Behaviour and heart rate in sheep when herded by Border collies with different background

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Sammanfattning

Vallhundar har under en lång tid använts som ett arbetsredskap i den dagliga hanteringen av fåren, men på senare år har intresset för vallning ökat som en hobby. Detta ledde till en debatt som resulterade i att Svenska Vallhundsklubben gav ut riktlinjer med avseende på träningsobjektens välfärd och hur träning av hundar skall gå till. Vid vallning utnyttjas fårens tendens att samla sig i en flock när de kommer i kontakt med rovdjur. Om en predator närmar sig förändras också fårens beteende genom att de blir tystare, de urinerar och defekerar mer och de kan också stampa i marken eller gå till anfall. De kan också ta tillflykt till ett skyddat ställe. Det finns rasbundna skillnader i hur långt olika fårraser flyr och hur lång tid det tar för dem att återhämta sig och börja bete sig avslappnat igen där hårt avlade raser har kortare återhämtningsperiod. Fysiologiska indikatorer på stress kan vara förhöjda kortisolvärden och ökad hjärtfrekvens. Syftet med denna studie var att studera hur fårens beteende och hjärtfrekvens påverkades när de vallades av tränade border collies, där vissa var bekanta och andra obekanta för fåren.

I denna studie användes tre fokalfår i en grupp på sex får och tio olika hundar, varav tre var fårägarens hundar. Fårens och hundarnas beteenden dokumenterades med hjälp av en digital videokamera när de interagerade och ett får utrustades med en pulsmätare, Polar Equine RS800 G3, för att också kunna mäta hjärtfrekvensen som sedan togs fram med hjälp av programmet Polar ProTrainer 5. Två olika moment utfördes vid separata tillfällen, en hämtning av gruppen med sex får och en delning där gruppen separerades i två mindre grupper. Filmerna analyserades sedan i Observer XT ®, version 11.0. Under analysen delades de olika momenten upp i olika avsnitt; före utgång av hunden, hundens upptag, flyttningsmomentet där får och hund interagerade, när hunden lämnade fåren och efter att hunden lämnat fåren. Sedan studerades hur fårens beteende förändrades i de olika avsnitten. Fårens beteende och hjärtfrekvens studerades också med avseende på de olika hundarnas egenskaper; bekanta eller obekanta, hundens ålder och om hunden stirrade på fåren (eng. eyeade) eller kroppsvallade.

Under både hämtningen och delningen galopperade fåren mer när de vallades av obekanta hundar. Fåren tittade mer på de obekanta hundarna under hämtningen men vid delningen tittade de mer efter de bekanta hundarna. Medelvärdet för hjärtfrekvensen 200 sekunder efter att hunden lämnat fåren var för hämtningen 108,1 slag per sekund och efter delningen var hjärtfrekvensen 124,5 slag per sekund. Delningen resulterade även i den högsta hjärtfrekvensen på 229 slag per sekund. Slutsatsen av denna studie är att det fanns skillnader i hur hundar med både olika bakgrund men också med samma bakgrund påverkade fåren och den viktigaste skillnaden i hur fåren reagerade på hunden var hundens eget beteende. En lugn hund gav lugna får. Fårens beteende kopplat till hjärtfrekvensen indikerade också att de kände sig mer stressade av att bli delade.

Summary

Sheepdogs have been used for a long time as a tool in the management of the sheep. However in recent years, the interest in herding has increased as a hobby which led to a debate which resulted in the Swedish Sheepdog Society issued guidelines on how the training of the dogs should be conducted with respect to the welfare of the sheep. The tendency the sheep have to flock when in presence of a predator is used when using sheepdogs. If a predator approaches, the conduct of the sheep also changes by that they become quieter, they urinate and defecate more and they can also stomp in the ground or attack. They can also take refuge in a protected location. There are breed disparities in how far the different breeds of sheep escape and how long it takes for them to recover and start behaving relaxed again, where intensely bred breeds have shorter recovery period. Physiological indicators of that the sheep is experiencing stress, can be elevated cortisol levels and increased heart rate. The aim of this study was to investigate how the behaviour and heart rate of sheep were affected by being moved by trained familiar and unfamiliar sheepdogs.

In this study, three focal sheep in a group of six sheep and ten different dogs were used, three of which were the sheep owners' dogs. The sheep and dogs' behaviour was monitored by a digital video camera when they interacted. One sheep was fitted with a heart rate monitor (Polar Equine RS800 G3) to be able to measure heart rate which later was analysed using the program Polar ProTrainer 5. Two different moments were performed, a gathering and a shed. The recordings of the behaviours were analyzed using The Observer XT ®, version 11.0. During the analysis the herding was divided into five phases; before the outrun, the lift, the herding where the sheep and dog interacted, when the dog left the sheep and after the dog left the sheep. The behaviour of the sheep was then recorded to see how it changed during the different phases. Both the behaviour and the heart rate were studied with regard to the differences between the dogs; familiar or not, the age of the dog and if the dog was loose- or strong-eyed.

During both the gathering and the shedding, the sheep galloped more when in contact with the unfamiliar dogs. The sheep watched the unfamiliar dogs after the gathering but after the shed they watched the familiar dogs more. The mean heart rate 200 seconds after the dog left the sheep at a gathering was 108.1 beats per minute and after a shed the heart rate was 124.5 beats per minute. The shed also resulted in the highest peak heart rate of 229 beats per minute. The conclusion of this study is that there seem to be differences in how dogs with different background but also with similar background, affect the sheep. The most important thing seemed to be how the dog behaved towards the sheep, not if the sheep was familiar or not, as well as if the dog was loose-eyed or strong-eyed and the age of the dogs. Calm dogs resulted in calm sheep. The behaviour and the heart rate of the sheep indicate that they got more stressed by the shed.

Introduction

Background

The interest in herding has increased over the last years (Hiller-Andreasson, 2014) so it is not just farmers who do it anymore, some people have taken up herding as a hobby as well as a way of exercising their dog. This has raised a debate among both animal rights organizations and the Swedish sheepdog society (SSS), whether it is alright for sheep to be used this way (Hanås, 2013). These questions resulted in that the Swedish sheepdog society gave some guidelines on how the training should be conducted. These guidelines state that the sheep should not be unduly stressed. However, the guidelines do not state what unduly stress is and neither do they state how much nor for how long the sheep can be used (SSS, 2013). The guidelines just mention that the trainer should stop and let the sheep rest if they look tired and do not want to move anymore (SSS, 2013).

The number of sheep in Sweden has steadily been on the up rise for many years, but this last couple of years the numbers have started to decrease slightly. In 2003, the number of adult sheep was somewhat more than 200 000, but 2013 the number had increased to 285 000 (Jordbruksverket, 2014). Sheep- and lamb products are getting more popular in Sweden. The meat consumption is growing (Jordbruksverket, 2013a) and skin products are getting more and more popular as well (Gotlandsnytt, 2013). Border collies are one of Sweden's most commonly used sheepdogs (SSS, 2014). The number of registered Border collies in Sweden has also increased from 2010 to 2013 by 17 % (SKK, 2014a; SKK, 2014b)

According to the Swedish Board of Agriculture (2013b), Swedish farmers have to look after their sheep at least once a day. This can prove to be difficult if there are many sheep in a big pasture. Therefore a herding dog can be used to gather all the sheep into a big group and fetch them which can make it easier for the farmer to attend the animals. Many sheep kept under extensive conditions, are often moved with dogs, mainly herding dogs but also guarding dogs (Coppinger & Coppinger, 2007). The dogs can also be used to keep the sheep away when the sheep owner has to work in the pen, for instance putting out feed or straw to them (Figure 1), especially during the winter when many sheep in Sweden are kept indoors (Christiernin, 2009). Although a dog can make it easier for the farmer, a dog can also cause elevated levels of the plasma cortisol, ACTH and heart rate in the sheep (Harlow *et al.*, 1987; Baldock & Sibley, 1990; Cook, 1996; Komesaroff *et al.*, 1998) which may indicate that the sheep are stressed. Sheep experience great stress if they get separated from their herd (Price & Thos, 1980; Cockram *et al.*, 1994). An alternative to dogs is to attract them to the farmer, either by using sounds or a bucket of concentrate. However, if the farmer has a larger herd this could prove to be dangerous because one can

Figure 1. The dogs keep the sheep away to make it easier to put in straw. Photo: Ida Andersson

risk being jumped at and knocked over by hungry sheep (Sjödin & Hammarberg, 2007). Another way of moving and handling sheep is by using fear evoking stimuli (Gonyou, 2000; Hutson, 2000) which for instance can be a rattle that contains small discs or something that creates noise (Beausoleil, 2006) which also may cause stress to the sheep..

Herding with dogs

The herding behaviour of dogs is considered to originate and correspond with how the wolf hunts. The difference, however, between how wolves hunt and dogs herd is that the dog does not follow through with the attack and kill the prey (McConnell & Baylis, 1985; Coppinger & Schneider, 1995). Coppinger *et al.* (1987) suggested that the aborted hunt is a result of neoteny, which means that a retardation of development of some characteristics, both morphological and behavioural. They found that Border collies influenced the sheep much like juvenile wolves and coyotes do before they learn to kill the prey, by stalking and using an intense gaze. Mech (1970) found that prey animals seem to be able to distinguish between when a predator is in hunting mode and not and acts accordingly. The sheep react in the same way in the presence of a trained Border collie as to a wolf; they start flocking (Hamilton, 1971; Manning & Dawkins, 1998) and keep track of the movements of the dog. Depending on the dog and its behaviour the sheep will stay still and challenge the dog or move away from the dog (Mech, 1970).

From the animal welfare point of view, the adeptness and adaptability of the dog is vital but the skills of the dog are also important for farmers since a bad dog can cause more work than help. There is not much published scientific literature about how sheepdogs work with stock. There are however some websites containing a lot of information about how sheepdogs work. One of them is the Swedish Sheepdog Society (SSS) which contains information on how the society thinks. They also have some rules on how to behave when herding that every member of the Swedish Kennel Club has to abide to (SSS, 2013). Another webpage is Herding on the web, which describes how Border collies work in a similar way. There are several kinds of herding dogs that can be divided into heelers and headers. Heelers move animals by gripping the hind legs and are mainly used on cattle to move them forward. Headers can be divided into strong-eyed dogs (Figure 2) and loose-eyed dogs (Figure 3) which are mainly used on sheep but also on cattle. This kind of dog stops running or fleeing animals by running around them and stopping them face to face. At what distance the sheepdog wants to work differs; some want to work close to the sheep and others prefer a greater distance to the sheep (Jones & Collins, 1993; Rorem, 2014; SSS, 2014). Some dogs easily grip the stock while others do not. Gripping is in some cases essential, especially if the stock attacks the dog or sometimes refuses to move. Dogs influencing the sheep by stalking

Figure 2. A strong-eyed Border collie is watching (eyeing) the lambs. Photo: Ida Andersson

and using an intense gaze are called strong-eyed dogs. They use this behaviour while lying down, standing up and while walking and trotting. When they run fast they usually cannot keep up the intense focus. They tend to be more sensitive on the flight zone of the stock and will in varying degrees show a will to balance the stock. This means that the dog show a will to keep the stock together. They also prefer to keep the stock still (Jones & Collins, 1993; Rorem, 2014; SSS, 2014). Loose-eyed dogs work more upright without crouching or overt staring and are not so sensitive towards the flight zone of the stock. They tend to work closer to the stock and are also more often more comfortable in close quarters such as stockyards, chutes and pens compared to strong-eyed dogs. These dogs have a stronger desire to keep the stock moving than strong-eyed dogs, and do so by wearing (moving from side to side) behind the stock (Jones & Collins, 1993; Rorem, 2014; SSS, 2014). In figure 2 and figure 3 the difference in how the dogs use their bodies can be seen. The strong-eyed dog is crouching while watching and the loose-eyed dog is standing upright while watching.

Figure 3. A loose-eyed border collie which is watching the sheep. Photo: Ida Andersson

Sheep have good long-term memory (Hutson, 1985) and can tell the difference between different individuals, both among themselves and between different dogs (Kendrick, 1991). When herding the sheep with a dog, the instinct the sheep have to flock in the presence of a predator, is utilized to collect everyone together (Hamilton, 1971). Many heading dogs have an inherit response when they see animals in the distance; to flank out and gather and fetch them to the handler. Border collies have a natural ability to go around the sheep and take them to its handler (McConnell & Baylis, 1985). There have been many observations where wolves have driven prey towards wolves lying in wait (Crisler, 1956; Kelsall, 1968; Mech, 1970). This behaviour is theorized to be the reason behind the sheepdogs desire to take the sheep to the shepherd.

