Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Sciences

The impact of gastrointestinal parasites on weight gain, activity patterns and behaviours in cattle on pasture

Gastrointestinala parasiters inverkan på tillväxt, aktivitetsnivå och beteende hos nötkreatur på bete

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Summary

Infections caused by gastrointestinal parasites are one of the most problematic health concerns for cattle all around the world. These parasites may cause a wide range of health problems ranging from subclinical disease to actual death. Animals infected with parasites usually respond to sickness with predictable pattern of behavioural changes. The aim with this master thesis was therefore to evaluate whether there were any differences in behaviour, activity patterns and weight gain between animals given a dose of parasites and animals treated with anthelmintics.

The study was performed at Götala Beef and Lamb Research Centre outside Skara, between 18 May and 15 September in 2016. The research animals consisted of 63 steers, where 31 of them were of dairy breed (Swedish Holstein, SLB, or Swedish Red, SRB) and the other 32 steers were crossbred animals (SLB/Charolais and SRB/Charolais). Two pastures were used consisting of permanent semi-natural pastures. The animals were divided into two separate groups with 31 and 32 animals in each group, where each group consisted of half purebred and half crossbred steers. One group of steers were given an oral dose of the parasites *Ostertagia ostertagi* and *Cooperia oncophora* while the other group was treated with anthelmintics. The body weight recordings were performed bi-weekly on Tuesdays and consisted of 10 weighing periods during the summer. In order to measure the activity patterns IceTags were placed on 20 animals, 10 in each group. The behaviours of each group of steers were recorded using direct observations that were performed during selected weeks with start in May. Mean number ± SE was calculated in percentages for each category of behaviour.

The current study revealed that parasitized steers had a lower weight gain throughout the pasture period than steers treated with anthelmintics ($P<0.005$). The average daily weight gain during different periods throughout the pasture period was significantly affected by treatment ($P<0.0001$) and period ($P<0.0001$). Anthelmintic treated steers had a higher mean daily weight gain during 31 May-14 Jun ($P<0.0001$), 29 Jun-12 Jul ($P<0.0001$) and 6-20 Sep ($P<0.05$) than infected steers. Significant interactions between period and treatment were also found on motion index and the number of steps taken, where the motion index ($P= 0.0005$) and the number of steps taken ($P<0.05$) was significantly higher in steers treated with anthelmintics. Significant interactions between period and treatment were also found on the number of lying bouts as well as the duration of lying and standing. The number of lying bouts was higher in steers infected with parasites ($P<0.05$) during 12-26 July. The duration of standing were higher in parasitized steers ($P<0.05$), while the duration of lying were higher in the anthelmintic treated steers ($P<0.05$) during 9-23 August. The results from the behavioural observation showed a different result where the infected steers appeared to walk more and lie less, which contradicts with the results from the IceTags. Moreover, social behaviours such as sniffing and licking others appeared to occur more frequently in steers with high parasite load than in steers with low parasite load. This study demonstrated that gastrointestinal parasites in steers at pasture cause a reduced daily weight gain and a decreased general activity level per 24 h, but an increased general activity level during day time.

Sammanfattning

Infektioner orsakade av gastrointestinala parasiter är ett av de mest problematiska hälsoproblemen hos nötkreatur runt om i världen. Denna typ av parasiter kan orsaka en rad olika hälsoproblem som sträcker sig från subklinisk sjukdom till en faktisk död. Djur som drabbas av infektioner orsakade av parasiter svarar generellt genom beteendemässiga förändringar. Syftet med denna studie var därför att utvärdera om det fanns några skillnader i beteende, aktivitetsnivå och tillväxt hos stutar som tilldelats en oral dos parasiter och de stutar som behandlats med avmaskningsmedel.

Studien genomfördes vid Götala nöt- och lammköttscentrum utanför Skara mellan 18 maj och 15 september, 2016. I studien användes totalt 63 stutar, varav 31 var av mjölkras (SLB eller SRB) och 32 var korsningar (SLB/charolais och SRB/charolais). Två beten användes där betesmarkerna nästan uteslutande bestod av naturbetesmarker. Stutarna delades in i två grupper med 31 respektive 32 stutar i varje grupp, där varje grupp bestod av hälften mjölkras och hälften korsningar. Ena gruppen tilldelades en oral dos innehållande parasiterna *Ostertagia ostertagi och Cooperia oncophora*, medan återstående grupp behandlades med avmaskningsmedel. Insamling av vikter för samtliga stutar utfördes varannan vecka på tisdagar och bestod av 10 vägnings perioder under sommaren. Aktivitetsnivån mättes genom användningen av IceTags som tilldelades 20 stutar, 10 i varje grupp. Beteendet hos stutarna dokumenterades genom direkta observationer som utfördes under utvalda veckor med start i maj månad. För de direkta observationerna beräknades medelvärden ± SE för varje kategori av beteende.

Studien visade att infekterade stutar hade en lägre tillväxt under hela betesperioden till skillnad från stutar behandlade med avmaskningsmedel ($P<0,005$). Den genomsnittliga tillväxten per dag påverkades signifikant av både behandling ($P<0,0001$) och period ($P<0,0001$). Stutar behandlade med avmaskningsmedel hade en större tillväxt per dag under 31 maj-14 jun ($P<0,0001$), 29 jun-12 jul ($P<0,0001$) och 6-20 sep ($P<0,05$) till skillnad från infekterade stutar. Studien visade även på signifikanta skillnader mellan period och behandling gällande rörelseindex samt på antalet steg, där rörelseindex ($P= 0,0005$) och antalet steg ($P<0,05$) var signifikant högre hos stutar behandlade med avmaskningsmedel. Signifikanta skillnader fanns även mellan behandling och period på antalet liggomgångar och ligg- och stå varaktigheten. Antalet liggomgångar visades vara högre hos infekterade stutar ($P<0,05$) under 12-26 juli. Varaktigheten var högst hos de infekterade stutarna vid stående position ($P<0,05$), och varaktigheten för liggande position var högre hos stutar behandlade med avmaskningsmedel ($P<0,05$) under 9-23 augusti. Beteendestudien visade ett annorlunda resultat där de infekterade stutarna föreföll röra sig mer och ligga ner mindre, vilket motsäger resultaten från Icetagsutrustningen. Sociala beteenden, som nosa och putsa andra individer, verkade förekomma mer frekvent hos stutar med hög parasitbelastning. Studien visade att gastrointestinala parasiter hos stutar på bete orsakar en reducerad tillväxt samt en minskad generell aktivitetsnivå per 24 h, men en generell ökning av aktivitetsnivån under dagtid.

