and chose three women and two men, who were in the age range 30–50 years. Two of the interviewees had AMS produced by Lely, two had AMS produced by GEA and one had an AMS produced by DeLaval. Two of the interviewees were part-time farmers (Silje and Inger) with additional jobs, while three were full-time farmers (Bjørn, Kari, and Jon). The interviews lasted 1–2 h, while one lasted 4 h. All interviews were recorded and transcribed.

The interviews focused on why the farmers acquired AMS, how they experienced the process of acquisition and instalment, how they learned to use the technology, the reactions of the cows, and problems and/or challenges experienced in the use of AMS. The questions were designed to obtain the farmers' stories about the appropriation of AMS and how they came to live with it. The interviews where semi-structured and took the shape of conversations around the topics mentioned.

To gain an understanding of the strategies employed by the farmers when implementing AMS, we also included a search for 'experience groups'. We found several that was either organized by AMS producers or farmers organizations so that farmers could share their experiences of using AMS. One example is the Facebook group *DeLaval VMS milking robot Norway*. The group was set up by DeLaval in March 2014. It has five moderators that are connected to this company. The group encourage users of DeLaval's robot to exchange experiences about the use of such technology. As of August 2020, the group has more than 1200 members. We became members of this group explaining that we are doing research on the domestication of AMS and that the group would help us form a picture of challenges with the technology and how farmers tried to solve them together.

As we became members of the group, we found that while DeLaval states that it will answer questions, most of the activity in the group is farmer driven. The discussions in the group were lively with quite a lot of activity. We found questions posted by farmers about a wide range of topics ranging from error messages from the AMS to how to repair failing parts or critique of DeLaval's billing policy. Most often it was other farmers that answered. This forum has given us insight into what issues farmers experience with AMS, how they collaborate to solve them and to build knowledge about their robots, while it also made us aware that domestication of such technologies is an on-going process. This helped sensitise us to the temporal differences of domestication as imagined by producers and practiced by users.

Although we were aware that qualitative data from the small group of interviewees would not allow us to identify any typical patterns, we anticipated that it would provide a possibility to demonstrate variation and not the least a more detailed exploration of parts of the domestication processes. The data included different AMS types and farm sizes, the level of service provided by retailers, individual farmer's knowledge and experience relating to the technology, and variation in numbers and types of cows on the studied farms. Our empirical ambition was to provide knowledge of the early phase of appropriation and integration of AMS with a specific focus on learning and the development of new socio-technical practices. We considered the following questions: What characterizes the phases of AMS domestication? More specifically, how does AMS work, how are the systems presented and what service do retailers provide? How do farmers and cows integrate AMS into their everyday life? What happens to the machines in the process?

2.1. AMS: design – marketing – support

The Norwegian market for AMS is dominated by three producers: Lely, DeLaval and GEA. Their machines differ somewhat in the details of their design, but in general they consist of an enclosed unit where the cow can enter through a gate that opens and closes automatically. The unit provides shelter for the cow while it is being milked. The space is narrow and directs the cow into the correct position for the robotic arm to reach her udder. Covers protect the cow and farmer from the mechanic and electric parts of the robot. Inside the sheltered milking space, the cow faces a feed table that is automatically filled with food concentrates to lure the cow into the space. As the cow enjoys her snack, a camera locates the cows' teats, and a robotic arm cleans them and attaches the suction cups that make the milk flow. After the milking, the teats are washed with a liquid that closes the milk tracts in order to keep microbes out and prevent mastitis.

Each cow wears a chip that communicates with a computer in the milking machine. The chip identifies the individual cow and registers when they have been milked, how much milk they produced and how long the milking took. It also registers how much the cow ate during the milking and if the cow has had her daily ration, the robot will not supply more. There is also an automated minimum interval between milking to ensure that opportunistic cows will not be able to enter the unit. Some machines have software that allows for the relation between feed concentrate and the amount of milk to be checked in order to optimize feeding according to the lactation cycle of the cow. The aim is to optimize the feed-to-milk ratio.

Additionally, AMS register the activity level of the cows and the information can be used to indicate the cows' fertility level and when they are in oestrus ('on heat'). The robot takes samples from the milk and different types of AMS provide different types analyses. Some machines also perform other checks such as cell numbers in the milk and the colour of the milk. All AMS check the quality of the milk and indicate whether it is suitable for human consumption. Milk that is unsuitable for human consumption is fed to calves or simply discarded. The robot does not need to be supervised at all times, but it will send an alert to the farmer's phone if it registers deviations. The farmer can choose which alarms he or she wishes to activate. The various machines have differing add-ons, such as scales for weighing the cows, and information about a cow can be shared with people outside the farm, such as the veterinarian or advisors at the dairy responsible for processing the milk.