When gathering the sheep from a distance, the gathering can be divided into several stages; the outrun, meaning the initial movements to go around and gather the sheep, the lift which means the initial movements the dog does to start moving the sheep and lastly fetching the sheep to the shepherd. This is a central part in most of the sheepherding trials. The afforded points a dog can get for this part is 50 in many trials and depending on type of trial and country the maximum points is 100-170 with more points awarded in more complicated trials. Another important part in many competitions is the shed which means that the dog and handler work together to divide the group of sheep into two smaller groups. This part is usually scored 10 points (SSS, 2012; ISDS, 2014).

It has been shown that sheep are able to discriminate between different human handlers depending on if their recent contact was a pleasant or unpleasant treatment (Fell & Shutt

1989; Boivin *et al.*, 1997). However, there is no scientific literature about if the sheep discriminate between dogs in the same way.

Genetics of the dog

The herding behaviour in dogs is controlled by genes which make it possible to breed on desired qualities (Arvelius *et al.*, 2013). Arvelius (2005) found that dogs that gripped the sheep tended to be more difficult to control when herding. In a study done by Coppinger *et al.* (1987) livestock-guarding dogs and herding dogs were raised together in the same environment and still the guarding and herding dogs started to display very dissimilar behaviours. The guarding puppies and young dogs frequently engaged in play-chasing and wrestling while the herding puppies and young dogs spent much time eyeing and stalking each other or imaginary objects (Figure 4). Arons and Shoemakera (1992) found that livestock-guarding dogs had lower levels of dopamine in the basal ganglia whereas Border collies had higher quantities of this neural transmitter.

Figure 4. A 13 weeks old Border collie which is already expressing stalking behaviour. Photo: Ida Andersson

Breed differences in the sheep

Some breeds of sheep are easier to herd than others. Primitive breeds have an agile physic and are often livelier. This coupled to a strong sense to flock (Hansen *et al.*, 2001; Karlsson, 2014) makes them good for training novice dogs. However, the Swedish breed "RYAFÅR" is an exception since they tend to not flock together as much (Karlsson, 2014). The heavier meat breeds are often not suited for novice dogs (Karlsson, 2014) because they do not have the same sense to flock and can therefore leave the herd when feeling stressed (Hansen *et al.*, 2001; Karlsson, 2014). Some meat breeds can also have a body composition that is not suited for moving excessively (Karlsson, 2014). The Dorper is as a breed easy to move for dogs because they are sensitive and responsive towards the dogs. They can however be a bit difficult to move if the dog is mentally not so strong (Bohlin, 2014).

Dog-broke

To get the sheep dog-broke means that the sheep will learn to respect and move away without panicking when the dog approaches them (Karlsson, 2014). How the stock get dog-broke is very important. The dog should be introduced in ways that minimize the stress so that the sheep will not associate the dog with unpleasantness. It is of great importance that the dog is calm when meeting the sheep for the first time (Sjödin & Hammarberg, 2007) because sheep can remember aversive incidents up to a year (Hutson, 1985). According to Karlsson (2014), this requires an experienced dog which can read the sheep and adjust the distance between itself and the sheep. If the dog is too close, the sheep will get stressed but if the dog is too far

away the dog might lose the sheep if they start running away, because then the sheep will have learnt to run when a dog approaches. The dog also must be strong enough mentally so it can grip the sheep if they do not move away or even attack the dog. Sheep are easiest dog-broke if they learn as lambs when following the ewe.

The stress physiology of sheep

Stress can be described as a condition when the homeostasis of the animal is threatened, either by intrinsic or extrinsic adverse forces. An acceleration of the respiration and cardiac output coupled with that the blood flow is redirected to the brain, heart and skeletal muscles occur in stressing situations (Chrousos & Gold, 1992). The body can react in various ways when in a stressing situation; often by the autonomic nervous system (ANS) or the hypothalamic–pituitary–adrenal (HPA) axis. The ANS comprises of two branches; the sympathetic nervous system and the parasympathetic nervous system. The sympathetic nervous system is most often activated when the animal is in a stressing situation resulting in an increased heart rate, higher pain tolerance and a decrease in the gastrointestinal tract (Ljung & Friberg, 2004). This system also controls the release of the adrenaline and noradrenaline. The parasympathetic nervous system is at the same time deactivated. The HPA axis regulates the release of cortisol which creates an energy mobilization to make more energy available. The extra energy can be used to make a flight from the danger easier (Minton, 1994). If the animals are exposed to longer periods with raised cortisol levels, the synthesis of the DNA can be inhibited and growth be reduced (Sjaastad *et al.*, 2010). Cortisol has a negative effect on the immune system as well (Sjaastad *et al.*, 2010). Plasma cortisol levels can be elevated after both physical and psychological stress (Hashizume *et al.*, 1994).

When animals are around stressors often or constantly they may sometimes develop chronic stress (Destrez *et al.*, 2013), but what determines if the animals react negatively on the stressors and aversive stimuli is their ability to cope in the situation (Ursin & Olff, 1995). Handling procedures can often be aversive towards the sheep and coupled with that sheep usually are moved by using fear evoking stimuli (Gonyou, 2000; Hutson, 2000) handling often causes distress in the sheep. Dogs are commonly used when handling sheep which can be seen as a fearsome stimulus because dogs can cause elevated levels of the plasma cortisol (Harlow *et al.*, 1987), ACTH (Komesaroff *et al.*, 1998) and heart rate (Baldock & Sibley, 1990) in the sheep. Therefore it is not unlikely that both inappropriate handling from man or dog can cause chronic stress. This can cause stereotypic behaviours, impaired fertility, reduced growth and immune function, an increase in parasites and/or deterioration in meat and wool quality (Dwyer & Bornett, 2004). When sheep are exposed to short term stress, several hormone levels change; prolactin, cortisol, T3 and T4 can increase but insulin and growth hormones have in some studies decreased (Yardimci *et al.*, 2013; Scott *et al.*, 1993). Schlink *et al.* (2002) injected sheep with cortisol to elevate the cortisol levels and this had a negative impact on the wool, i.e. the staple strength was reduced. The wool fibre tended to be thinner and more fragile resulting in that the fibre tended to segregate and even become detached from the animal. The longer the sheep were exposed to elevated levels, the longer the effect stayed. Ansari-Renani and Hynd (2001) had come to the same conclusions earlier.

Repeated negative experiences can, in humans, induce chronic stress which can heighten fearfulness (Glaser *et al.*, 2006). Destrez *et al.* (2013) found in their study, where lambs were exposed to unpredictable and aversive elements, that the lambs had lower cortisol levels and heart rate. This can point to chronic stress, and these lambs were more fearful. This may be an indication that increased fearfulness can be used as a sign to detect chronic stress.

The average heart rate of adult sheep when resting is 70-80 beats per minute, while lambs have slightly higher heart rate (The Merck Veterinary Manuals, 2012). MacArthur *et al.* (1979) found, by using a telemetry system that the heart rate of wild sheep after being disturbed returned to baseline in less than 200 seconds. The majority of the heart rate responses to disturbing stimuli preceded or occurred in the absence of overt behavioural reactions. Hansen *et al.* (2001) found when domestic sheep were exposed to a man with a dog that the recovery times for the sheep to stop caring about the stimuli were between slightly under 100 seconds for heavier breeds to approximately 200 seconds for lighter breeds. MacArthur *et al.* (1982) obtained the same results by observing mountain sheep, however the animals did not withdraw in the same degree as found before. Syme and Elphick (1983) found that heart rate can be used to identify social stress in individuals in groups of sheep.

The reaction to predators

Through breeding and domestication many sheep breeds are heavier than the more primitive breeds and are also calmer and more productive (Chessa *et al.*, 2009). Though sheep have maintained many of the original behaviours, their anti-predatory behaviour is not as strong anymore, probably due to that they are protected by man and that breeding has created a slight alteration in the gene material (Eggen, 1995).

Most prey animals have a flight zone which is determined by the animal's flight distance. This means that the animal will let the predator approach to a certain distance before responding. Mech (1970) observed that wolves can be around caribous without the caribous seeming to care about them. This may indicate that the prey can distinguish between when a predator is on the hunt or not. Mech (1970) also observed that as soon as a hunting wolf aborts its hunt, the wild sheep will stop fleeing, probably to save energy. MacArthur *et al.* (1979) found that when free-ranging canids came in contact with wild ewes, their heart rate increased to maximum levels. They also found that most of the time the heart rate increased, the sheep did not have any motor activity. A later study showed the same result (MacArthur *et al.*, 1982).

The main form of defence that sheep use when predators approach is flight for cover (Geist, 1971; Bleich, 1999), probably because they generally are too small to mount a successful defence. This behaviour can be called refuging (Lima, 1998). When they reach their refuge, their movements decrease to avoid getting noticed. However, ewes may sometimes remain and protect their lamb, especially if the predator is of a smaller size. The ewe then stands over her lamb and kicks in the ground (Dwyer, 2004). Smaller predators can be chased away (Hansen *et al.*, 2001). Another defence mechanism is flocking (King *et al.*, 2012), which means that a group of animals gather together when feeling threatened. This is probably due to that the more animals that keep an eye on the surroundings; the sooner the attack of the

predator will be detected. Another reason for flocking is that the risk for an individual to fall prey to the predator reduces. This is called the selfish herd-theory (Hamilton, 1971) were the stronger individuals tend to be in the middle of the flock. Sheep also synchronize their grazing and resting behaviour, which presumably also is an anti-predator defence mechanism because it reduces the risk of being spotted by the predator (Dwyer, 2004). Sheep tend to vocalize less and urinate and defecate more in the presence of a predator (Romeyer & Bouissou, 1992).

Difference between breeds, sexes and rearing conditions

Hansen *et al.* (2001) found that heavier breeds which have been intensely bred had lower antipredator behaviour than more primitive, lighter breeds. The heavier breeds were less likely to escape when in presence of stuffed predators and they also had shorter recovery period. Romeyer and Bouissou (1992) found differences between the two meat breeds "Îie-de-France" and "Romanov" sheep, which were reported by farmers to be to very divergent in their reactions. Romanov sheep were more fearful than Îie-de-France sheep. It was also found that they were more fearful if dam-reared compared to artificially reared lambs. None of those differences were found in Îie-de-France sheep. There were also differences between sexes; rams tended to be less fearful than ewes, and ewes and lambs tended to flee more than the rams (Vandenheede & Bouissou, 1993). Ewes also seemed to be more watchful and rams were more independent from the herd (Dwyer, 2004).

Reactions to novel objects, dogs and humans

The University of Western Australia have been breeding since 1990 on the behaviour of Merino sheep and gained through these two lines. One of the lines have been bred on more active animals (MA) and the other line were less active (LA) in their behaviours. In a study made by Beausoleil *et al.* (2012) the sheep from the different lines were tested to see how they would react in the presence of a variety of different stimuli; a box, a human and a dog. The MA-sheep were more active and vocal no matter the stimuli than the LA-sheep were. The MA-sheep were more watchful in the presence of a dog than the LA-sheep. Baldock and Sibly (1990) found that the heart rate when being moved by a dog increased from 80 beats per minute (bpm) to 163 bpm, but 30 minutes after the herding the heart rate was 111 bpm. Romeyer and Bouissou (1992) measured fear reactions of domesticated sheep placed in four different situations involving a surprise effect, the presence of a human, the presence of a novel object and an unfamiliar environment. They found that in the presence of an unknown human, the sheep were more quiet, less active and defecated more compared to when in the other stressing situations. Bouissou and Vandenheede (1995) findings support this but they also found that the fear reaction decreased over time as the sheep got habituated with a human among them.

King *et al.* (2012) found in their study that sheep tended to observe which sheep were closest to them before deciding where to move towards the middle, either move directly to the middle or more outside the middle, when a dog approached them. Syme (1981) concluded that vocal and uncooperative animals tended to be in the middle or the back of the group while being driven by dogs as a mob through a yard. In a study made by Dove *et al.* (1974) where dominance patterns among sheep were studied, they found that the more dominant individuals positioned themselves in the middle of the group when forced to move.

Baldock and Sibly (1990) found that when a dog approached the sheep, their heart rate increased and they became more watchful. Upon gathering the sheep with the help of a dog, their heart rate was 3.5 times faster than normal, but according to Kilgour and de Langen (1970) the cortisol levels did not increase significantly when a dog gathered the sheep and held them in a pen for three minutes, see Table 1. The cortisol levels in two sheep that were bitten did however increase significantly. Beausoleil (2006) found that the cortisol levels were significantly higher in the presence of a barking dog compared to a human using a rattle to create noise. After contact with a human holding a rattle, it took 45 minutes for the cortisol levels to reach normal levels compared to 60 minutes when they had been in contact with a barking dog.