Introduction

Since herbivory is a well-known route for parasite transmission cattle are in considerable risk of parasitic infections during the pasture period. Many species of gastrointestinal parasites are shed to the environment through mammalian faeces and transmitted to the animal during grazing. The surrounding herbage is therefore regularly contaminated with infective third stage larvae (Hutchings et al., 2003). Due to the negative effects on performance and wellbeing of grazing cattle gastrointestinal parasites are of major concerns during the pasture period. These negative effects are associated with economical losses ranging from costs of anthelmintics to significant declines in daily weight gains (Fiel et al., 2012).

Animals infected with parasites usually respond to sickness with predictable pattern of behavioural changes. These changes typically involve inappetence, reduced social behaviour and increased rest (Hart, 1988; Szyszka et al., 2013). Since behavioural changes may be the first observable signs of illness when an animal is infected with intestinal parasites these changes may have a diagnostic value. These changes may have significant importance due to the exposure of any clinical signs of sickness and distress before the breakout (Szyszka et al., 2013). Except from the behavioural changes, performance may also be a useful indicator of parasite infections as well as the wellbeing of the animal. Illness often results in reduced feed intake and consequently poor growth which is due to the increased metabolic and nutritional demands caused by parasites (Kyriazakis et al., 1998).

A reduction in feed intake along with impaired growth is well documented as a consequence of sub-clinical parasitism in cattle and other ruminants (Fox et al., 1989; Taylor et al., 1989; Kyriazakis et al., 1998; Forbes et al., 2004; Szyszka et al., 2013). Similarly activity levels and postures, such as number of steps taken and standing behaviour, have been found to be affected by parasitism. In general, the activity levels in parasitized animals frequently are decreased when faced with a parasitic health trial. For instance parasitized animals tend to lie more and move less (Szyszka et al., 2013).

In order to improve the profitability of the production and to avoid deterioration of animal welfare cattle production need to control infections caused by intestinal parasites. This is often achieved through the use of anthelmintics (Gasbarre et al., 2001).

Literature review

The natural behaviour in cattle while on pasture

On pasture cattle normally spend approximately 95 % of their time engaged in the main behaviours such as grazing, ruminating and resting. Behaviours such as ruminating and resting generally are performed during either lying or standing (Kilgour et al., 2012). The behaviour shown to be allocated the most time amongst cattle is grazing (Linnane et al., 2001; Kilgour et al., 2012). According to Kilgour et al. (2012) cattle spend on average 6.1 hours on grazing during the hours of daylight. However in the individual herds the grazing time ranged from 5.0-7.3 hours. A former study reported that the grazing time occupied approximately 10-11 hours each day (Hall, 1989). In contrary, the animals were observed during both day and night, hence the difference in grazing time between these two studies. Linnane et al. (2001) had comparable data where the cattle grazing times were found to be 10-11 hours per day. In general the main grazing time occurs during daytime with peak periods occurring during sunset and sunrise. Cattle are crepuscular animals which may explain the peak periods around sunrise and sunset (Linnane et al., 2001). The grazing intensity has been shown to be slightly higher at sunrise (61-79 %) than sunset (50-73 %). A smaller grazing percentage also occurred during the middle of the day, primarily during the period 10.00 to 13.00 (Kilgour et al., 2012).

In relation to the grazing behaviour that mainly is performed during daytime the average duration of ruminating occurs primarily at night (Hall, 1989). Cattle spend in general 6-7 hours per day ruminating where each period lasts for approximately 45 minutes (Kilgour, 2012). The major part of the rumination is performed while lying down, but might also be performed while doing other activities such as standing or walking (Hall, 1989; Kilgour, 2012).

Allogrooming is an important behaviour amongst cattle due to the communicative and social function. According to Laister et al. (2011) social licking have been described as a positive social behaviour performed either spontaneously or after agonistic interactions. Social licking has been suggested as a positive behaviour with several functions. Except from the hygienic effects social licking also contribute to establishing and maintaining bonds between individuals (Laister et al. (2011). According to observations by Sato et al. (1991) social licking was not only performed by dominant animals but also the subordinated animals. The solicited licking was mainly oriented to the head and neck while unsolicited licking also was directed to the back and rump (Sato et al., 1991). However self-grooming is also considered important due to its reflections of a good general health and wellbeing of the animals (Albright and Arave, 1997).

Despite the fact that cattle have the possibility to perform a normal behaviour while on pasture, they might be faced with a health challenge in terms of parasite infections which may cause changes in their behaviour (Szyszka et al., 2013).

Gastrointestinal parasites in cattle

Infections caused by gastrointestinal parasites are one of the most problematic health concerns for cattle all around the world. Gastrointestinal parasites might cause a wide range of health problems ranging from subclinical disease to actual death, depending primarily on the parasitic load and the general health of the animal (Schutz et al., 2012). Impaired performance has also been demonstrated as a consequence of parasite burden (Fox, 1993; Forbes et al., 2004; Szyszka et al., 2013). Even though there are several important pasture-borne intestinal parasites, *Ostertagia ostertagi* and *Cooperia oncophora* are considered to be the two most economically important parasites in temperate parts of the world (Fiel et al., 2012). *O. ostertagi* and *C. oncophora* infects the abomasum and the small intestine respectively and the infection usually cause signs of disease (Lützelschwab et al., 2005), where a changed behaviour might be the first obvious sign (Szyszka et al., 2013). Larvae of *O. ostertagi* and *C. oncophora* are almost found on all pastures where cattle are grazing and therefore virtually all cattle are infected (Nilsson and Sorelius, 1973).

Life cycle

In grazing cattle *O. ostertagi* and *C. oncophora* normally occurs as mixed infections. These parasites have a direct life cycle with a free-living phase outside the host and an internal phase inside the host (see figure 1). The internal phase, also called parasitic phase, starts when the animal is infected with third-stage larvae (L3) through ingested herbage (1). The ingested larvae then travel to the abomasum or small intestine, which is their operative site. In the abomasum or the small intestine the larvae develop into fourth and fifth stage larvae to become mature adult worms in order to retain the life cycle with new offspring (2). The produced parasite eggs are subsequently voided with the faeces from the infected animal to the surrounding pasture (3). Each egg, which contains first stage larvae hatches and matures within the faeces in order to become third stage larvae (4, 5). The matured L3 larvae are then transmitted to the surrounding herbage where they either are ingested by an animal or die. In this manner the life cycle can remain complete and in constant progress (Fiel et al., 2012).