From a non-technical perspective, the design of AMS may seem straightforward and when it works as intended it should simplify the milking process and farmers' workload. However, first, both the farmers and the cows need to learn how to use the machine. The cows' behaviour is guided by the need to be milked and the availability of food. By contrast, the farmers need to learn the technical features of the machine as well observe their cows' behaviour and adjust the machines accordingly. Before examining these processes, we first look at how AMS is presented by the machine producers and suppliers, how the machines are marketed and what type of education and support system they provide. In other words, we consider the question of how producers and retailers try to influence the process of domestication.

AMS producers follow several strategies for marketing their technologies. They have web pages with information about the technology, how to contact sellers, financial schemes for purchases, technical services support, and channels for communication regarding service, support and customers' stories where AMS farmers explain why they installed the technology, why they chose a particular producer, and the outcome of the procurement (GEA 1; DeLaval 1; Lely 1).

There are differences in how the producers sell their machines. We for instance see this in their naming. Lely's 'Astronaut' points toward space missions and high-tech, while DeLaval's abbreviation 'VMS' stands for voluntary milking station and points more towards the animal welfare aspects of the technology. Lely also states that their robot Astronaut A4 is 'The natural way to milk' that gives guaranteed 'top-quality milk' by giving individual attention to each cow through 'smart technology'. This results in 'more fredom, more control' for the farmer that can adapt the specifications of the robot to her wishes and needs (Lely 2). DeLaval's web page, focus on that they offer 'integrated solutions to improve dairy producer's production, animal welfare and quality of life' and present a set of challenges that dairy producers face and how DeLaval's robot solve these (DeLaval 1).

Although the producers' branding relies on many of the same methods and mediums, they market their machines in different ways. Lely uses the size of the company and the fact that they are the biggest producers of automated milk machines in the promotion of their machines. Their machines are promoted as user-friendly for the farmer and do not cause stress for the cows. DeLaval promote their machines by stating that they will improve animal welfare, farm profitability, food safety, and labour effectiveness. Whereas Lely and DeLaval mention the effects that their machines will have on the animals and the life of the farmer, GEA focus more on the technical aspects of their machines. However, all three producers seem to agree that their machines will ease milking and increase efficiency on the farm. Additionally, they all agree that their machines are user-friendly and easy to install, set up and use.

While the branding of the machines can say a lot about how producers imagine the farmer and her concern, the actual sale of the machine relies on sales representatives at local or regional level. In Norway, GEA robots are imported and sold by RL teknikk A/S and DeLaval robots by the cooperative Felleskjøpet, whereas Lely has their own regional centres that collaborate with the company Fjøssystemer. As such, the producers rely on local and regional vendors that are in direct contact with potential customers, provide information and sales materials, and help to plan the procurement of robots (Felleskjøpet 1; Landteknikk 1; Lely 2).

The process of appropriation is designed to begin with farmers talking to agricultural advisors or reading a brochure, accessed online or at the dealer's, which contains information on all aspects of AMS, ranging from financial arrangements to how to prepare the farm for AMS. Farmers can find information about who they will collaborate with in the planning of the farm building for AMS (entrepreneurs, electricians, plumbers, Norsk landbruksrådgivning, Tine and Nortura). Additionally, the brochures contain advice on details ranging from door height and width, floors, walls, water, and lights to electrical installations and telecommunications, as well about the help they could expect in the installation process (Lely 3; DeLaval 2). It is evident from the brochures that both the process of installing AMS involves a wide range of consultants, and that the support offered is used as a sales argument by the producers.

Once the farmer has signed a contract with the producers, 'farm management support' is implemented. This means setting up the robot and its programming, as well training cows and farmers in its use. The producers use trained technicians to install the robots, while they collaborate with Tine, the largest nationwide dairy cooperative in Norway, in matters relating to attuning animal feed, milk quality, herd management, and animal handling to the new milking system. The farmers need to learn how to utilize AMS in order to perform many of the calculations relating to, for example, milk quality, feed and herd management. After having installed AMS and educated the farmer in its use, Tine consultants visit farms after the AMS have been in use for some time, to discuss adjustments to both the AMS and the calculations (Lely 3; Felleskjøpet 2).

In the presentation of their service and support system, Lely states:

> 'our expert consultants with hands-on experience stand for optimization of the performance of your herd, making sure you get the optimal benefit out of our products and services. Our passion for innovation does not stop at the technical features of our products but continues far beyond that point to cover all practical and management aspects on your dairy farm' (Lely 4: 31).