Table 1. An overview over cortisol levels and heart rate when sheep has been exposed to different stimuli reported in scientific papers

Stressors	**Cortisol (ng/ml)**		**Heart rate (bpm)**	**Reference**
	Before	After		
Barking dog	11.9	45.3	-	Beausoleil, 2006
Driving by a dog	4.0	8.5	-	Kilgour & de Langen, 1970
Bitten by dog	4.0	16.0		Kilgour & de Langen, 1970
Human with a rattle	8.56	40.0	-	Beausoleil, 2006
Shearing	13.5	36.7	80	Yardimci *et al.*, 2013
Hoof care lying down	13.7	34.3	73	Yardimci *et al.*, 2013
Loading on a truck	13.6	32.6	66	Yardimci *et al.*, 2013
Standing still, isolated	-	-	92.2	Syme & Elphick, 1983
Moved by human	-	-	138.5	Syme & Elphick, 1983
Moved by dog, 500 m	-	-	163	Baldock & Sibly, 1990
Man with a leashed dog	-	-	124	MacArthur *et al.*, 1982

Ewes that had been exposed to rough flocking by dogs a couple of weeks after mating, had an increased embryonic mortality (Doney *et al.*, 1976). The ewes should therefore not be exposed to stressful dogs up to six weeks after mating (Karlsson, 2014) Researchers have studied how reproduction is affected if the sheep have to walk long distances to eat. Sejian *et al.* (2012) found that even though the ewes got elevated cortisol levels when being forced to walk long distances, the reproduction hormones were not affected negatively. The body temperature of the foetus was constant when ewes had been forced to move (Laburn *et al.*,

2002). Ten 121 days pregnant ewes were forced to exercise on a treadmill for three weeks to observe how exercise stress would influence the uterine blood flow. The total uterine blood flow was not altered after training, but the distribution was changed in favour of the placenta. Blood flow was evenly distributed within the placenta before and after exercise, which might be a compensatory mechanism for the foetus (Curet *et al.*, 1976). Roussel *et al.* (2004) exposed ewes during their last five weeks of gestation to two stressful elements twice a week until lambing. The ewes were placed alone in a pen without any contact for an hour. The next time they were placed in the pen, it contained a dog kept behind a gate. Cortisol levels were measured repeatedly. The lambs were then compared to other lambs which had not been prenatally stressed. The results were that there were no adverse effects on the behavioural and cortisol responses when being stressed. However, the birth weights were higher amongst the prenatally stressed lambs and they expressed more explorative behaviours. Dalton *et al.* (1980) found that lambs which were underweight at birth had a higher mortality rate.

Many studies have been made on ewes where they had been sheared during gestation. The ewes were sheared during winter and therefore exposed to cold stress, which made them eat more to keep up their body temperature (Piccione *et al.* 2002). This has been considered the reason for the increased birth weights. The same results have been shown when pregnant ewes have been sheared during the summer but the reason for this could be because of a reduced heat stress (deNicolo *et al.*, 2008). However, there have been studies where the ewes were sheared during gestation, and although they were not exposed to heat or cold stress the weight of the lambs still increased (Corner *et al.*, 2007; deNicolo *et al.*, 2008).

Beausoleil *et al.* (2005) conducted a behavioural study where they tested how the behaviour of the sheep differed when in contact with different stimuli; a cardboard, a Border collie, an Angora goat with horns and a human, with the box serving as the control on how they reacted on new items. The Border collie was accustomed to work with sheep. Both the goat and the dog were tied down and unable to move much during the trial. To minimize the impact of a new environment in the results, the sheep were habituated in advance. The sheep showed less aversive behaviour towards the box and they explored the pen but in the presence of the dog they were more fearful and vigilant and they hardly explored the pen. They also stomped in the ground and watched the dog more than they did with the other stimuli.

Aim

The aim of this study was to investigate how the behaviour and heart rate of sheep were affected by being moved by trained familiar and unfamiliar sheepdogs. To answer the purpose of this study the following questions were asked;

- Will the heart rate increase more when sheep are herded by an unfamiliar dog than by a familiar dog?
- Will there be a difference in how the sheep responds to the different dogs in the same categories the dogs are placed in?
- Will the sheep behave differently when being herded by unfamiliar dogs compared to the familiar dogs?

- Is the heart rate and behaviour of the sheep different during a gathering compared to a shed?

Hypothesis:

- The heart rate will increase more for the sheep when in contact with the unfamiliar dogs.
- The response of the sheep will differ when being herded by different dogs.
- The sheep will be calmer around familiar dogs than unfamiliar dogs
- The heart rate and behaviour will not be the same for a gathering as a shed.

Materials and Method

Animals and housing

This study was conducted in the autumn at a private sheep farm north of Uppsala. The farmer had 65 adult ewes and 3 pure bred Dorper rams. In the summertime the animals were out in a pasture and during the wintertime they were housed inside a barn where they were fed *ad libitum* of silage and water. The animals were placed in different pens depending on sex, age and gestation. There were some pure bred Dorper and the rest was a cross of Dorper, Leicester, Dorset and Suffolk but the farmer was slowly trying to replace the cross bred for pure bred Dorper.

These animals were used for the training of herding dogs so they were therefore familiar to being herded by a variety of different dogs using different herding techniques, strong-eyed or loose-eyed dogs. These kinds of sheep were chosen because it decreased the possibility that the sheep would react in a negative way towards the unfamiliar dogs. They had also been moved by dogs since they were lambs and living with their mothers.

In the study six ewes were used, two of them were eight months and four of them were one year and seven months, see Table 2. They were all a cross of Dorper. They were housed outside and fed *ad libitum*, on the first occasion they ate grass and on the second occasion they were fed silage. This made the sheep walk to the silage after the shed was finished. The dogs that were used were all Border collies and trained for herding sheep; see Table 3 for their level of education and other details. Dogs D and I had never shed before. The only criteria for the dogs to be able to participate were that they were able to gather and fetch the sheep to the handler. Descriptions on how the different experience levels were divided are presented in Table 4. The grouping of the dogs was decided based on both the owners description and by studying how they cooperated with the owner to move the sheep.

Table 2. Information of the individual sheep which were used as focal animals and carried the heart rate monitor and their average heart rate (beats per minute, bpm) when they were grazing before being herded

Sheep	Breed	Age	Mean heart rate
1:	Dorper x Suffolk	8 months	106
2:	Dorper Leicester Dorset	8 months	109
3:	Dorper Leicester Dorset	21 months	96

Table 3. The different dogs used in this study with their level of education, how they work with sheep, which sheep they moved and how many times in total they herded the sheep

Dog	Sex	Age (years)	Level of education	Eye	Herded sheep	Gather/shed	Number of times the dog herded
A	Female	5	3	Strong-eyed	1, 2, 3	Gather, shed	5
B	Female	3	2	Strong-eyed	1, 3	Gather, shed	4
C	Male	2	3	Strong-eyed	2	Gather	2
D	Male	2	2	Loose-eyed	3	Gather, shed	2
E	Male*	7.5	3	Loose-eyed	1, 3	Gather, shed	5
F	Male	1.5	2	Strong-eyed	1, 2, 3	Gather, shed	6
G	Female	8.5	2	Strong-eyed	2	Gather	1
H	Female	1.5	1	Strong-eyed	2	Gather	2
I	Male*	7.5	1	Loose-eyed	1, 3	Gather, shed	2
J	Female	2	1	Strong-eyed	1, 2	Gather	2

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Table 4. The Border collies were grouped into three classes by how much experience they had

Level of experience	Description
1	In the beginning of their training/education
2	Basic training with experience with working with sheep
3	Trained with much working experience

Study design

Before the study was started, all the sheep that were going to carry the heart rate monitors were familiarized with the equipment. A pilot study was made to assure how long time it took for the heart rate to go back to normal and to control how long time it took for the sheep to start behaving like they do when there are no dogs or humans around them. Which behaviours to observe from both the sheep and the dogs were also decided during the pilot.

On the first occasion the temperature was about 5-7 C° and slightly windy. During the second occasion it was slightly colder, about 1-3 C° with occasional bouts of rain. The sheep were on the second occasion sheared which they had not been on the first days this study took place.

The study took place in two different pastures where the gathering took place in a larger pasture (about 100 x 100 m) and the shedding took place in a smaller pasture (about 50 x 50 m). The sheep were used to both pastures, both for grazing and for training.

Gathering
This experiment was designed to imitate how sheepdogs are used by farmers out in the field. The sheepdogs were asked to gather the sheep, which were grazing on the pasture, then move the sheep about 180 meters. The dog gathered the sheep by running around them and then started walking towards the sheep. The sheep were then fetched to the handler and then driven back to where they were from the start by the dog. This took from 1-3 minutes; the sheep were then left alone for about 20 minutes until the next dog did the same thing.

Shedding
The sheepdog were asked to gather and fetch the sheep to the handler and then the handler and dog worked together to shed the group into two smaller groups which were then moved together into one group again. The dog was directed to stalk after the sheep which carried the heart rate monitor.

Behavioural recordings

The herdings were filmed using a Sony Handcam (Sony ® HDR-PJ240E, China) which was mounted on a tripod at 20 meters from the place where the herding started. The order in which the dogs got to herd the sheep were randomly selected. Different dogs were used on the same group of sheep. Three of the dogs were the sheep owners' dogs and therefore familiar with and to the sheep. The behaviours which were studied can be seen in Table 4. When the sheep started to graze, ruminate and spread out after being herded was also recorded. It was decided in advance that the herding would be aborted if a sheep got injured, for instance becoming lame but also if the sheep seemed reluctant to move or started to pant with an open mouth.

The behaviour of both the sheep and the dogs were analysed from the videos with The Observer XT ®, version 3.0 (Noldus Information Technology, The Netherlands). The herding was split up into five phases during analysing; before start of herding (called 'before'), dog approaching the sheep (called the 'lift'), dog starting to move the sheep (called the 'herd'), the dog leaving the sheep (called 'leaving') and lastly what the sheep did after the dog left (called 'after'). The duration and frequency of defined behaviours were recorded both in sheep (Table 5) and dogs (Table 6).

Table 5. The selected behaviours of the sheep which were observed when a dog approached and moved the sheep

Behaviour	Description	Gather/shed
Walk	A four-beat gait used when moving slowly	Both
Trot	A two-beat gait that are a little faster than walking	Both
Gallop	A two-beat gait that are a little faster than walking	Both
Attack	Lowering of the head and start moving towards the dog	Both
Stomp	Stomp with legs in the ground	Both
Ruminate	Re-gurgitating a bolus and chewing on it	Both
Flock	The sheep gather together to a group	Both
Split	The dog shatter the group by coming in too close causing the individual distance among the sheep to increase	Both
Watch	Standing watching the dog	Both
Stand	Standing still	Both
Spread	The sheep have moved away from each other	Both
Divide	When the sheep is divided into two groups by the handler	Shed
Gather	The sheep flock together after shedding	Shed

Table 6. The selected behaviour of the dogs which were observed when in contact with the sheep

Behaviour	Description	Gather/shed
Stalk	Following the sheep with a lowered head	Both
Gallop	A two-beat gait that are a little faster than walking	Both
Trot	A two-beat gait that are a little faster than walking without lowering of the head	Both
Lie down	The dog is lying down	Both
Wear	Moving from side to side in an arc behind the sheep	Both
Stand	Standing still	Both
Leave	When the dog is called off from the sheep	Both
Outrun	When the dog starts running to gather the sheep	Both
Flank	Go around the sheep in a given direction	Both
Between	When the dog go in between the two groups	Shed

Heart rate

The heart rate was measured by putting a heart rate monitor on one of the sheep and the heart rate was later analysed using the program Polar ProTrainer 5 (Polar Oy, Finland). To be able to place the heart rate monitor on the sheep, they had to be sheared on the thorax. To do that the sheep owner held the sheep while the sheep got sheared. Electrode gel (Blågel, Cefar compex, Sweden) was used on the skin under the heart rate monitors. The sheep carried the monitor for approximately three hours each time. One sheep at the time was carrying a heart rate monitor that recorded heart rate per second in a watch (Polar Equine RS800 G3, Polar Oy, Finland) mounted on the sheep. The equipment was placed on the sheep while the owner held the sheep. The sheep were then let out in the same pasture as the herdings were going to take place, for an hour to graze before being herded. The heart rate monitor was randomly altered between three sheep before the group of randomly assigned dogs had herded them. The average heart rate when the sheep were grazing was calculated by taking heart rate data for seven minutes before the sheep were moved by dogs and 40 minutes after the heart rate monitor was placed on them, with the heart rate recorded every second. 200 seconds after the dog left the sheep; the heart rate of the sheep was observed and recorded. The number of seconds was chosen because Mac Arthur *et al.* (1979) found that after 200 seconds the heart rate had returned to baseline after being exposed to predators in the wild.