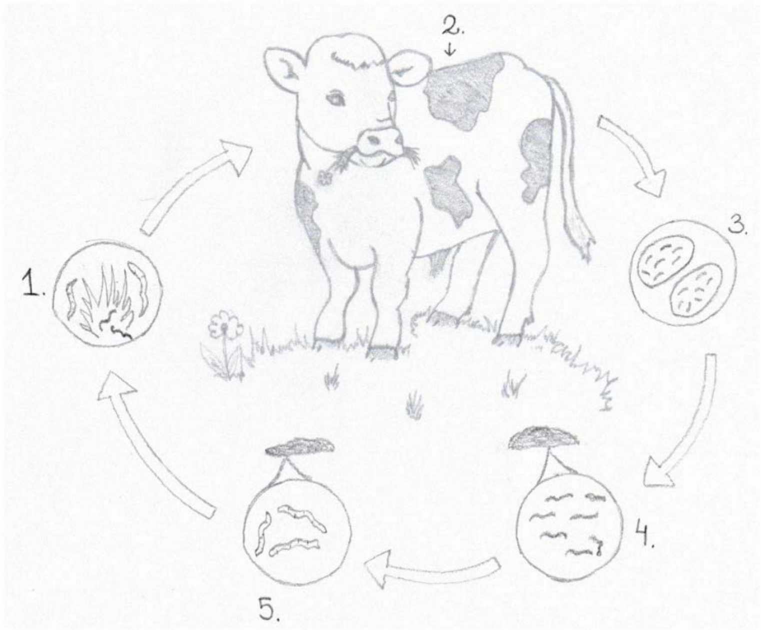


Figure 1. Schematic picture describing the life cycle of *Ostertagia ostertagi* and *Cooperia oncophora*. The life cycle starts when L3 larvae are ingested with the herbage by the animal and remain complete when these larvae then produce new offspring that are shed with the faeces in order to be ingested when matured into L3 larvae. For more detailed description see text (Drawing: Lisa Johansson).

Both the proportion of the development as well as the time for the start of maturity is dependent on the temperature (Fiel et al., 2012). Even the survival of the eggs as well as the different stages of the larvae is dependent upon the surrounding temperature (Pandey, 1973). Pandey (1973) found that the optimal temperature for survival was 4 ˚C both for the first and third stage larvae, but also for the parasitic eggs. The same study reported that 90 % of the third stage larvae survived after 52 weeks of storage in 4 ˚C. This indicates that lower temperatures are more favourable than higher ones in terms of survival (Pandey, 1973). However, Ciordia and Bizzell (1963) reported that the optimal temperature in terms of development for free-living stages of *O. ostertagi* was 25 ˚C. Poor development was also demonstrated if the temperature fell below 6 ˚C. An increased mortality was moreover seen if temperatures exceeded 32 ˚C (Ciordia and Bizzell, 1963).

The prepatent period, which refers to the period where L3 larvae are ingested until the eggs are shed in the environment, is approximately 3 weeks. Under certain circumstances this period may be delayed for several months which are due to inhibition of larvae development. *O. ostertagi* is one of several gastrointestinal parasites which have the ability to arrest the development of its larval stage. The arrest normally occurs at an early L4 stage whereby the parasite avoids the dispersal of its eggs on the pasture during years when the developing conditions are unfavourable. This is a survival strategy which prevents an increased mortality of the free-living stage larvae (Lützelschwab et al., 2005).

Effects on cattle

Studies have for decades reported several negative effects such as reduced weight gain, reduced feed intake and changed general behaviour on grazing cattle due to parasite infections (Fox et al., 1989; Taylor et al., 1989; Kyriazakis et al., 1998; Forbes et al., 2004; Szyszka et al., 2013). These undesirable effects may be more or less distinct in their expression. Moreover there are large variations in the susceptibility to parasite infections between individuals (Gasbarre et al., 2001).

Grazing behaviour

Reduced voluntary feed intake is a common observation in association with parasite infections. Gastrointestinal parasites normally reduce the availability of nutrients to the host animal; both through reduced voluntary feed intake but also by reducing the efficiency of the absorbed nutrients. The contribution to the impaired performance of these two mechanisms is to some extent dependent upon the species of the parasite along with the operative site in the gastrointestinal tract. Furthermore the impairment may be due to the number of parasites that are established in the gastrointestinal tract. The extent of impairment will however be modified dependent on factors such as age and breed along with nutritional status of the host animal (Coop and Kyriazakis, 1999). Forbes et al. (2000) found that heifers naturally infected with parasites during pasture grazed for a shorter time per day, i.e. 105 minutes less, compared with animals treated with anthelmintics, ten weeks after the turnout on pasture. Furthermore the voluntary feed intake was affected where infected animals consumed 0.78 kg dry matter (DM) less herbage than uninfected animals. However these changes were not apparent only two weeks after the turnout on pasture. This may be due to that the heifers in this study were supposed to be naturally infected with parasites through the herbage intake and therefore they needed to consume sufficient amounts of herbage before any clinical signs could be apparent (Forbes et al., 2000). These findings are in agreement with the study by Fox et al. (1989) who found that the voluntary feed intake in calves, infected with 10 000 parasitic larvae per day, was significantly reduced from day 37. The greatest depression in feed intake was however seen on day 46 when the appetite was decreased with 76.8 % in comparison with the ad libitum feed control group. Despite the anthelmintic treatment on day 46 the differences in appetite between the two groups sustained until the end of the study. This study was however performed indoors in individual pens (Fox et al., 1989).