DeLaval states that 'With Tine and Felleskjøpet we offer counselling and planning of the cowshed and for secure start-up and education when the need is there. When you choose the DeLaval VMS™ Series, the counselling package is included' (DeLaval 2: 12). Not least, they claim to 'treat every farm, every farmer, every cow, even every teat, –individually and adapt the process to meet individual needs, to create a better place to be for cows, you and your family' (DeLaval 2: 2).

Thus, the producers of AMS dos not only sell technology, but also sell systems of support and service. The systems are presented as a helping hand to the farmers, but also demonstrates how producers try to direct the domestication process through assisted learning and by guiding the farmers' experiences over time. This can be viewed as part of a collective domestication process. According to Ask and Sørensen (2017), there are two ideal types of collective domestication. The first type is moral community-based domestication, whereby the collective domestication of technology is 'tacitly distributed and performed by the members in an autonomous fashion. A shared understanding across the collective of what is to be achieved, supported by the material features of the collective practice, help to orchestrate the process' (Ask and Sørensen, 2017: 76). The second ideal type of collective domestication is managed domestication, whereby 'disagreements about goals, about the material features of the group's activities, and about the right ways to perform these activities' makes it necessary to negotiate and organize the domestication (Ask and Sørensen, 2017: 76).

The producers' apparatus for facilitating the appropriation of AMS constitutes a form of managed domestication. In this regard, producers focus as much on the farmers' learning as on the adaption of the technology: the farm is adapted to AMS, technology arrives at the farm, is installed, and from then on the farmer learns how to operate the milking machine. The modifying work is directed towards the farm and the farmer rather than towards the technology itself. This is an important part of what the producers are marketing. Not only are they selling machines, but also, they are selling a system of support and service. As such, this can be understood as a process whereby the farmer forms relations with the robot, as well with the service and support systems of the AMS producers.

From our examination of the producer materials, we found that AMS are designed to allow the farmer to control all aspects of milk production, from milk quality to animal health, in a better way than before, while also easing their workload. The success of the technology relies not only on the machinery itself, but also on a rather large system of marketing and support. A range of informational materials is used to promote technological designs and are available through local dealers that are in contact with local and regional farming communities. Both materials and the local dealers' consultants are presented as sources of information to help the farmer in the decisions relating to AMS, as well as with matters ranging from financial issues to the design of the farm buildings, instalment of AMS, education relating to the use of AMS, herd management, and follow-up services. Thus, the appropriation of AMS also connects the farmer to what could be described as a large system aimed at facilitating a managed domestication of AMS. This raises the question of how is such as system is experienced from the users' perspectives?

3. Domestication as continuous processes of learning

Information and assistance seem to be crucial when AMS producers introduce farmers to the technology. Farmers have to work with various types of consultants to not only to make plans for the installation of AMS, but also in order to programme and operate them after the introductory phase. This raises the question of what happens when the consultants have left the farm and farmers are alone with the cows and machines?

Kari, a part-time farmer, did not find the use of the installed AMS easy. The process of adapting the farm building to the milking machine had been significantly delayed and the costs higher than estimated. While the farmers had received help with the installation, Kari explained that the man who had helped them to start the robot and showed them how to operate it had only spent 1 day at the farm:

'You are pushed out in deep water. They teach you the basics. We received a folder with a laminated page with 'recipes', if this happens, if that happens, then this, so that we could help ourselves. And then we have a service agreement, which means we can call if something happens'.

Bjørn, a full-time farmer who built a new cowshed in 2015 and installed AMS explained that the first four days after installing the robot were '[…] horrible […]. We lived in the cowshed and in all we had about 30 cows that we had to train […]'.

Bjørn's wife Inger, who had a 50% job besides farming, joined the conversation and stated:

'The first time was the worst, then it got easier and easier. Some [cows] even went by themselves after two to three attempts, others we had to work on for a week. There was a big difference between the cows.'

The couple also explained that the amount of milk was about half the normal amount in the first two weeks with the AMS, but that it normalized after one month. Jon, a full-time farmer who had an education within agronomy, had to give priority to the work with his cows during in the initial phase of using the AMS. The cows did not accept the changes as easily as he had expected. He solved the problem by recruiting two strong friends who could push nervous cows into the milking machine, while he and a technician from Lely focused on the basics of the programme and computer.