Figure 5. Sheep 3 with the heart rate monitor and watch mounted on her. Photo: Ida Andersson

Data analysis

The data analysis of the behaviours and heart rate were performed with SAS (Statistical Analysis System Inc., Cary, USA) version 9.7. In the analysis the dogs were divided into familiar and unfamiliar where the dogs of the sheep owner were put as familiar since the sheep were used to being moved by these dogs. The age of the dogs were divided into two categories; the dog up to three years old were named young and the dogs above three years old were named adult. The dogs were also divided into loose-eyed or strong-eyed. The dogs were grouped into the categories by being observed when herding and by asking their handlers.

The number of observations was grouped according to the interactions between the sheep and the dog (for gather: n=16, for shed: n=9). Three different prerequisites were taken in consideration when it was studied how different dogs affected sheep; if the dog was familiar or not, if the dog was loose-eyed or not and the age of the dog. All behaviours performed by both the dogs and the sheep were Poisson distributed and therefore the median and Q1 and Q3 were calculated. The heart rate of the sheep was however a bit skewed to the right.

Results

The median duration the sheep were herded during the gathering was shorter than during the shed (Figure 6).

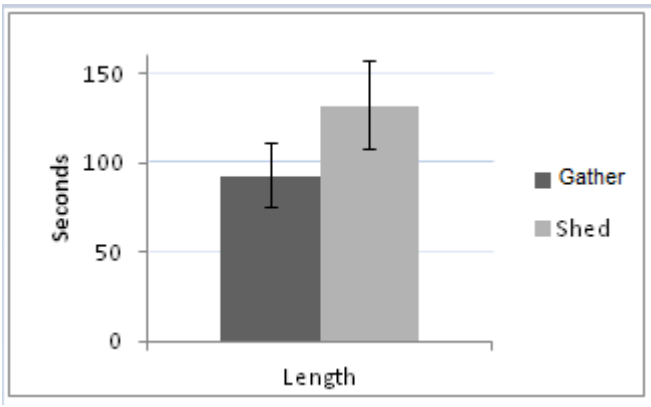

Figure 6.The duration of the median (Q1, Q3) in seconds, (gather n=16, shed n=9).

Behaviour of the dogs

As can be seen in figure 7 stalk, lie down and flanking were the most common behaviours performed during both the gathering and the shed. Flanking and lie down were used more during the shed and they stalked more during the gathering. During the lift the most common behaviour were stalking and lying down.

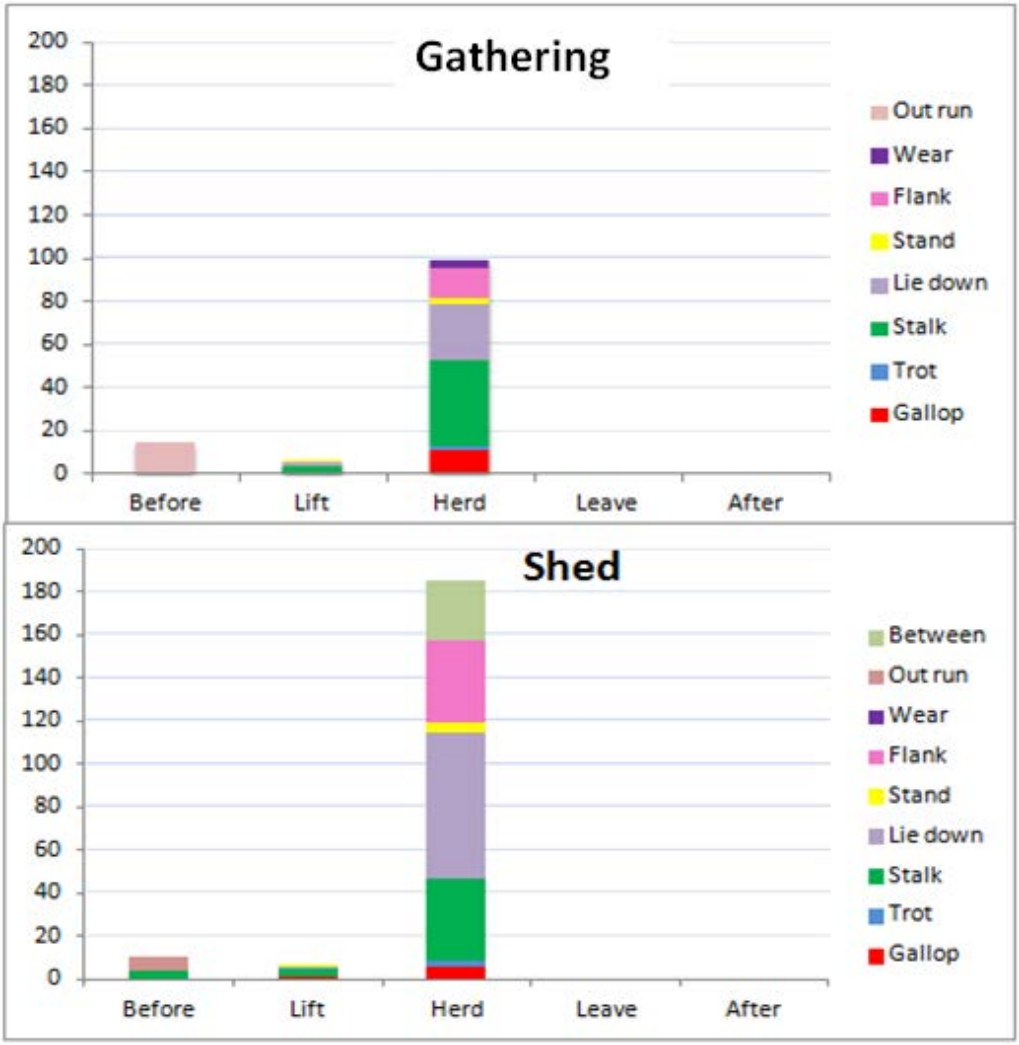

Figure 7. Mean duration in seconds of the expressed average behaviours of all the dogs, (gather n=16, shed n=9). The standard error can be seen in Appendix I.

However, some dogs galloped during this phase. The most commonly used behaviours were stalk, lie down and flank for both the gather and the shed during the phase ‘herd’. The conducted behaviours were mostly expressed when the handler gave the dog commands. However, a behaviour the dogs did without commands that calmed the sheep down were flanking while driving the sheep towards the handler. It was noted that some dogs, both older and younger, were running too fast after the sheep without any commands and therefore making the sheep run away from them.

A more thorough description of how each individual dog acted when herding in this study can be seen in Table 7. When studying the films it could be seen that the handler also had an indirect effect on the sheep by being too slow to give commands to the dog which can be seen

Table 7. Descriptions of how each individual dog acted when herding the sheep

Dog	**Description**
A	A strong dog that moved the sheep with ease but took many decisions on her own. She galloped after the sheep at a high speed, making the sheep run faster and she did not make any move to go around them to stop them or slow down and did not listen to her handler. Uncooperative. Been reported by handler to grip/bite uncontrolled at the sheep when younger.
B	Mostly worked calmly behind the sheep but then sometimes lost the calmness and ran fast after the sheep.
C	An obedient dog which moved the sheep with ease. Increased the distance between himself and the sheep if they started to move faster.
D	A calm dog that kept a distance to the sheep. He sometimes looked towards the handler. Worked more upright.
E	A strong dog but he sometimes bit the grass and looking towards the handler when given commands. Made many abrupt and hurried movements around the sheep. Worked upright sometimes. Uncooperative. Been reported by handler to grip uncontrolled at the sheep.
F	A strong dog which moved the sheep with ease but occasionally moved too fast after the sheep.
G	A calm and careful dog that move the sheep with ease but did not make them run fast.
H	Moved fast around the sheep in the beginning but calmed down after a while. Untrained but quite obedient.
I	A calm dog that sometimes ran fast around the sheep. Worked more upright. Untrained and not so obedient.
J	Moved fast around the sheep but was obedient.

in the figures. The dog was obedient but the handler let the dog come to close to the sheep which resulted in that the sheep ran away. Some dogs in some situations however, fixed this by themselves, most often by flanking which resulted in that the sheep started to calm down and walk again rather than running. When the dogs walked slowly after the sheep, they lowered their head, gazing intensely towards the sheep, both loose-eyed and strong-eyed dogs exhibited this behaviour. When the dog came up so that it was side by side or three or nine o'clock to the sheep, they slowed down.

Dog E often did sudden movements, which cannot be seen in any of the figures, and generally walking too fast after the sheep. The sudden movements he did, like rising very fast or doing a fast movement with his head made the sheep run away from him. This made Dog E move faster after the sheep to keep up with them which in turn made the sheep run faster. He did not flank much to try to stop them. This was managed by the handler by stopping the dog until the sheep calmed down, see figure 10. Dog C sometimes slowed down or flanked by himself when the sheep started to move faster.

Behaviour of the sheep

The sheep reacted the same towards all dogs when starting; as soon as the dog and handler started to move into position in preparation for the outrun, the sheep started to watch toward the dog and handler. They watched when the dog started to approach them and when the dog came closer they flocked together and if the dog continued to come closer they started to move away. If the dog approached the sheep at a fast pace, galloping or trotting fast, the sheep started to gallop away (Figure 10). Different approaches can be seen in the visualizations below, see figures 8-10. In these figures the complexity of the interaction between the sheep, dog and handler is visualized by the different expressed behaviour. Sometimes how the sheep behaved, controlled how the dog and handler had to act so that they would not to lose the sheep and sometimes the behaviour of the dog controlled how the sheep behaved. If the dog

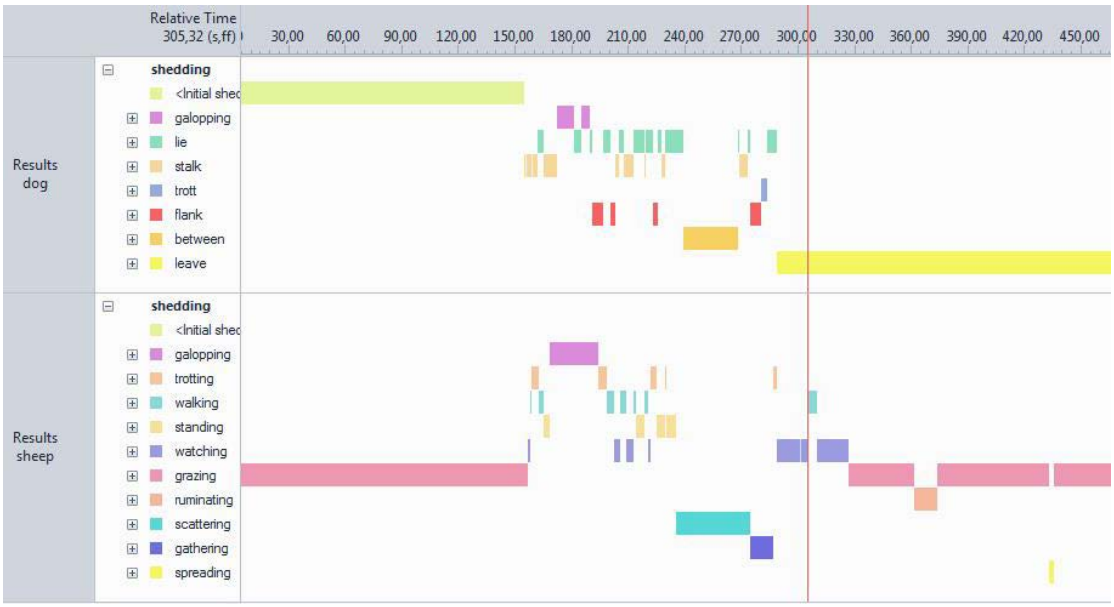

Figure 8. Visualization of dog A together with sheep 1 during the shed. This one occasion generated the highest heart rate, both among gathering and shedding.

calmly stalked after the sheep while eyeing them, the sheep also walked calmly. If the eyeing was disturbed by the dog looking away the sheep started to run away from the dog, an example on that can be seen in figure 9.