Szyszka et al. (2013) examined the extent of temporal changes on feeding behaviour of bulls infected with the parasite *O. ostertagi*. During the study the feeding behaviour was monitored with 24 h video recordings and the observations were divided into three different periods, prepatent parasite, predicted peak of parasitism and post dosing with anthelmintics. The study showed no significant effects on feed intake during the first two periods. On the contrary, the meal frequency was decreased during the third period for animals infected with parasites, seven weeks after the initial trial. The reduction in feed intake was 17 % for the parasitized animals compared with the two parasite free groups (Szyszka et al., 2013). Similarly, in a simulation model developed using data from former studies, Berk et al. (2016) found a reduction in the feed intake for three different trickle doses of infective larvae. The magnitude of the reduction was however greatest at the largest doses. The doses were 3,500, 7,000 and 14,000 L3 larvae and these were administrated on a daily basis.

A decreased grazing time is assumed to be associated with the reduced appetite that is common in combination with parasitic infections. The reason for the reduced appetite in parasitized ruminants may be attributable to the limitation of further infections, which might be a consequence of parasite infections (Forbes et al., (2000). Parasite induced inappetence has also been hypothesised to allow a greater dietary selection for ruminants (Kyriazakis et al., 1998).

Weight gain

The impaired growth caused by parasite infections is partly due to the reduction in the voluntary feed intake, but also to the increased metabolic and nutritional demands on the host animal. Furthermore gastrointestinal parasites generate increased losses of endogenous protein, which might be a potential cause of the reduced weight gain in cattle (Kyriazakis et al., 1998). Szyszka et al. (2013) found that bulls infected with a trickle dose of 300,000 *O. ostertagi* larvae in total started to gain weight at a slower rate from day 21 compared with bulls from the control group. However until day 21 all bulls regardless of treatment gained weight at a similar rate (935 g/day). Forbes et al. (2000) also found that animals infected with parasites gained weight at a slower rate than animals treated with anthelmintics. This study examined the effects of nematode parasitism on growth in young grazing cattle. The daily weight gain in parasitized heifers was shown to be 150 g/day less than in heifers treated with anthelmintics. The daily weight gain in anthelmintic treated heifers was 800 g/day and only 650 g/day in parasitized heifers during the same period (Forbes et al., 2000). By the use of a simulation model where data from several prior studies was used in order to investigate the consequences of *O. ostertagi*. Berk et al. (2016) noted that the effect on body weight was greater in animals given larger doses of parasites. As the parasite challenge increased the larger negative impact on the weight gain in form of impaired growth. This was mainly due to the reduced feed intake, but also from the damage caused by the parasites (Berk et al., 2016). Burggraaf et al. (2007) also found that larger doses have a negative impact on the weight gain. Calves that received doses with mixed species infection levels of 4,000 to 10,000 L3 per day showed a reduction in liveweight gain with 130-200 g/day compared to calves given regular doses of anthelmintics. Moreover they found that there were no differences in liveweight gain between calves treated with anthelmintics compared to calves treated with parasitic doses of 1,000 to 2,000 L3 stage larvae daily. Hence to avoid production losses due to parasite infections in beef cattle the ingestion of parasites should not be higher than 4,000 larvae per day (Burggraaf et al., 2007).

Activity patterns

Animals faced with a health challenge are generally more inactive than healthy animals in meanings of lesser movements and a more frequent lying behaviour (Hart, 1988). To the authors knowledge there are only a few studies that have been evaluating the behavioural changes in terms of activity patterns and postures in cattle caused by gastrointestinal parasites. Szyszka et al. (2013) investigated the extent of the potential changes in activity, posture and feeding behaviour in parasitized cattle. The reversal of the behavioural changes after treatment with anthelmintics was also examined. The study showed that the number of steps taken along with the average lying and standing episode frequency was decreased after day 21 in animals infected with parasites. The decrease was 41 % for the number of steps taken. Moreover the average duration episode of lying and standing was increased with 52 % and 55 % respectively in parasitized animals. However before day 21 the activity patterns were similar between animals infected with parasites and animals treated with anthelmintics (Szyszka et al., 2013).

Another study (Szyszka and Kyriazakis, 2013) examined the relationship between the infective dose of parasites and the behavioural changes in cattle. The animals used in the experiment were bull calves which were randomly assigned into four different treatment groups. The bull calves in the first three groups received a total parasitic dose of 75,000, 150,000 and 300,000 L3 stage larvae respectively. This study showed that calves given the largest dose of parasites in general were more inactive than the other groups. The average number of steps taken after day 36 was 2,834 for the highest dose compared with 3,971 for the control group. Moreover they found that the average lying and standing episode duration was increased with 25 %, while average lying and standing episode was decreased with 22 % for animals given the highest parasitic dose (Szyszka and Kyriazakis, 2013).

A reduced activity may also lead to a reduction in self-grooming as well as the grooming of other individuals. The reduction in grooming will result in a dull hair coat (Hart, 1988).

Treatment against gastrointestinal parasites

Anthelmintics

Due to the economic impact and welfare issues caused by gastrointestinal parasites anthelmintics are being more and more frequently used in cattle production. It is well-known that gastrointestinal parasites inhibit the optimal growth and productivity in cattle, therefore the importance of anthelmintics in order to control the parasites (Gasbarre et al., 2001). By removing the parasitic worms inside the host animal anthelmintics efficiently reduce pasture contamination. Hence, anthelmintics prevent the spreading of eggs to the pasture by breaking the parasitic life cycle inside the host animal. The anthelmintic treatment can be given as an injection or as a single or repeated drenching pour-on (Epe et al., 1999).

Merz et al. (2005) examined the effects of naturally acquired gastrointestinal parasite infections on weight gain in yearling cattle during pasture period. They found that parasitized animals tend to gain weight at a slower rate when not treated with anthelmintics. During a 143 days grazing season the average daily weight gain for parasitized animals were 6.6 kg less during the whole period than for animals treated with anthelmintics. On the contrary, treatment with anthelmintics was shown to increase the average daily weight gain in yearling beef cattle (Merz et al., 2005). Furthermore, the voluntary feed intake and grazing time, that also are generally declined during parasite infections, have been confirmed to be modified when the parasite burden are controlled with the use of anthelmintics (Forbes et al., 2004). Hence, both the voluntary feed intake and grazing time improves almost immediately once the animals are treated with anthelmintics (Forbes et al., 2004).