The AMS producers' instruction manuals and brochures give the impression that the use of an AMS is a rather straightforward process if the instructions are followed and the farmer has taken the time to learn how to operate the system. Unexpected situations are left to service and support personnel and are neither mentioned nor discussed in the producers' literature. Although a very detailed instruction video by Lely might be expected to present some challenging scenarios, this is not the case (Fjøssystemer). In the video, cows are simply transformed into 'AMS cows' from the moment they are brought through the AMS unit and finish their first automated milking process.

Bjørn and Inger's story about the time taken before the milk totals reached the normal amount indicates that the cows is overlooked in the instruction manuals, and not least they are overlooked in the Lely video. All the interviewed farmers reported that they had to spend time familiarizing their cows with the technology, while producers seemed to expect that the cows would get used to the milking machine in a rather frictionless way. The interviewees' and producers' understanding of the timeline of such work also differed: while the producers' assisted domestication process ended after some days, the farmers and their cows continued the learning process for weeks.

Furthermore, the producers' strategy for successful domestication was to trust the technology to work as expected and to provide the farmer with sufficient instruction and support. Although time seemed to be a crucial factor, there was not always sufficient time allowed for the cows. Jon story demonstrates an even larger collective had to be mobilized to make the learning process possible for the cows as well as for the farmer, as his friends had to helped him push the cows through the milking machine so that he could focus on learning how to use the computer. We could have read the situations where farmers had to use quite a lot of time to familiarize cows with the robot as an instance of cow resistance to a new technology. However, as pointed out by Darnhofer (2020) they can also be seen as instances where more-than-human relations are formed around, and with, the robot. Furthermore, such relations does not simply form, but demands work by a range of actors.

Learning is about shared experiences and the interviewed farmers had formed a larger collective in order to learn from each other. The farmer's association in the norther part of the county of Trøndelag (Nord-Trøndelag Bondelag) has a list of different 'experience groups', such as a 'robot club' which has been formed to share 'practical use of robots' – there is a 'robot gang' in Stod Municipality and in one area there is a group called 'mentor for milking robot' (Bondelaget). Individual farmers also engage with their colleagues more informally. Inger and Bjørn for instance, invited their neighbours into their barn to see and learn about the robot they had installed. Also, they have had visits from other people from their region and elsewhere in Norway.

In addition to farmer driven groups sharing information and experiences with AMS, Lely and DeLaval have established online forums on Facebook. Here farmers share and discuss experiences with AMS between themselves and the producers. One example is the Facebook group *DeLaval VMS milking robot Norway.* The kind of question raised in this forum can be exemplified with a farmer that had trouble with a cow that was not registered by the robot. The strange thing was that:

'she is milked, and everything is ok until she is to be let out of the robot. Then the back gate opens to let a new cow in, but not the front gate. I have tried to change the transponder in the (cows) ear, but still the same happens. It is just this cow, and it has been like this since the first time she went through the robot. Anyone with the same experience or that have some tips?' (Forum 1 23.06.20).

Several farmers joined in the conversation and speculated about the cause of the issue. Some suggested that the size and colour of the cow might cause the photocell of the robot to not 'see' it, while other suggested that the photocell might be dirty, or a combination of the two. Finally, the farmer figured out that a cleansing of the photocell helped. The combination of a dirty lense and the color of the cow 'blinded' the robot.

As seen in this example then, farmers meet both live and online in order to solve issues with the robots. While Ask and Sørensen's concept of managed domestication (Ask and Sørensen, 2017) fit well with the domestication of AMS as perceived by the producers of such milking systems, it does not quite fit with the interviewed farmers' experiences. Although they received help from the AMS producers, it was only in the very early phases of integrating the technology into everyday life on their dairy farms. Once the short process of managed domestication was over, another kind of collective domestication seemed to take over, one that was more akin to the community-based domestication identified by Ask and Sørensen, although the community element extended beyond the human and included the cows.

According to the farmers' stories we recorded, learning to live with AMS had very much to do with training the animals in how to relate to the system. While the materials from the producers showed that they amongst other things marketed their AMS as adding animal welfare and their programs for teaching the farmers how to use AMS, animals were first and foremost to gain better welfare through various schemes for surveillance, and cow training was not an issue. While, as Carolan (2020) shows, labour costs is an argument for AMS, the labour of training animals is not necessarily included in this.

However, the labour of integrating AMS on the farm, goes beyond the unnoticed work of training animals. As shown by the question we cited from the Facebook group, it also involves machines. This becomes visible through farmer stories of cows that need time to get used to machines, but also machines whose conduct seem divergent because of dirty lenses etc. These are topics that show that domestication is not over when managed domestication end. Hence, any study of AMS domestication should target a multispecies collective domestication process that extends further in time than what seems to be imagined by the producers. Cows do not simply become AMS cows once they have been through the system, and the robots have histories of development that stretch well beyond the design and introduction phase as pointed out by Bear and Holloway (2019). First then, let us investigate how farmers work with their cows to create AMS cows.