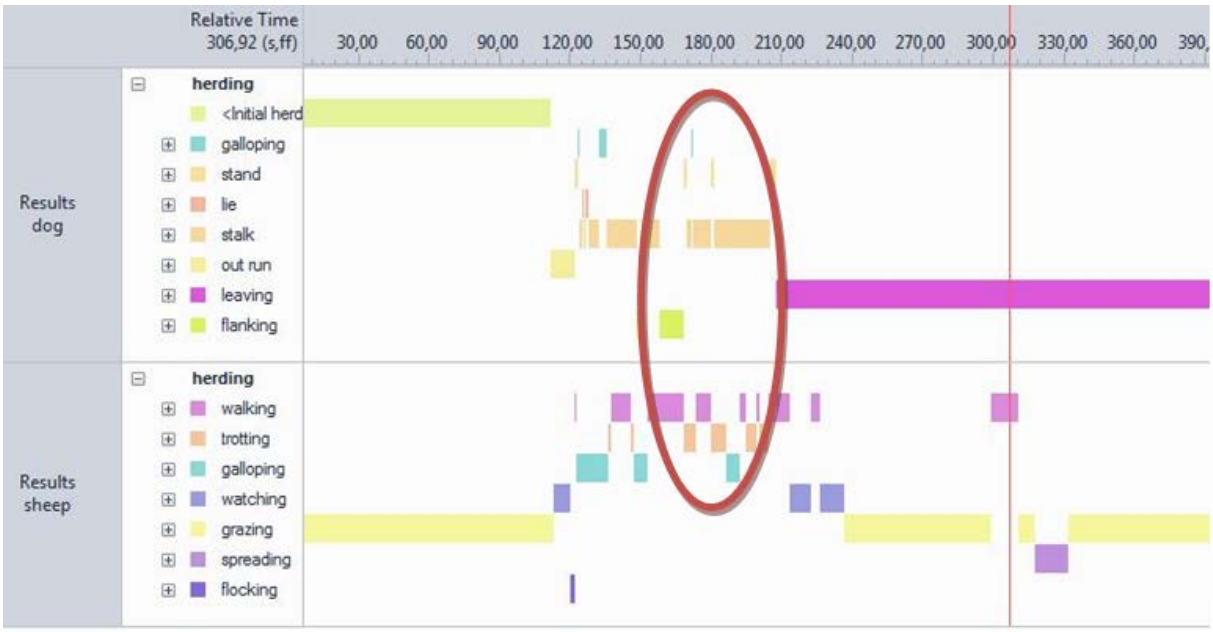

Figure 9. Visualization of dog C with sheep 2 during a gathering. In this visualization it could be seen that when the dog stopped and watched the handler, which can be seen inside the red circle, the sheep immediately started to run away from the dog.

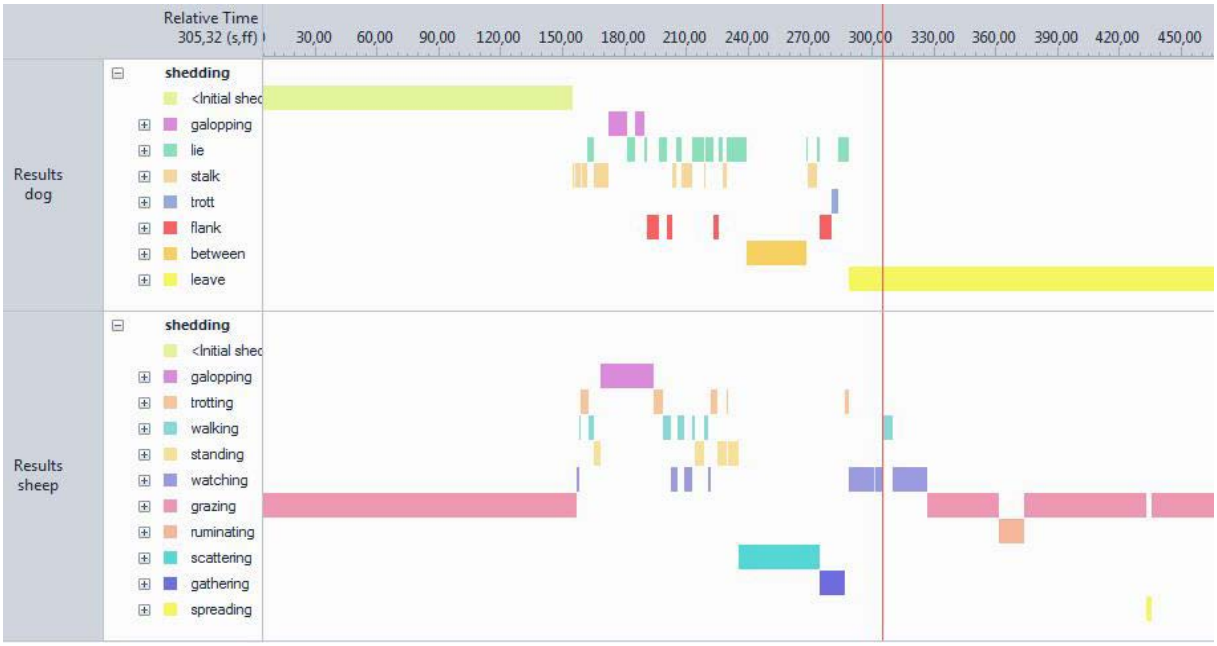

Figure 10. Dog E moving sheep 1 during a shed. This dog approached the sheep during the lift in gallop which caused the sheep to start galloping too. This visualization illustrates how active both the dog and the handler need to be in order to control and manipulate the sheep to do what is desired.

As soon as the dog started to leave the sheep to get back to its handler, the sheep stopped and watched until the dog and handler disappeared to the other side of the fence, see figures 9 to 11. When the dog left, many of the ewes urinated. They also tended to urinate if they for some reason stopped walking while being herded.

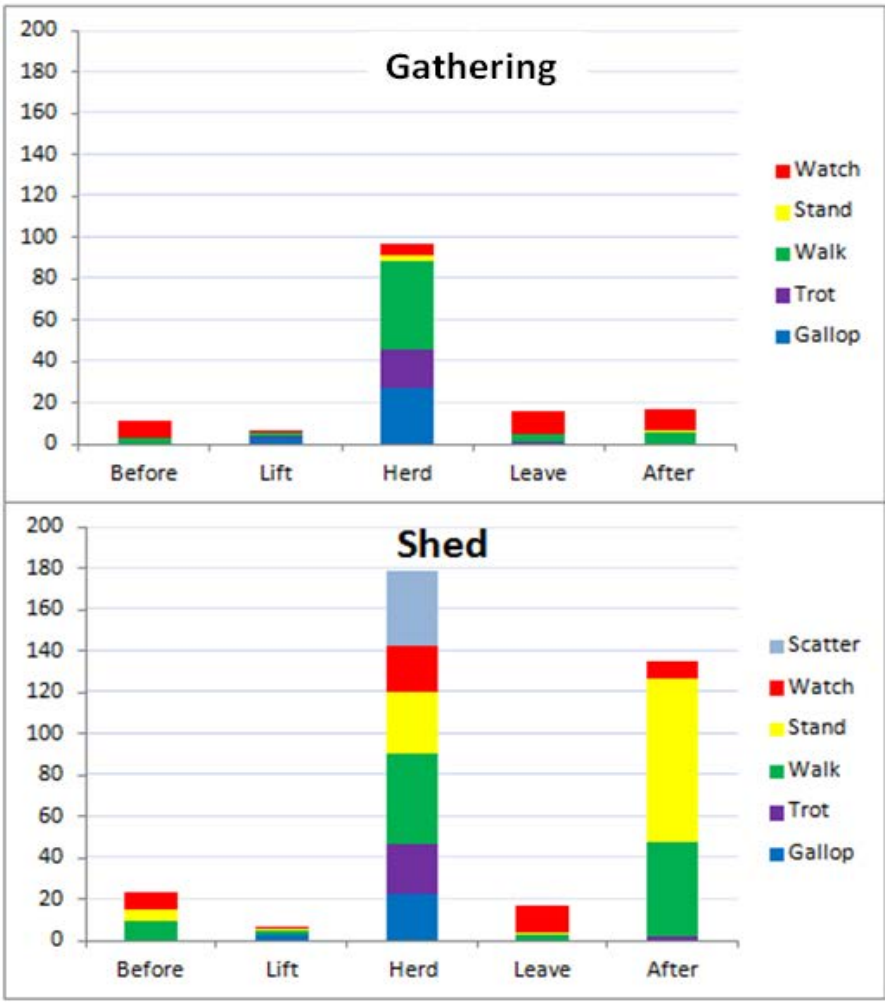

Figure 11. Mean duration in seconds of the studied behaviours expressed by the sheep during the gathering and the shed, (gather n=3, shed n=2).The standard error can be seen in Appendix I.

When comparing the gather with the shed (Figure 11) it can be seen that on average, the behaviour expressed most by the sheep was walking both during the gather and the shedding. The sheep seemed to watch more during the gather during all phases. The ewes did watch more during the phase 'herd' when being shed compared to the gather where they watched after the dogs more during the phase 'leave' and 'after'. When the sheep stopped and watched it could be noted that they also tended to urinate. It could also be noted that when the sheep stopped when being moved they behaved differently depending on the dog. For the dogs that moved them with ease, the sheep within the group switched places with each other even though the group did not move, before the group started moving again. This behaviour could not be seen as clearly when they were being moved by "weaker" or inexperienced dogs because the sheep stood more still. In the phase 'after' during the shed the sheep were standing more after the shed than the gather. The ewes galloped and trotted more during the

gathering. When being shed, the sheep stomped their feet in the ground four times towards the dogs which did not happen during the gathering. No attacks toward the dogs were observed. The dogs spilt the sheep 5 times and four of those times happened during a gathering.

There were not many differences in how the sheep behaved in respect due to if the dog were familiar or not (Figure 12). However, it appeared that the strong-eyed dogs made the sheep walk and watch them more compared to the loose-eyed dogs but loose-eyed dogs seemed to make the sheep trot more than the strong-eyed dogs (Figure 12). The younger dogs appeared to make the sheep gallop, trot and walk more compared to the adult dogs (Figure 12).

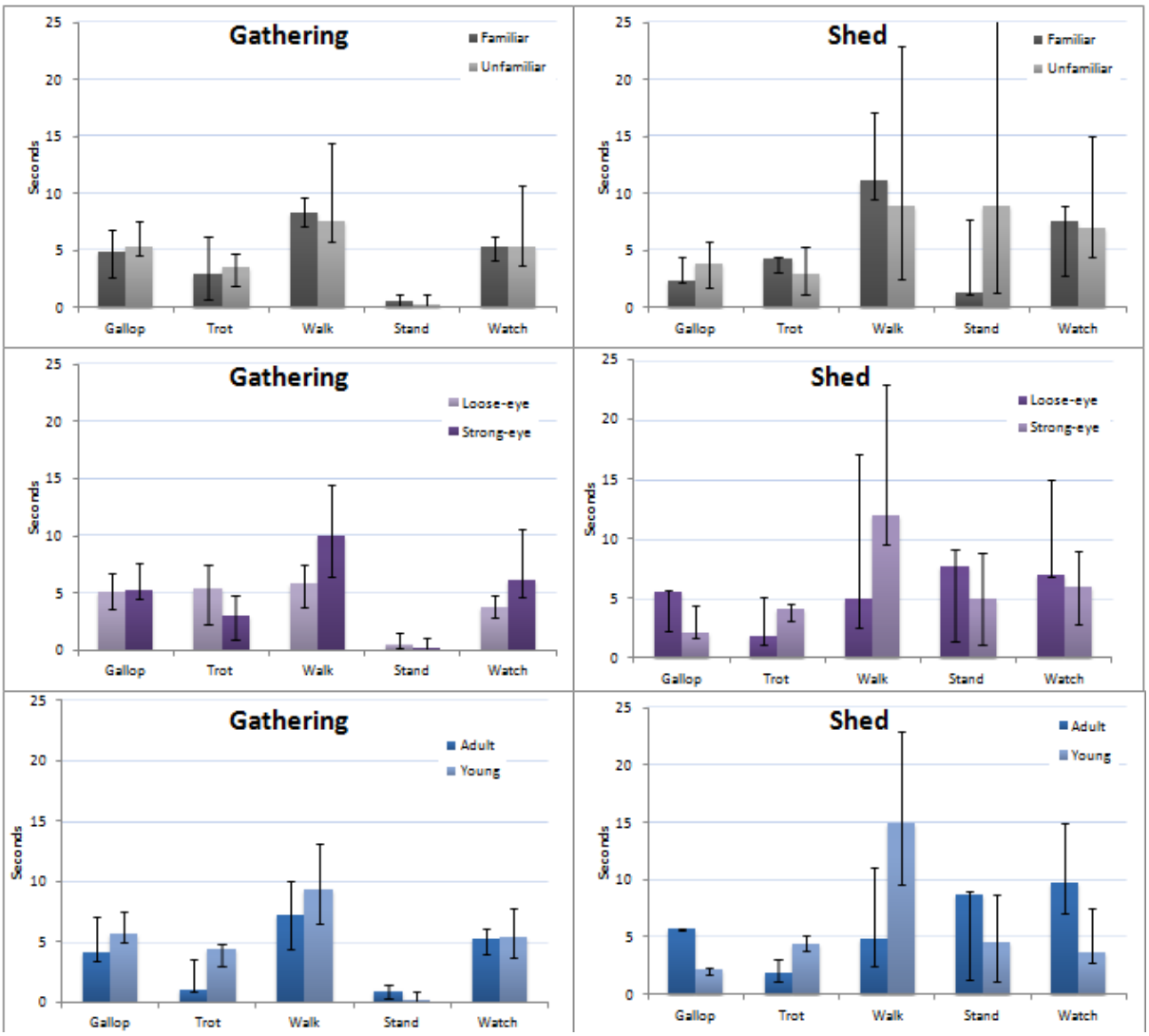

Figure 12. The duration of how the studied behaviours in seconds (median ± Q3, Q1) altered with respect to which type of dog that was herding the sheep. During the gathering, n=3 for familiar dogs; n=7 for unfamiliar dogs; n=3 for loose-eyed dogs; n=7 for strong-eyed dogs; n=4 for adult dogs; n=6 for young dogs. During the shed, n=3 for all categories.