Aims and questions

Since animals infected with gastrointestinal parasites usually respond to sickness with predictable pattern of behavioural changes the purpose with this master thesis was to investigate the behaviours, activity patterns and weight gains of steers, half of dairy breed and half of dairy-beef breed crosses, with high or low parasitic load on pasture. The objective was to evaluate whether there were any differences in behaviour, activity patterns and weight gain between animals given a dose of parasites and animals treated with anthelmintics. This study was part of a larger study made by Johan Höglund at Department of Biomedicine and Veterinary Public Health in Uppsala in collaboration with Anna Hessle at Department of Animal Environment and Health in Skara.

The study intended to answer the following questions:

- How is the weight gain affected by high respective low parasitic load?
- Which influences does high parasitic load compared to low parasitic load have on the activity patterns?
- Does the behaviour of infected steers differ from non-infected steers?

Predictions

Steers with high parasitic load were predicted to have inferior activity- and behavioural patterns along with reduced weight gain. Inferior activities as well as reduced behavioural performance refer to less movements and more resting behaviour, along with more seldom grazing etcetera than for animals with low parasitic load. The weight gain was predicted to be lower among steers with high parasitic load in comparison with animals with low parasitic load.

Materials and methods

Two animals from the group of steers with high parasitic load were dewormed during the study due to reduced general condition and poor growth. The data received from these animals were treated as missing values and are therefore not included in the given results.

Animals and pasturelands

The study was performed at Götala Beef and Lamb Research Centre outside Skara, between 18 May and 15 September in 2016. The study was approved by the Swedish Committee of Experimental Animals Gothenburg (Dnr: 187-2014). This research is part of a larger study performed at Götala. The research animals consisted of 63 steers, where 31 of them were of dairy breed (Swedish Holstein, SLB, or Swedish Red, SRB) and the other 32 steers were crossbred animals (SLB/Charolais and SRB/Charolais). The animals originated from an organic dairy farm, but the purebred animals were before the transport to Götala Research Center housed at another farm. During the pre-pasture period the steers were housed indoors in boxes and throughout this period the animals were fed a total mixed ration *ad libitum*. Water was provided *ad libitum* in water cups. The steers were approximately 7-12 months old at the beginning of the pasture period and approximately 12-17 month at the end. The average weight of the purebred steers before the pasture period was 300 kg S.D. = 69.3), with steers weighing minimum 190 kg and maximum 421 kg. For the crossbred steers the average weight before pasture period was 326 kg (S.D. = 78.7), with steers weighing minimum 185 kg and maximum 493 kg.

Two paddocks with semi-natural pastures were used in this research (see fig 2). The pastures were approximately 14 ha each. Each pasture was provided with an area, which the animals had to enter through one-way gates, where water in cups and minerals (Lantmännen effect optimal) was offered to the animals. To exit the animals had to pass through either one of two scales.

Figure 2. Map over the two different pastures. The red area represents the pasture where the steers with low parasite load grazed and the blue area where the steers with high parasite load grazed. The crosshatched lines are the area where the water and automatic weighing stations were placed.

Experimental design

Pre-experimental period

Before the actual experiment four individuals were given an oral dose with a mixture of 5,000 infective third stage larvae (L3) of *O. ostertagi* and *C. oncophora* (in total 10,000 larvae). These four individuals would then act as proliferators in order to collect more larvae for later use. The larvae were given diluted in approximately 1 dl water in the corner of the mouth. After three weeks faeces were collected from these four animals. The faeces were collected rectally several times a day and there was a need of approximately 20 kg faeces from these individuals in order to cover the parasitic need. All faeces were sent to Uppsala for analysis.

The animals were divided into two separate groups with 31 respectively 32 animals in each group, see table 1. Each group consisted of half purebred dairy and half crossbred dairy-beef steers (Table 1). The group with 31 steers were released in pasture 1 and the other group with 32 steers were released in pasture 2. The steers in pasture 2 were the animals who received an oral dose of the parasites *O. ostertagi and C. oncophora.* The animals in pasture 1 were treated with anthelmintics (Noromectin from N-vet in Uppsala, low parasitic load). By the assistance of a faeces sample it was confirmed that the animals that were given an oral dose of parasites was infected with the given parasites. Before the pasture period, which started on the 3 of May, all the steers were weighed on two consecutive days.

Table 1. Describes the distribution of the steers, which pasture the animals were released in, if they were purebred or crossbred and what treatment that was used.

Pasture	Total number of animals	Breeds	Treatment
1	31	15 purebred and 16 crossbred animals	Anthelmintics
2	32	16 purebred and 16 crossbred animals	Oral dose with parasites

Experimental period

The experiment started when one group of steers (high parasitic load) received an oral dose of 10,000 larvae each of a mixture of *O. ostertagi and C. oncophora*, just before the release on pasture. The doses were given individually to the animals meanwhile the animals were standing in the scale with their head fixed. All doses were diluted in approximately 1 dl of water and given by a large shoot in the corner of the mouth. On the same day as the start of the pasture period and the experimental period, all the animals that were intended to be released in pasture 1 were treated with anthelmintics (low parasitic load) and thereafter every fourth week during the pasture period. The anthelmintics were administrated with 0.5 mg per kg bodyweight. All the animals were thereafter released in their respective pasture on the third of May.

Body weight recordings

The steers were brought into the stables to be weighed in order to control the weights with the common methods on the farm every second week. The manual weighing was performed bi-weekly on Tuesdays and consisted of 10 weighing periods (2-17 May; 17-31 May; 31May-14 June; 14- 29 June; 29 June-12 July; 12-26 July; 26 July-9 Aug; 9-23 Aug; 23Aug-6 Sep and 6-20 Sep). These are the weights that have been used for evaluation of weight gain in this master thesis.

To record the body weights of the steers while on pasture two automatic weighing stations (from Hencol) were placed in each paddock (see fig 3). Two of the scales, one in each paddock, were operated by solar cells and the other two scales, also one in each paddock, were operated on line current. The scales were placed in front of the water area and in order to get access to the water and minerals the steers needed to pass through gates right in front of the scales. From the water area point of view, the steers needed to pass through the scales to get access to the grazing lands. In this manner the weights of the steers were recorded on a daily basis or at least several times a week. To stop the steers from entering the grazing lands in another way than through the scales there were fences on the sides of the scales. As these weights need more data handling and cleaning out false weights they were not used in this master thesis.

Figure 3. Shows a picture of the two automatic weighing stations. The scale to the right was operated on solar cells and the scale to the left was operated on line current (Photo: Lisa Johansson).