3.1. Discipline and familiarization as learning

The farmers learning process with respect to AMS extends beyond that imagined by Lely, both in time and in the collectives it includes, and this had much to do with the cows. While Bjørn and Inger spent a significant amount of time on introducing their cows to the milking machine, the consequences of cows not accepting AMS may be dire. Silje told us that she had to 'let a cow go' (i.e., to the slaughterhouse) after having repeatedly chased it into the milking machine over the course of three months. Kari explained the issue as follows:

> 'the physical shape of the cows is much more important in a AMS farm than in a traditional stall-based barns, for example, the height of their legs and their udder, so it cannot be taken for granted that all the cows can come along when transferring from a stall-based shed to a robotic shed. You might have to slaughter them.'

Jon pointed out that with AMS cows had to have strong udders that tolerated intensified milking and higher production pressure:

> 'I don't have room for animals that eat as much as the others, but only produce 5000–6000 L. At the end of the line, you need to get money in and the cheaper you can produce the milk, the more you earn. This again makes it possible to tend better to the cow, the farmer and the farm. So, you cannot be too charitable to a cow that might earn her right to live on another farm.'

Jon sold cows that were generally healthy but not suited to the demands of his production system. However, he sent cows with a high cell count in their milk, that had damaged feet or genetic defects for slaughter because otherwise they would pass on their defects to new generations. Bjørn stated that in the past, before AMS, cows lived longer but it had become almost unprofitable to have health care for sick cows. For instance, he said that if a cow developed mastitis, it 'doesn't get a second try, but has to walk [be slaughtered]'.

These findings are tangential to the findings of Driessen and Hautnick (2014) and strengthen their claim that normative concerns are relevant in technology development. Jon for instance had to remake his ideas about how long a cow lasts, what care it should get, and what constitutes a good cow in relation to AMS. According to Driessen and Hautnick, such new moral ideas also affect the use of AMS. We find examples of such interrelations between moral ideas and farmers use of AMS in the interview with our farmers. Silje explained that she used the computer to:

> '[…] gain an overview, or look at the screen, where I see how much feed concentrate, they have eaten during the day. That might be 100%, but if the number suddenly is very low, and the cow has not eaten or milked herself, then it might be that she is sick or something like that.'

Kari told us that one day she had noticed on her computer that one of her cows was unusually active. Her husband thought it might be that the cow was in oestrus but nevertheless they started to observe the cow more closely. They found that another cow was 'riding' her a lot and that this was registered as 'activity' by the machine. Kari and her husband took measures to separate the cows and stop the 'bullying' by transferring the bullied cow to the 'welfare department' of their barn. She explained that the hierarchies of the herd became more visible following the installation of the AMS.

Our findings support the finding by Holloway et al. (2014) that the discourse of cow freedom that accompanies AMS could rather be seen as new ways of disciplining bovine life. The introduction of AMS is often followed by a manipulation of bovine bodies so they fit with agricultural productivism and its technologies. However, from the perspective of domestication, killing animals that do not quite fit an automated system is a case of non-domestication, whereas breeding and herd management point more to the classical anthropological domestication theory's focus on domestication as taming (Lien, 2015). In a Foucauldian perspective, these strategies can be said to point to a new 'political anatomy' scripted into the new technology that shapes what bovine bodies and behaviours it will accept (Foucault, 1995: 28). However, as pointed out by both Foucault (1995) and Holloway et al. (2014), discipline is also related to care for self and others.

Silje and Kari for instance, used the information collected through the AMS system not only to control feed to growth ratios or milk quality, but reinterpreted activity and feed intake as signs of cow well-being. Thus, they use the information gathered by the system in a creative way that go beyond what was intended by those designing the systems. These re-interpretations of information also can be said to go beyond simple ideas of cow freedom and show how other ideas of animal welfare than productivity can guide the use of AMS. It is not necessarily so that new moral ideas affect the use of AMS, but we can say that these seem to co-evolve (Driessen and Hautnick, 2014). As farmers use AMS for gathering information concerning cows, they learn how to utilize the information in creative ways that seem to be developed in tandem with their ideas of a good cow life and the role of a good farmer.