It appeared to be more differences in how the sheep reacted towards the different dogs during the shed. While familiar dogs appeared to make the sheep trot and walk more, the unfamiliar dogs appeared to make the sheep gallop and stand more (Figure 12). The strong-eyed dogs appeared to make the sheep trot and walk more. The loose-eyed dogs made the sheep gallop

and stand more (Figure 12). It appeared as though the adult dogs made the sheep gallop, stand and watch more but the younger dog caused the sheep to walk more (Figure 12).

For how long time it took for the sheep to start grazing/ruminating after the dog left, varied a bit between the different sheep and occasion, as can be seen in figure 13. There was a difference between the gathering and the shed where it appeared to take longer time for the sheep to start grazing/ruminating after a shed compared to after a gathering. The biggest difference between the gathering and the shed could be seen in sheep 1 where it took approximately 100 seconds longer to start grazing again. It took longer time for the sheep to start spreading out and creating distances between them compared to when they started grazing. In figure 12 it can also be seen that the time for them to start spreading varied between the sheep and the occasions. For sheep 3 there was almost no difference between the gathering and the shed. For sheep 1 there was a difference of almost 100 seconds between the gathering and the shed.

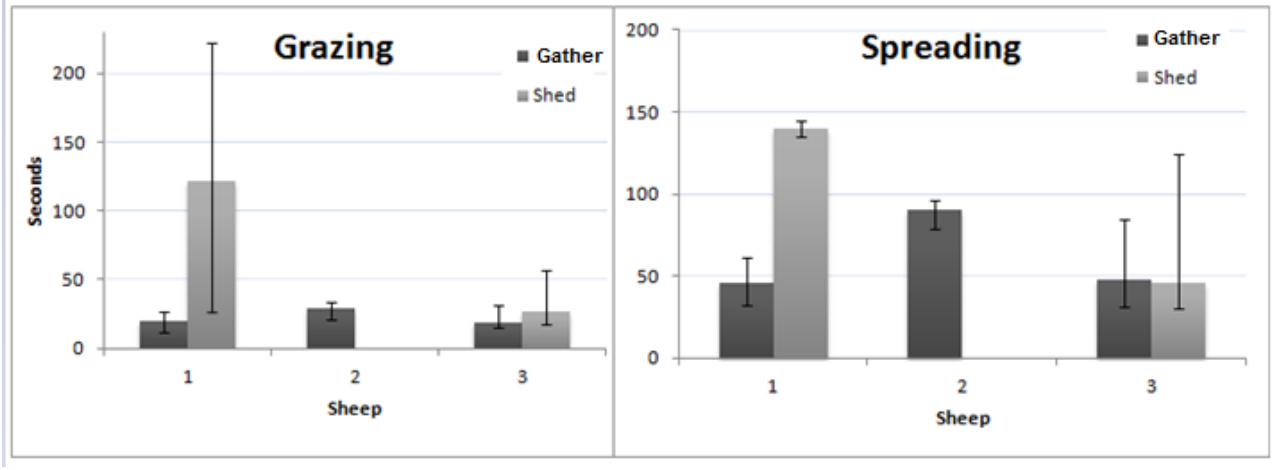

Figure 13. The duration in seconds (median ± Q3, Q1) it took for the sheep to start grazing and start spreading out and creating distances between each other after the dog left. For grazing during the gathering, n=6 for sheep 1 and n=5 for sheep 2 and 3. During the shed, n=4 for sheep 1 and n=5 for sheep 3.

Heart rate

The mean heart rate 200 seconds after the dog left the sheep was after the gathering 108.1 bpm and after the shed 124.5 bpm. Dog G with sheep 2 during the gathering had the lowest heart rate of all interactions, (Figure 14). During the shed, the dog that generated the highest peak of the heart rate was A which is one of the sheep owners own dogs. The dogs B and E also made the heart rates of the sheep increase above 220 bpm. For the other three dogs, D, F and I, the peak heart rate were around 200 bpm. As can be seen in figures 14 and 15, the heart rate increased more during a shed compared to a gathering. During the gathering, the heart rate fluctuated more between the different dogs but during the shed the heart rate raised to above 200 bpm for all dogs, see Appendix II. During the gathering the heart rate varied from 150 bpm to slightly over 200 bpm.

The heart rate increased very fast as soon as the dog approached which in the figures 14 and 15 was at 100 seconds. It can be seen that this happened both at the gathering and the shed.

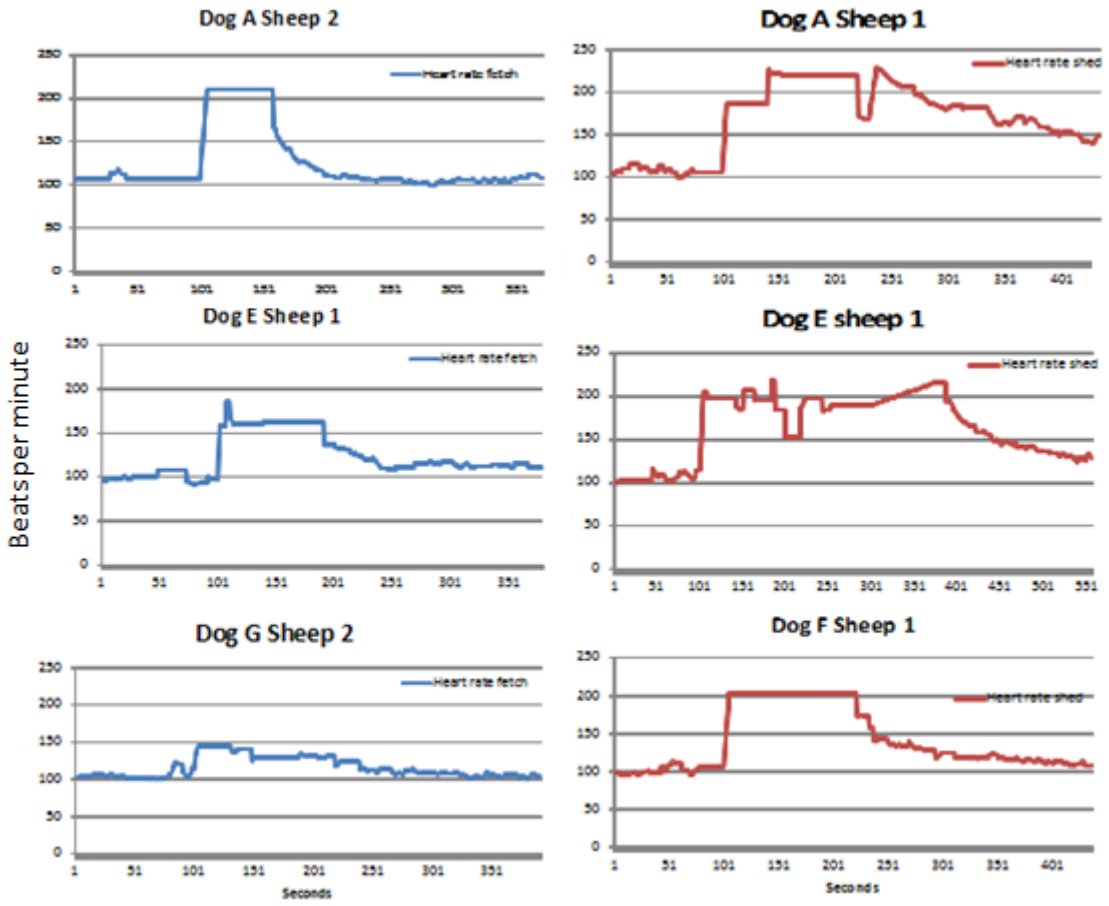

Figure 14. Heart rate (bpm) in sheep when three different dogs performed a gathering and fetch (left diagrams with blue lines) or a shed (right diagrams with red lines).

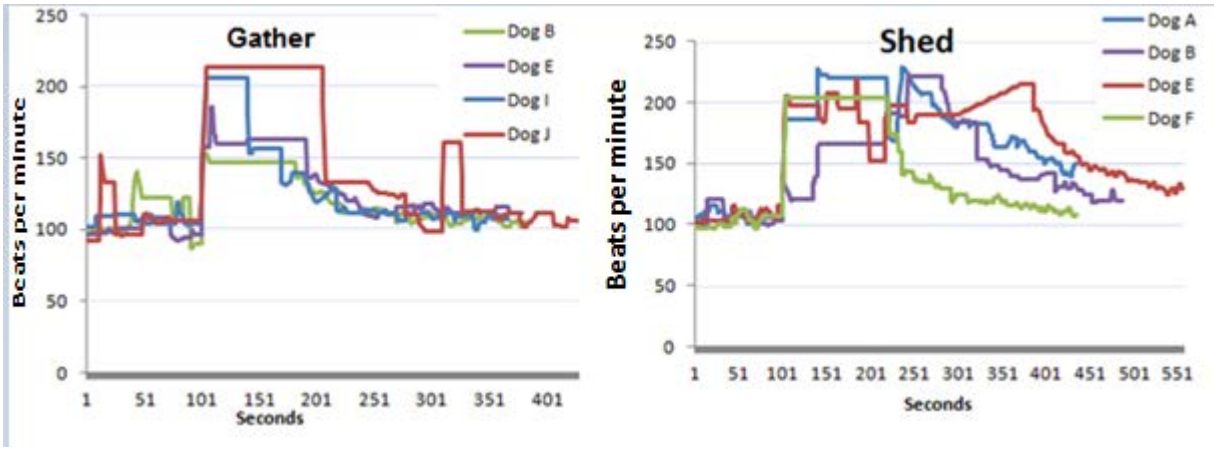

Figure 15. Changes in the heart rate of sheep 1 between four dogs and how the heart rate differed between the gatherings compared to the shed. At 100 seconds the dog approaches.

The average heart rate 200 seconds after the dog left between the individual sheep, did not differ much, see figure 16. The baseline of sheep one was 106 bpm and 200 seconds after the dog left the heart rate was 106 bpm. For sheep 2, the baseline was 109 and after the dog left she had a heart rate of 108 bpm. Sheep 3 was older than the other two sheep therefore she had from the start, a lower heart rate. Her baseline was 96 bpm and after being herded her heart rate was 101 bpm. However between the gathering and the shed, a noticeable difference could be seen where the shed generated higher heart rate. The heart rate peak during the herdings varied a bit between the different sheep. Sheep 1 and 2 had similar average peaks during the gathering but sheep 3 had a higher heart rate during the gathering and during the shed the average peak of the heart rate did not increase more than during the gathering. In sheep 1 the average peak of the heart rate was higher during the shed compared to the gathering.