Activity patterns

In combination with the second manual weighing of the animals, that occurred two weeks after the release on pasture, 20 (10 animals in each group) animals were assigned with one IceTag (IceRobotics Ltd, UK; see fig 4) each in order to be able to record their activity level. The data acquired from the Icetags were for motion index, lying, standing, number of steps taken and number of lying bouts per animal. Each record received from the Icetags provided a date and the time spent on respective behaviour. The IceTags were placed on the largest steers on their left hind leg. The IceTags were used on the animals for three different periods. The periods were 14-29 June, 12-26 July and 9-23 August. Between these periods the IceTags were removed. The data were downloaded as activity per 24 h, per hour and per minute. For practical reasons only data on activity per 24 h were used in this master thesis. The same animals were assigned with the IceTags during the different periods. At the same time as IceTags were placed on the animals 4 steers per group got a GPS collar placed around their neck (VECTRONIC Aerospace GmbH, Berlin). The data from these recordings have not been used in this master thesis.

Figure 4. A picture of an IceTag, which is a device that record the activity level (Photo: Katarina Arvidsson Segerkvist).

Behavioural observations

The behaviours of the steers were recorded using direct observations by in total three different observers over the whole study. The observations were performed during selected weeks with start in May and with the last being made in September. For these weeks the observations were performed during 3 or 4 days. The weeks were selected depending on the different life stages of the parasites used in the experiment. The observations were mainly performed between 13.00 and 15.00, with exception from two dates in May but also the last observation week in September, where the observation period was from 9.30 to 12.30 and 12.00 to 14.00 respectively. The reason for having the observations mainly between 13.00 and 15.00 was because the steers were predicted to be more active in the afternoons.

The recordings were divided into four periods, where each period lasted 30 minutes. The observer went between the two groups of steers and observed one group for 30 minutes (period 1) and then switched to observe the other group for 30 minutes (period 2). Then the observer switched group once more and observed the two groups respectively for additionally two more periods (period 3 and 4). In this way each group of steers were observed for 60 minutes in total.

Within each period the numbers of animals performing different behaviours were recorded instantaneously at one minute intervals. A timepiece was set to provide a signal every minute. The body positions (lie, stand or walk) and the behaviours recorded on the steers on pasture and their definitions are shown table 2.

Table 2. Ethogram of general behaviours recorded for the two groups of steers

Behaviour	Description
Lie	Lying on the ground, with curled legs and with the head lifted or touching the ground.
Stand	Standing having the head facing in any direction, but the head could be moved.
Walk	Move a few or many steps at a regular and fairly slow pace.
Grazing	Standing in front of the feeder/grass with their head placed into it.
Sniff/lick itself	Placing/moving mouth and nose to a close distance to itself.
Sniff/lick other	Placing/moving mouth and nose to a close distance from another animal.
Sniff/lick object	Placing/moving mouth and nose to a close distance from an object, such as an tree or rock etc.
Drink	Standing in front of the water cups with their head placed there or at wet parts of the ground.

Statistical analysis

The data were analyzed in SAS software (Statistical Analysis System institute, Cary, USA) version 9.4. Before using SAS all the data were processed in Microsoft Excel 2010 in order to be able to analyze the data in a correct manner. For the behavioural recordings mean number ± standard error (SE, proc means) was calculated in percentages for each category of behaviour. Similarly, mean numbers and SE were calculated for the average weight gains over the whole grazing period. The average weight gains for the whole period were furthermore analyzed with an ANOVA model in order to observe if the variables breed or treatment, or else the interactions between breed and treatment influenced the average weight gains. To analyze potential differences in weight gains between each weighing period a mixed liner model (proc mixed) was used. The model was used in order to investigate if the weight gains of the animals were affected by breed, treatment or period, or else the interactions between treatment and period.

The activity and posture data received from the IceTags was downloaded with the Icerobotics software as one summary of records per day. Data from two IceTags (both from two steers with low parasite load) were not received due to problems during the download. Therefore these values were treated as missing values. SAS was used to calculate mean numbers ± SE for each behaviour. Furthermore the Icetags data were analyzed separately for each behaviour with the mixed liner model (proc mixed) in order to investigate if the variables period, breed or treatment, or else if the interactions between period and treatment influenced the different behaviours. Prior to analysis the data on number of steps taken were log-transformed in order to normalize the distribution. Correlations were also performed between weight gain and activity patterns with the Pearson correlation coefficient. Splitting up data into treatments did not give any significant correlations. Therefore, the data was analyzed without sorted by treatments.

Results

This study demonstrated that gastrointestinal parasites in steers at pasture cause a reduced daily weight gain and a decreased general activity level per 24 h, but an increased general activity level during day time.

Body weight recordings

The weight recordings from the first manual weighing, 2-17 May, were excluded from both the group with high parasite load and the group with low parasitic load. This was due to the massive weight loss that emerged for all the animals. This weight loss was however expected because weight loss is a common observation in combination with release on pasture (Hessle et al., 2011).

Daily weight gain during the whole pasture period

The changes in body weights between treatments and breeds throughout the experiment are shown in figure 5. There was a significant effect of treatment where steers with high parasite load had a lower weight gain during the pasture period than steers with low parasite load (P= 0.0003, F= 15.04). There was however no significant effect of breed on weight gain during the grazing period (P= 0.17, F= 1.90). There were neither any interactions between breed and treatment on weight gain (P= 0.14, F= 2.22).