The disciplining of, and new ways of caring for, the bovine body and the herd is accompanied by what we call 'novel pedagogical practices'. For example, when the AMS service personnel left the farm, Kari developed a practice whereby she and her husband placed special emphasis on helping young heifers getting through the milking machine before they had calved and started producing milk. She claimed that this method familiarized them with the sounds and movements of the milking machine. Furthermore, Kari and her husband constructed a system of barriers to steer the animals into the milking machine, so that they would not have to chase them. Inger and Bjørn told us that they had one cow that was a 'kicker', which meant that the cow tended to kick the robot when her udder was almost empty of milk. As the kicking could have damaged the robot, Inger used the robot's manual function to milk the cow: 'the cow is nice and kind […] and she comes when this is done. The cow walks around a bit, then puts her feet half-way into the robot before she stops and waits for me to arrive.' For Inger, this did not take much time because the cow was ready and waiting.

Thus, the interviewed farmers used other strategies than adapting cows' anatomy to the machinery. Instead of industrializing the organism by adapting the herd to the machine standards (Schrepfer and Scranton, 2004), Kari focused on familiarizing her cows with the milking machine and adapted the surroundings to simplify their way into it. Inger and Bjørn went as far as to make special adjustments for one particular cow. These cases show alternative ways to facilitate cows' learning that go beyond biological herd disciplining. The farmers had developed alternative approaches that allowed them to avoid culling cows that were not suited to AMS by developing novel pedagogical practices. As such, domestication of AMS means disciplining cows, but also innovation and adjustments to farmers' practices.

While domestication theory in technology studies has focused mainly on the 'cognitive processes related to learning of practice' in human users and in the socialization of technology (Sørensen, 2006), the examples from our study show that in order to integrate multispecies learning there is a need to widen the concept of learning and socialization. Learning can be facilitated in four ways: (1) stimulus-response learning of practice by giving the cow feed, (2) herd learning represented by culling and breeding, (3) learning through force by pushing or steering the cow through the milking machine, and (4) learning through familiarizing the cows with the machine. In this understanding of 'learning' there is a form of socialization: not only can cows become adapted to the milking machine, but also the relation between farmers and cows is reformed though the use of the machine. Our point is not to present an exhaustive list of the ways learning happens in cow–farmer relations but to shed light on the necessity to study such matters empirically. Including animals as actors in domestication stories necessitates the inclusion of learning strategies that are not solely cognitive, but distributed, embodied and relational.

3.2. Learning as continuous distributed improvisation

We have shown that the interviewed farmers and their cows were active agents in the domestication of AMS, and that they changed and adapted through their meeting with the machinery. In the following we examine whether and how the milking machine was part of that process of learning. From an STS perspective it is crucial to include technology in the process of domestication. Therefore, it is necessary to answer the question: How does AMS learn?

A DeLaval manual states that when the robot is introduced to new cows or when a cow returns to milking after having had a calf, the 'VMS station needs to learn how to locate the udder and teats' (DeLaval 3). This is a process whereby the farmer assists the machine in its locating efforts, thus adapting the machine to the individual traits of each cow or to changes in the cows. If the process is executed successfully, the farmer is instructed to press the button 'robot training executed' (DeLaval 3: 127). However, the manual also states:

> '[… automatic] fixation of teat position is not suited for cows that are not used to VMS and robotic arms. Even if they have enough experience with the stall to accept manual fixation with a robotic arm and joystick, inexperienced cows will jump and move too much for a successful fixation to happen. (DeLaval 3: 127)'

The focus on machine learning was also evident in our conversations with the farmers. For instance, Kari explained that the workings of the robot were more about programming than intelligence because the robot used statistics from the last five successful attempts to milk a cow. Inger made similar statements, as she told us that they had to 'teach' the robot what the cow's udder looked like when the cows entered the milking machine and that this was a matter of patience. Each cow had to be 'put on', meaning that the robotic arm had to be steered manually to the cow's udder. Initially, this work was continuous. Bjørn confirmed Inger's statement and claimed that the robot was 'stupid'. He said: 'especially when heifers enter, the machine pushes their bellies and touches their feet [during attempts to locate the teats], making the animals uneasy'. Further, he stated that when heifers had calved, another test of patience arose as the robot often no longer recognized their udders, leading to 'pushes here and there, washes wherever, and pushes again'. Inger talked about similar situations and explained that she would become impatient and override the machine by 'putting [the cups] on manually.' These challenges are in line with the findings of Driessen and Hautnick (2014).