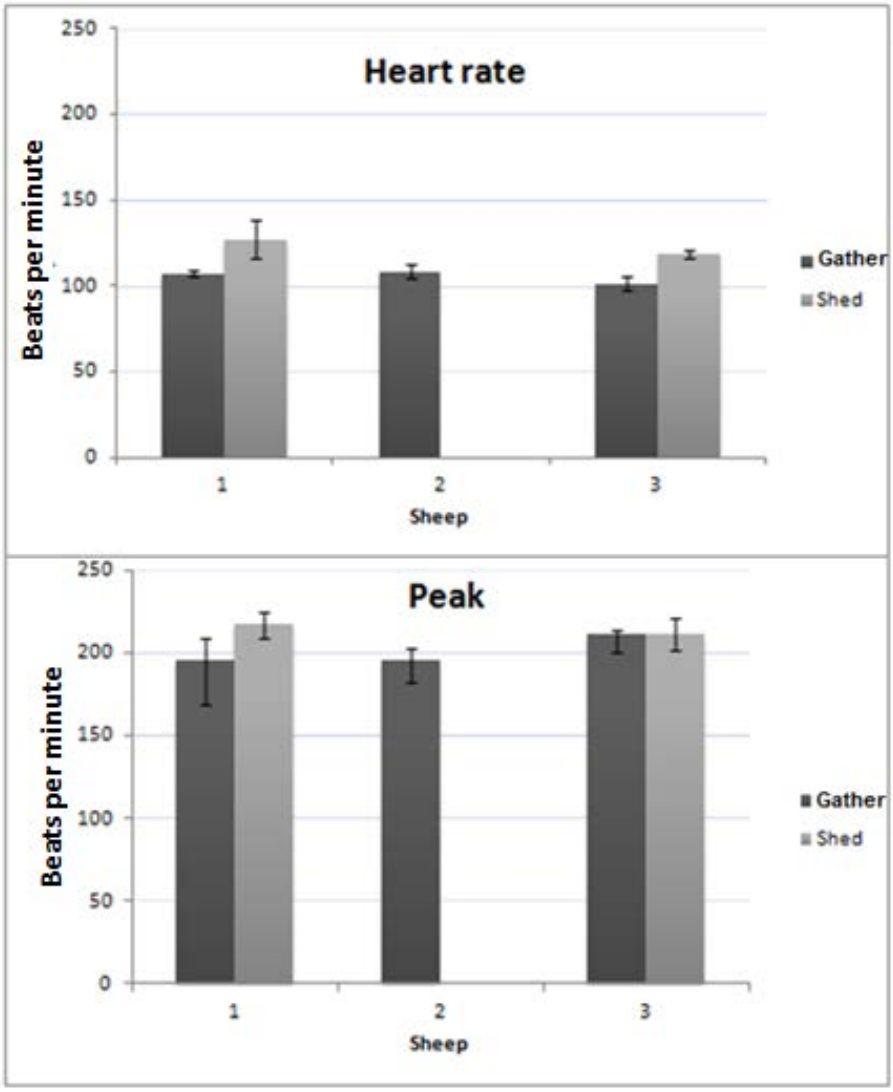

Figure 16. The heart rate (median ± Q3, Q1) 200 seconds after the dog left and the peak of the heart rate (median ± Q3, Q1) for each sheep individually during both the fetch and the shed. During the fetch, n=5 for both sheep 1 and 2, n=4 for sheep 3. During the shed, n=4 for sheep 1 and n=2 for sheep 3.

It could be seen that during the shed, the sheep had consistently higher heart rate but some dogs generated higher heart rates also during the gathering. The overall highest heart rate sheep 1 got during a shed with the dog A and it reached 229 beats per minute, see Appendix II, and the behaviour of both the sheep and the dog can be seen in figure 9. Dog G generated the lowest heart rate in sheep 2 and it reached 145 bpm. Dog B also generated a low heart rate, 147 bpm in sheep 1.

The median heart rate and the peak of the heart rate 200 seconds after the dog left, did not differ much with respect to what kind of background the dogs had (Figure 17). Since there were too few dogs in each category, statistic measurements were not possible to do but the heart rate and the peak of the heart rate appeared to be consistently higher during the shed than during the gathering (Figure 17).

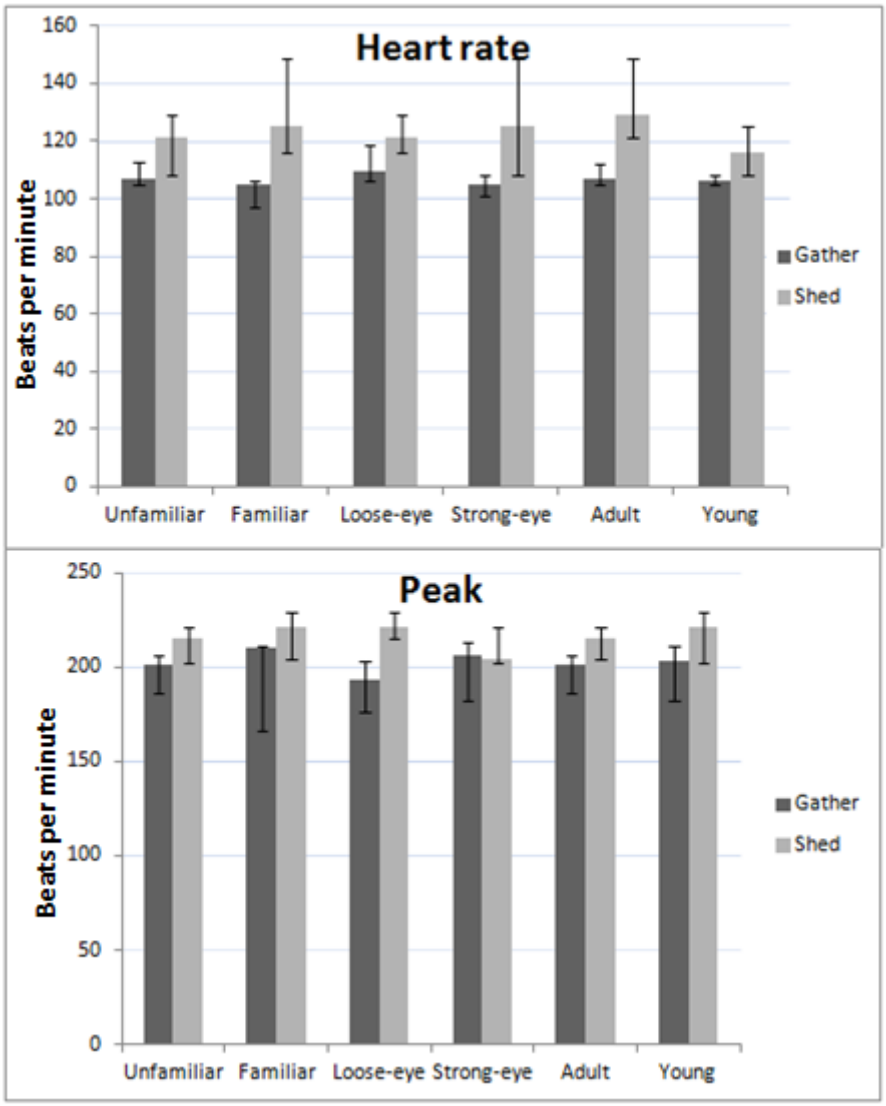

Figure 17. Heart rate (median ± Q3, Q1) in beats per minute 200 seconds after the dog left and the peak of the heart rate (median ± Q3, Q1) for the sheep with respect to different categories the dogs were group into during both the fetch and the shed. During the fetch, n=9 for the unfamiliar dogs, n=5 for the familiar dogs, n=4 for the loose-eyed dogs, n=10 for strong-eyed dogs, n=5 for adult dogs and n=9 for young dogs. During the shed, n=3 for all categories.

Discussion

When being moved by dogs, the sheep may be forced to alter direction and move at a faster pace than they themselves would have chosen. Studies have shown that even though the ewes had been forced to move and therefore suffered from lighter stress, the ability to reproduce and the foetuses were not affected (Laburn *et al.*, 2002; Sejian *et al.*, 2012). This could be an indication that increased movements that occurs when being herded may not be detrimental to the reproduction as long as the sheep will not be driven too hard. Regarding the literature study, it seemed like barking dogs were more stressing compared to just being moved by a dog when looking at the cortisol levels. When in contact with a barking dog, the blood plasma cortisol level increased almost four times (Beausoleil, 2006). In an older study (Kilgour & de Langen, 1970) it was found that when sheep were moved blood plasma cortisol increased about two times, but when being bitten by a dog the levels increased four times compared to baseline. This result indicates that maybe the sheep do not experience the dogs as overtly stressing and frightening as long as they do not bite. However, when being in contact with a human with a rattle, the cortisol levels increased almost as much as in contact with a barking dog (Beausoleil, 2006). This may be a hint that sheep regard humans and dogs the same way; as a potential threat toward them. General weaknesses in most of the studies involving sheep that had been moved or come in contact with dogs were that the authors did not state whether the sheep were used to be around dogs. Even if they were used to dogs, a new dog can also be stressing for the sheep if they are not used to being in contact with unfamiliar dogs. In the study made by Kilgour and de Langen (1970), the cortisol levels were lower compared to the other studies (Beausoleil, 2006; Yardimci *et al.*, 2013) (Table 1) and a reason for this may be that this study is much older and therefore other measurement techniques were used.

The behaviour of the dogs

Dog A sometimes galloped after the sheep really fast which made the sheep run away from the dog. In these sequences it looked more like the dog chased the sheep instead of herding them. This is probably the reason why this dog generated the highest heart rate even though the dog was familiar for the sheep. Also dog B exhibited this behaviour a few times but since she was generally calmer, the sheep did not seem to react so strongly when she came towards them.

Dog E was quite obedient when it came to the command ‘lie down’ but did not seem to want to ‘flank’ (he did not want to go sideways from the sheep). He made the sheep run away from him, probably because he often did sudden movements with his head and if lying down he jumped up quickly and started galloping towards the sheep before walking more slowly. Dog A and E were both reported by their handlers to previously have gripped/bitten uncontrollably at the sheep and both of them were from time to time uncooperative towards the handler, dog A did not always stop and dog E did not always ‘flank’ on commands. This corresponds to what Arvelius (2005) found about dogs that gripped tended to be hard to control. Dog A and E did not however, exhibit any gripping during this study.

Dog C was a strong dog that moved the sheep with ease and since he was very obedient towards his handler and also adjusted the distance between him and the sheep by himself, the sheep mostly walk calmly before him. Dog F was another strong dog that moved the sheep

with ease, but he was not as obedient and did not by himself adjust the distance between him and the sheep, which is probably a reason why the sheep run more for him compared to dog C. Dog I was not so trained and obedient and sometimes he ran fast around the sheep. It looked like he did it when he could not get the sheep to move or did not understood what was asked from him by the handler.

The behaviour of the sheep

After the dogs finished the 'outrun' (the initial movement by the dog to gather the sheep) behind the sheep they started to approach the sheep during the 'lift' (to get the sheep to start walking toward the handler). When coming closer to the sheep most of the dogs slowed down and/or lied down before continuing to stalk after the sheep. However some of the dogs never stopped or slowed down, they just continued galloping toward the sheep which made the sheep start to also galloping away. Therefore if the sheep should walk calmly away when the dog approaches it seems prudent that the dog in turn approaches calmly. When a dog approached the sheep they became watchful and when the dog came closer they flocked together which coincides with what Baldock and Sibly (1990) found. These findings match how sheep reacted to both Border collies and wolves by flocking to both (Manning & Dawkins, 1998), which may be an indication that the sheep can experience trained sheepdogs as predators. There was a variation between the dogs at what distance that they started to affect the sheep when approaching them during the lift. This however, would require further studies with other equipment than what was used in this study.

When the sheep stopped and watched the dog during herding it looked like they were testing the dogs' ability to make the sheep move and/or apprehensive towards the intentions of the dog depending on how the dog behaved. With the dogs that moved the sheep with ease, the sheep did not stand still for so long and even though the group did not move, the sheep switched places with each other. If the dog was not so strong (being able to move the sheep with ease) or experienced the sheep stood the ground more and did not move around so much within the group and the dog had to come closer to the sheep before they started to move again. A reason for this behaviour may have been that the dominant sheep wanted to put more distant to the threat, so called selfish herd theory (Hamilton, 1971). The sheep watched the dogs more during the phase 'herd' when being shed. A reason for this could have been that the dogs were in closer contact with the sheep which the sheep may have found uncomfortable.

When the handler called the dog off the sheep reacted instantly, often by stopping any locomotor activities and just watched after the dog when the dog left. This behaviour correlates to what Mech (1970) found about wild caribous and wolves. Mech (1970) found that wolves could walk among the caribous without them reacting to the wolves when the wolves seemingly did not care about the caribous. When Dog C stopped and watched its handler for a second the sheep started to gallop away from the dog (Figure 9). This suggests that the sheep are very sensitive towards the dog which may be a good thing to keep in mind when using sheepdogs to move stock. It could be observed that the sheep in this study tended to urinate when the dog left them but they also urinated if they stopped during being moved

by dogs. Romeyer and Bouissou (1992) found that sheep urinate more in the presence of predators so this could indicate that the sheep see the dog as a threat.