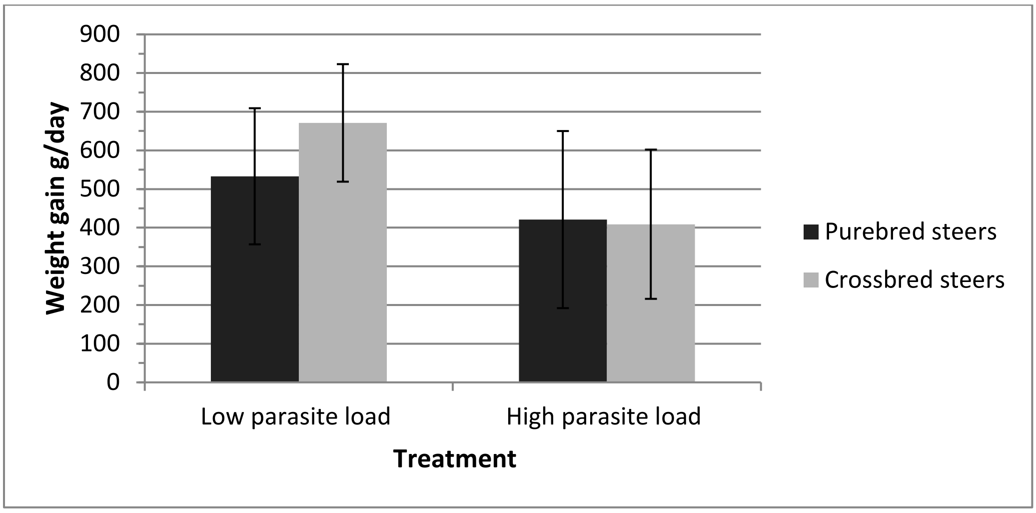
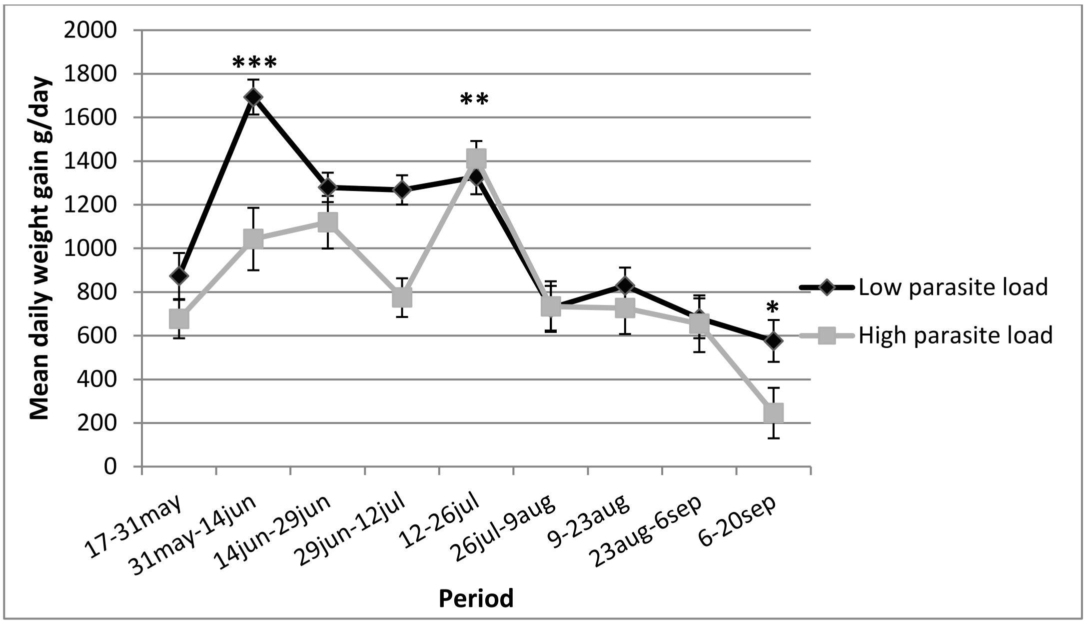


Figure 5. Mean daily weight gain (± SE) of crossbred and purebred steers with high- respective low parasite load during the whole pasture period (17 May - 20 Sep) (n=16/treatment except for purebred steers with low parasite load n=15).

Daily weight gain between different periods throughout the pasture period

The changes in body weights between treatments and the different periods throughout the experiment are shown in figure 6. There were significant effects of treatment (P<0.0001, $F_{1; 530}$= 19.10) and period (P<0.0001, $F_{8; 530}$ = 22.20) on the daily weight gain. There was also a significant interaction between period and treatment (P= 0.0033, $F_{8; 530}$ = 2.93). There were significant differences during three out of nine pasture periods (see fig. 6). Steers with low parasite load had a higher mean daily weight gain during 31 May-14 Jun (P< 0.0001), 29 Jun-12 Jul (P= 0.0006) and 6-20 Sep (P= 0.0204) than steers with high parasite load.

a)



b)

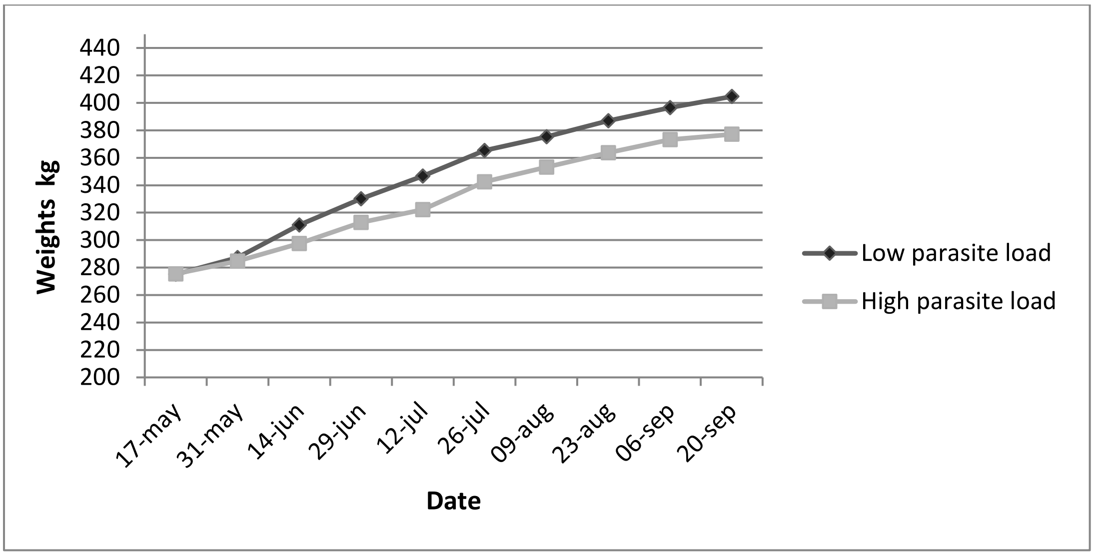


Figure 6. a) Mean daily weight gain (± SE) during different pasture periods between steers with high- vs. low parasite load (* P ≤ 0.05, *** P ≤ 0.001), b) Mean weight in the steers during different pasture dates.