According to the farmers, the robot needed to be 'trained' and continuously adjusted in order to locate the teats of individual cows. In this process, the farmer did not control the automatic processes of the machine through programming with a keyboard, but by steering the robotic arm so that it would find the right position for particular cows. The robot technology had to be adapted to handle the diversity in the udders and teats. That DeLaval's user manual states that the machine is not able to do this on its own and that it can only be done with cows that are somewhat used to the machine (DeLaval 3), points to the limits of machine learning, but also highlights that as a term 'machine learning' is problematic, as it is not the machine alone that learns. Thus, as well as technicians teaching the farmers how to move cows through the milking unit, we also found that the farmers and cows together had to adapt the milking robot to the features of individual cows. A robot on one farm will not necessarily work on, or with, cows from other farms or when the cows' bodies change. As such, the automatic aspects of AMS are highly localized in both time and space.

While the farmers and the cows participated in teaching the machines how to milk individual cows, other people also participated, as the information gathered by AMS on the cows was shared. For instance, the consultants from the Tine dairy were able to view the data (milk quality and feed) if they were allowed access to the AMS in order to make adjustments to the robot. Kari allowed such information to flow but said that no one was allowed to make changes to the robot without telling her and her husband. On one occasion changes had been made without her knowledge and she complained 'they cannot make changes without telling us because then they start overriding us and take the responsibility away from us. It is our robot, our production.' By contrast, Bjørn and Inger had allowed the Tine consultants to adjust the robot's automated feed supply. According to Bjørn, having experts work on the problem made them feel safe:

> 'One has to believe that when you ask an expert, you get the right answers. I think it is fine because without them we might have continued making mistakes forever. Now, it is possible to adjust right away if the consultants see that the farmer is doing something very wrong. '

It takes more to teach AMS to operate automatically than human-animal teachers. For instance, Inger told us that one day she had been out when Bjørn had come running up to the farm because 'our son had called and said that we needed to restart the robot'. There had been a break in the electricity supply to the farm and their son had received an alarm message from the robot. This could cause problems because, according to Inger, 'if a cow is inside the robot, the doors will not open, and she will be stuck'. She stated:

> 'it is the biggest weakness of a technology that costs over one million [NOK] that it does not have a memory that can restart if the electricity comes back […] many other technologies restart in such situations.'

Another issue in relation to failures in electricity supplies emerged in the interview with Kari, namely that if the robot was not restarted quite quickly, the cows' udders would fill with milk, making them bigger than normal and causing pain for the cow. This in turn would have consequences for the robot, as it would have problems recognizing that particular cow in the future.

Eastwood et al. (2017) has shown that the adoption of AMS does not only rely on farmers, cows and technologies, but a wider range of actors, infrastructures and circumstances both on the farm and beyond. We found similar issues. Problems with machine learning continuously arose as cows changed and infrastructure breaks appeared. Also, the farmers' stories about machine learning were consistently relational. Teaching the milking machine how to milk and function automatically involved work not only by the service personnel who set up the machine, but also work by the farmers and various consultants (Higgins et al., 2020). AMS then, is a technology that exist and does its work in a larger network in the farm, but also beyond the farm.

Another important aspect in AMS domestication, is the tinkering that allow farmers and cows to continue the development of technology beyond producer intentions (Bear and Holloway, 2019; Higgins et al., 2017). Because of this, we believe it might also indeed be sensible to talk about the machine learning as a relational process. AMS does not learn by itself, but in relation to individual cows and with farmers as a kind of teachers. This is a process that is further complicated because the relations that kept AMS automated and learning also involved other technologies and cows whose bodies and behaviour changed over time and according to circumstances. As such we need to go beyond mapping relations in space, but also add time as a factor. This underlines how the domestication of AMS is a continuous and multifaceted process that involves extensive learning how to handle unexpected events that might occur long after the machinery has been installed.

Milking in a robotic cowshed is in stark contrast to the representations of a manual on milking dating from 1900 (Ødegaard, 1900). The front cover shows an image of a young girl sitting on a small stool beside a cow. Between her legs she has a bucket, and her fingers are firmly placed around two of the cow's teats. The manual was intended to educate milkmaids in how to milk cows, described as 'work of the utmost importance' and a 'tool for producing good milking cows' (Ødegaard, 1900: 54). While the author of this manual targeted one actor, the use of AMS involves a range of actors and learning strategies. This means that in an ideal world where actors and factors such as cows, humans and infrastructures can be kept stable, AMS should function automatically after an initial period of training. However, the interviewed farmers' stories revealed that while it might take a village to raise a child, it takes at least one farmer, cows, various consultants, and stable electricity grids to keep AMS automated over time. This points towards an understanding of machine learning that does not equate with autonomous machines. If anything, machine learning in AMS relies on a more distributed set of actors and learning strategies than traditional forms of milking do. Leaning on studies of the implementation and adoption of new agricultural technologies, and other kinds of technology adoption (Higgins et al. 2017, 2020; Eastwood et al., 2017; Orr, 1998), we could claim that the domestication of AMS demands a kind of learning that is continuous distributed improvisation within a domestication triangle consisting of humans, technologies and cows.