In this study the sheep used a longer time in the phase 'after' to stand when the shed was finished but during the gathering the sheep watched more compared to during the shed. A reason for the sheep to stand together could have been that they did not feel safe to start to spread out and start to graze. During the shed the sheep walked more during this period but this was likely because they walked back to their silage.

The sheep watched the familiar and unfamiliar dogs just as much but there was a larger variation for the unfamiliar dogs which can indicate that the sheep actually watched the unfamiliar dogs more depending on which dogs that was moving them. The shed had similar results but the sheep watched the familiar dogs slightly more. A reason for this could have been that the sheep knew how the familiar dogs would act and since especially one of them were quite forceful when interacting with the sheep they became vary, but the unfamiliar dogs still had a larger variation. The sheep also stood still more during the shed, especially after the dog left which may be an indication that the sheep did not feel safe to start behaving like they normally would do without the presence of a predator, like grazing and ruminating.

The differences in the behaviour of the sheep when comparing loose-eyed dogs to strong-eyed dogs were as the literature described (Jones & Collins, 1993; Rorem, 214; SSS, 2014) because the loose-eyed dogs made the sheep run more and the strong-eyed dogs made the sheep walk more. This is consistent with loose-eyed dogs wanting to keep the sheep in motion and strong-eyed dogs wanting to keep the sheep still. During the gathering the sheep watched the strong-eyed dogs more and a reason for this could be that these kind of dogs behave more like a predator would by stalking and using an intense gaze (eyeing) and Coppinger *et al.* (1987) found that by using this behaviour Border collies influence the sheep in the same way as juvenile coyotes and wolves do. During the shed, contrary to the gathering, the sheep watched the loose-eyed dogs more but this could be because the loose-eyed dogs were not so experienced with shedding, with two out of three dogs had never shed before, and maybe therefore they gave mixed signals which may have confused the sheep.

The young dogs during the gathering made the sheep exhibit more of all the studied behaviour except standing. A reason for this could have been simply because it took longer time for the younger dogs to complete the given task. During the shed the adult dogs made the sheep gallop, stand and watch more which may be an indication of that the sheep found the adult dogs more intimidating. However it is important to note that the adult dogs in this study during the shed, two of them were loose-eyed and the third dog was strong-eyed, tended to gallop after the sheep which made the sheep gallop away from the dog.

It varied between the three ewes how long time it took for them to start grazing and spreading out after the dog left but the shed generated longer time for the sheep to start relaxing again and a reason for this could possibly be that the sheep found the shedding more stressing.

In this study the results indicates that the sheep were able to discriminate between the dogs when they had been in contact with them. Dog A was a familiar dog but they still reacted in a

negative way by trying to run away which corresponds to what Fell & Shutt (1989) and Boivin *et al.* (1997) found about how sheep can discriminate between human handlers depending on if the contact had been pleasant or not.

Heart rate

Much like the study conducted by MacArthur *et al.* (1979), it could be seen that the heart rate on most of the occasions had returned to the baseline 200 seconds after the dog left after the gathering. Also in the study of Hansen *et al.* (2001) the heart rate went back to baseline under 200 seconds when the sheep had encountered a man with a dog. Contrary to their findings Baldock and Sibly (1990) found that the heart rate after 30 minutes was still higher than before the sheep were moved. This discrepancy may be because in Baldock and Sibly's (1990) study they did not mention if the sheep were resting in the beginning and maybe grazing later. Before the sheep were moved they had a heart rate of 80 bpm which is normal for resting and 30 minutes after being moved they had a heart rate of 111 bpm which is similar to the heart rates found in the present study when the sheep were grazing, often less than 200 seconds after the dog left. The study of Baldock and Sibly (1990) also did not mention what pace the sheep were moved at, if the sheep were used to being moved by a dog and if they were, if the dog used was of a similar type that they were familiar to.

The heart rate of the sheep in this study was overall higher during and after the shed compared to during and after the gathering. This could have been because the sheep found the shed more stressing. Another reason could be because during the shed the sheep-dog interaction were slightly longer compared to the gathering. However, by comparing the behaviour of the sheep, they showed more stressing and antipredatory behaviours like stomping in the ground and watching more after the dogs during the shed compared to the gathering. That they exhibited more fearful behaviours during the shed was not that surprising since sheep experience great stress if they get separated from their herd (Price & Thos, 1980; Cockram *et al.*, 1994) and that combined with the presence of predators, both human and a dog, would increase the risk that the sheep would get stressed.

The heart rate of the sheep regarding the categories of the dogs did not differ much but what was slightly surprising was that the familiar dogs generated higher peaks of the heart rate during the shed than the unfamiliar dogs. A reason for this may be that the sheep found dog A more stressful than any of the other dogs because fog A run after the sheep therefore making the sheep run more. Dog G and dog B generated the lowest heart rates in the sheep, both during the gathering. These dogs were calm and did no noticeable sudden movements around the sheep and it was probably therefore the sheep did not run so much. Dog G was not familiar for the sheep while dog B was. This may indicate that it is the behaviour of the dogs that is the most important thing when trying to reduce the stress for the sheep.

Further studies

Studies have shown that prenatally stressed lambs had higher birth weights (Piccione *et al.* 2002; Roussel *et al.*, 2004; Corner *et al.*, 2007; deNicolo *et al.*, 2008). Dalton *et al.* (1980) found that lambs which were underweight at birth had a higher mortality rate. This might be an indication that a little stress caused by the use of dogs during gestation can be positive on

the lamb survival, especially if the pregnant ewes live under less than optimal conditions, but this would need further investigation. Another subject to study in the future would be how sheepdogs affect production. If the farmer has a dog that stresses the sheep much how would that influence the embryonic mortality, the lamb survival and growth and the quality of the wool?

To further study the differences how different dogs affect the sheep in various ways, it seem to be better to use a gathering than a shed according to this study since a larger variation could be found during the gathering, probably because they felt less stressed and nervous during this compared to the shed and therefore they distinguished more between the different dogs. Studies should also be made to further evaluate how the sheep are experiencing a shed because in this study there were indications that the sheep found the shed stressing and since it is a common component in trials it could be a good idea to study the effect it has on the sheep more.

A source of errors in this study was that the dog was not always completely visible in the video films which were a problem when the dog started to affect the sheep at a long distance because it was impossible to catch both dog and sheep on the film then. The tripod on which the camera was mounted was sometimes difficult to turn which made it hard to keep up when the animals were moving. Since the animals sometimes were far away from the camera, and it was not possible to zoom because then the sheep or the dog would have been out of sight, more subtle behaviours could not be recorded. Even if the animals were near the camera those subtle behaviours were missed if the animal were positioned in the wrong direction from the camera. The urinating was not recorded because when the sheep were around 100 meters away and in a flock it was difficult to observe if they urinated and also which ewe that did it. If doing this study again at least two video cameras should be used to be able to keep track of both the sheep and the dog from different angles.

The fact that the study took place in to different pastures could have affected the results but since the sheep were used to both pastures both for grazing and training with dogs, it was deemed better to use the smaller pasture for shedding. A reason for that was if the dog and handler lost control over the sheep they would not be able to run so far away, making it more difficult to complete a shed and probably stressing the sheep more.

One parameter that was not taken into account was how much experience the handler had which can have had an effect on how the dogs behaved. An inexperienced handler may not give the right command to the dog in time which could be seen in the films. It was also slightly problematic to look at how long time it took for the sheep to start spreading out after the dog left because the sheep did not start creating distances from each other if they were ruminating. Another problem in this study was that it was unnecessarily difficult to compare the dogs when the numbers in each category of dogs and sheep-dog interactions were different. It would have been better to have the same number of dogs of each category, for instance the same amount of loose-eyed dogs as the strong-eyed dogs.

Conclusion

The conclusion of this study was that there seem to be differences in how dogs with different background, but also with similar background, affect the sheep. The heart rate was higher after the shed compared to the gathering which may indicate that these sheep found the shed more stressful than the gathering. The behaviour the sheep expressed during the shed supports this. However, the most important thing seemed to be how the dog behaved towards the sheep, not if the dogs was familiar or not, loose-eyed or strong-eyed or even the age of the dogs. Calm dogs resulted in calm sheep.

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Personal communication

Bohlin Jasna. 2015.01.07

Appendix I.

This table shows the standard error for the studied behaviours expressed by the sheep when being moved by dogs.

Moment	Phase	Gallop	Trot	Stalk	Lie	Stand	Flank	Wear	Outrun	Between
Gather	Before	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00
Gather	Lift	0.39	0.05	0.77	0.42	0.14	0.00	0.00	0.00	0.00
Gather	Herd	2.19	0.74	8.52	7.41	1.53	3.21	1.96	0.00	0.00
Gather	Leave	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gather	After	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shed	Before	0.00	0.00	2.23	0.00	0.00	0.00	0.00	3.40	0.00
Shed	Lift	0.81	0.28	1.68	0.74	0.65	0.00	0.00	0.00	0.00
Shed	Herd	3.62	2.45	7.76	18.29	3.78	10.24	0.00	0.00	9.99
Shed	Leave	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shed	After	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Moment	Phase	Subject	Gallop	Trot	Walk	Stand	Watch	Scatter
Gather	Before	Sheep	0.00	0.00	1.20	0.35	2.64	0.00
Gather	Lift	Sheep	1.02	0.83	0.54	0.38	0.89	0.00
Gather	Herd	Sheep	4.25	3.45	11.53	1.22	1.93	0.00
Gather	Leave	Sheep	0.28	0.12	1.08	0.00	5.87	0.00
Gather	After	Sheep	0.00	0.00	1.97	0.34	3.10	0.00
Shed	Before	Sheep	0.20	0.25	3.29	2.87	3.61	0.00
Shed	Lift	Sheep	1.96	0.36	0.67	0.37	1.00	0.00
Shed	Herd	Sheep	7.15	4.38	12.13	9.99	5.97	0.00
Shed	Leave	Sheep	0.00	0.31	1.42	0.23	4.79	11.14
Shed	After	Sheep	0.38	0.95	11.44	52.46	3.37	0.00

Appendix II.

This table show the length of the herding, how long time it took for the sheep to start spreading out and grazing/ruminating after the dog left, the peak of the heart rate during being herded and the heart rate 200 seconds after the dog left for each individual dog and herding.

			Number of seconds after the dog leaves				Beats per minute	
Sheep	**Dog**	**Moment**	**Length of herding**	**Spread**	**Graze**	**Ruminate**	**Heart rate peak**	**Heart rate**
	H	Gather	139	95.86	30.89	-	196	121
	C	Gather	96	109.78	29.1	-	212	119
	J	Gather	144	78.48	47.82	-	196	105
2	G	Gather	91	54.62	21.19	-	145	105
	A	Gather	72	173.14	16.25	-	210	108
	H	Gather	200	-	-	36.36	210	105
	C	Gather	111	71.67	28.26	-	152	110
not sheared	F	Gather	125	60.85	21.59	-	184	108
	I	Gather	66	32.3	11.34	-	206	107
	J	Gather	131	60.93	26.36	-	213	107
1	B	Gather	84	54.25	26.56	-	147	105
	E	Gather	79	37.53	4.67	-	186	112
	A	Gather	83	90.75	41.54	-	-	-
not sheared	F	Gather	94	30.23	12.35	-	-	-
	A	Gather	69	-	-	45.18	220	87
	B	Gather	94	-	-	-	211	97
3	D	Gather	118	31.39	14.61	-	166	106
	F	Gather	72	84.42	-	18,42	214	101
	E	Gather	98	47.38	30.76	-	201	125
not sheared	I	Gather	99	-	-	67	194	89
	A	Shed	271	-	21.59	-	-	-
	F	Shed	75	-	136.7	-	-	-
	B	Shed	75	-	35.9	-	-	-
13134	E	Shed	115	134.87	22.46	-	-	-
	A	Shed	134	144.14	37.48	-	229	155
	E	Shed	257	-	405.0	-	215	122
	B	Shed	188	-	11.11	-	221	125
sheared	F	Shed	136	-	-	324.12	204	108
	D	Shed	108	188.75	57.65	-	202	116
13075	E	Shed	129	59.33	-	26.83	221	121
	B	Shed	133	29.0	17.02	-	-	-
	F	Shed	157	32.3	8.95	-	-	-
sheared	I	Shed	79	-	57.03	-	-	-

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