4. Conclusions

Our ambition in this article has been to understand the domestication of AMS with a specific focus on learning. We have investigated the role of the producer and service personnel and analysed the concrete practices involving cows, farmers and machines to understand how the processes of domestication developed.

Producers of AMS (DeLaval, Lely and GEA) tend to represent the domestication of the technology as a process of managed domestication whereby their expert systems aid and guide the farmer so that he or she learns how to be an 'AMS farmer'. As such, the domestication process as imagined by the producers is a fairly straightforward process that is quite limited in time. We have also pointed out that while the producers describe how the farmer is aided in the process, there is little focus on the animal users of AMS. Cows become AMS cows once they have successfully been put through the milking machine. The farmers' stories differed significantly from these portrayals of the domestication process. Not only did the farmers involve the cows as users of AMS, but they also involved a wider collective than that of the expert system offered by the producers and a time frame that stretched well beyond that of the producers.

The examples of how AMS was domesticated show that AMS provided increased flexibility for the farmers as well as for the cows. However, in line with previous studies of AMS from a social science perspective (Holloway et al., 2014; Driessen and Heutinck, 2015; Bear and Holloway, 2019), this came at a price. The farmers' milking routines did not depend on the clock as they used to in the past, but at the same time the farmers needed to be ready to intervene when problems occurred. When the cows were released from their stalls, they could walk freely but could also be 'captured' by the milking machine and remain trapped in the unit. Moreover, in order for the machine to function correctly, the body of the cow needed an appropriate shape. Ensuring the 'proper' shape could require quite drastic actions, as some of the interviewees reported. One solution was to assist the machine and help the cow, while another was to remove the 'wrong' cows from the herd. In other words, AMS represented both force and freedom for its users.

To study the domestication of technology is to study a process of integration with a parallel focus on how users and the technology change in the process. In previous studies of domestication, the users targeted have been humans. This means that domestication theory as formulated within technology studies has focused on cognitive processes of learning rather than on other types of learning how to live with a new technology. Similar issues are visible in how AMS producers conceptualize their users. However, when we study the domestication of AMS the cows become central actors and their way of learning is important to make the system work. We have also seen that in learning to use the technology one has to build on a larger network of helpers. That is, when studying the domestication of AMS, one needs to flesh out strategies of domestication that are not described in existing domestication theory literature because AMS domestication is a distributed and multispecies process (Lie and Sørensen, 1996; Berker et al., 2006).

We follow Bear and Holloway in their suggestion that we need to include technologies as more than outside force that affect human and animal behavior. The concept of 'divergent conduct' allows for not only humans and animals to become actors, but also opens for an approach to the machines as lively and unpredictable and whose 'actions' are situated in the socio-material networks of the farm and beyond (Bear and Holloway, 2019). As such, one of our findings is that the issues arising when integrating AMS to farm cannot solely be understood by taking farmers and cows into the equation. Instead, it is necessary to take the triangle between machines, humans and animals as a point of departure. Robots don't only diverge because of design or user errors, but also because the networks they are part of change. The key example in our story has been how changes in cow udders and farmers that use the manual function of the machine as well as electricity breaks can hamper the automatic functioning of robots. While robots might be learning machines, machine learning, and functioning, is no less situated than human or animal learning.

While previous studies of domestication of technology have analysed domestication as a two-way process whereby technology and users mutually shape each other, our study of AMS revealed what we call a *domestication triangle*. In line with Butler and Holloway (2016), we found that the processes were entangled and that the actors in the triangle were dependent both on each other and on change in relation to each other: The machines shaped the routines of the cows and farmers, and the behaviour of the cows and farmers shaped the functions of the machines. Thus, we show not only that the farmer-cow relationship is shaped by the machine, but that the machine is also produced in relationships that change and co-evolve. The point here is that the machine can be seen as also being unpredictable and situated, just as cows and farmers are (Butler and Holloway, 2019). In that sense, the domestication triangle consists of quite different actors, humans, cow and machine, but 'liveliness' is a feature they share, and machine learning must be viewed as part of the domestication triangle.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrurstud.2021.03.006.

Author statement

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