Activity patterns

Motion index

The changes in motion index during three different periods (14-29 June, 12-26 July and 9- 23 August) are shown in figure 7. There was a tendency of an effect of treatment in the motion index where steers with low parasite load had a higher motion index (P= 0.078, $F_{1;\ 15}$ = 3.59) when compared to steers with high parasite load. There was however a significant effect of period on motion index (P<0.001, $F_{2;\ 32}$ = 71.48). Motion index was significantly higher in 14-29 June, compared to 9-23 August and in 12-26 July compared to 9-23 August. There were also significant interactions between period and treatment (P <0.0001, $F_{2;\ 32.1}$ = 17.49). During 14-29 June the motion index was significantly higher in steers with low parasite load (P= 0.0005, fig 7). There were however no significant differences between treatments in the other two periods.

There was a significant correlation between motion index and the daily weight gain (P<0.05, r=0.47) during 14-29 June. There was however no significant correlation during 12-26 July and 9- 23 August.

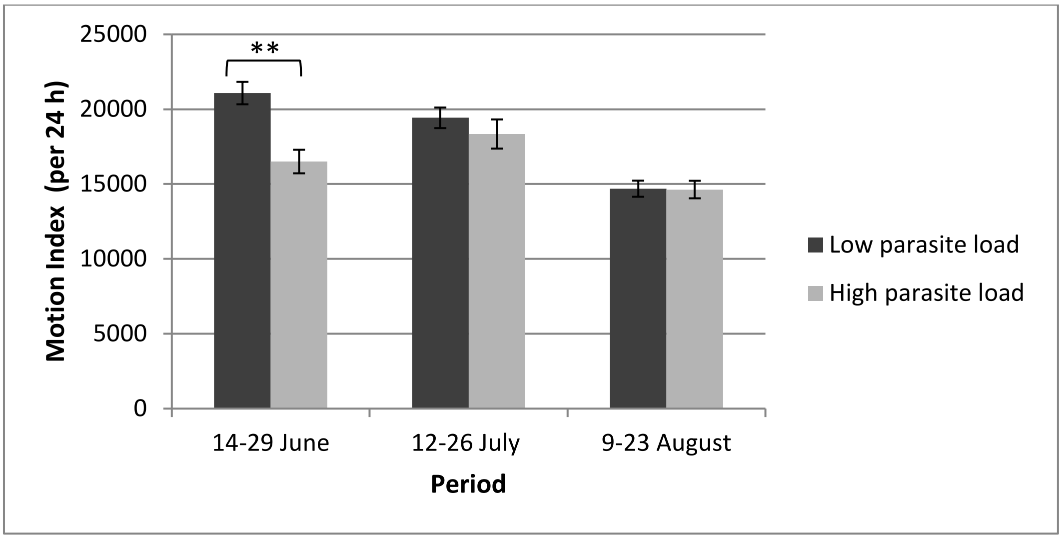


Figure 7. Mean motion index per 24 h (± SE) in steers with high vs. low parasite load at pasture at three different periods (n=10 steers/treatment, ** P ≤ 0.01).

Duration of lying

The duration of lying during three different periods (14-29 June, 12-26 July and 9- 23 August) are shown in figure 8. There was a significant effect of period on duration of lying (P= 0.0026, $F_{2;\ 32.2}$ = 7.20). The duration of lying was significantly higher in 12-26 July compared to 14-29 June and in 12-26 July compared to 9-23 August (fig. 8). There were also significant interactions between period and treatment (P= 0.0023, $F_{2;\ 32.2}$ = 7.35). During the 9-23 August the duration of lying was significantly higher in steers with low parasite load (P= 0.0284; fig 8). There were however no significant differences between treatments in the other two periods or overall for the study.

There was a tendency of a correlation between duration of lying and the daily weight gain (P<0.1, r= -0.43) during 14-29 June. There was however no significant correlation during 12-26 July and 9- 23 August.

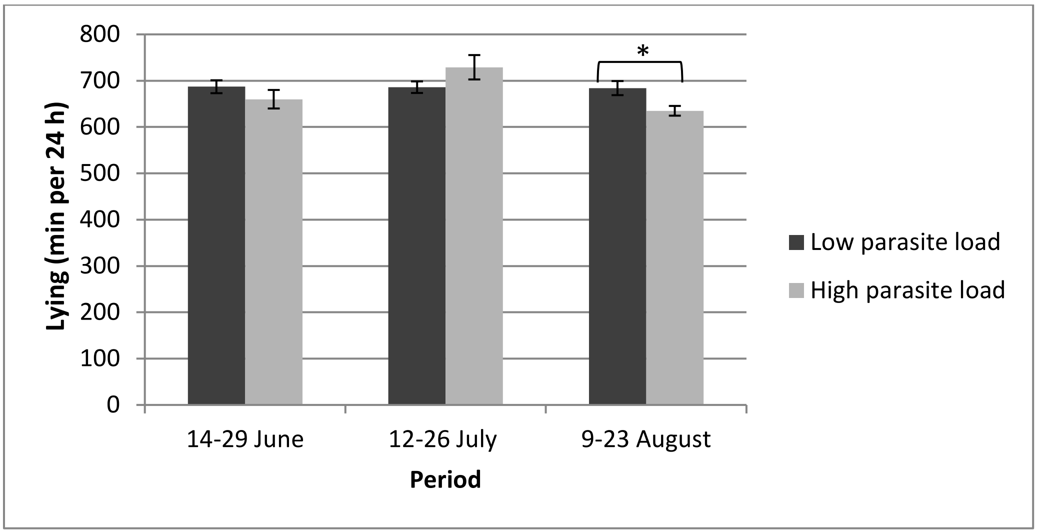


Figure 8. Mean duration of lying in minutes per 24 h (± SE) in steers with high vs. low parasite load at pasture at three different periods (n=10 steers/treatment, * P ≤ 0.05).

Duration of standing

The duration of lying during three different periods (14-29 June, 12-26 July and 9- 23 August) are shown in figure 9. There was a significant effect of period on standing (P= 0.0040, $F_{2; 32.2} = 6.60$). The duration of standing was significantly higher in 14-29 June compared to 12-26 July and in 9-23 August compared to 12-26 July (fig 9). There were also significant interactions between period and treatment (P= 0.0017, $F_{2; 32.2} = 7.82$). During 9-23 August the duration of standing was significantly higher in steers with high parasite load (P= 0.0191; fig 9). There were however no significant differences between treatments in the other two periods.

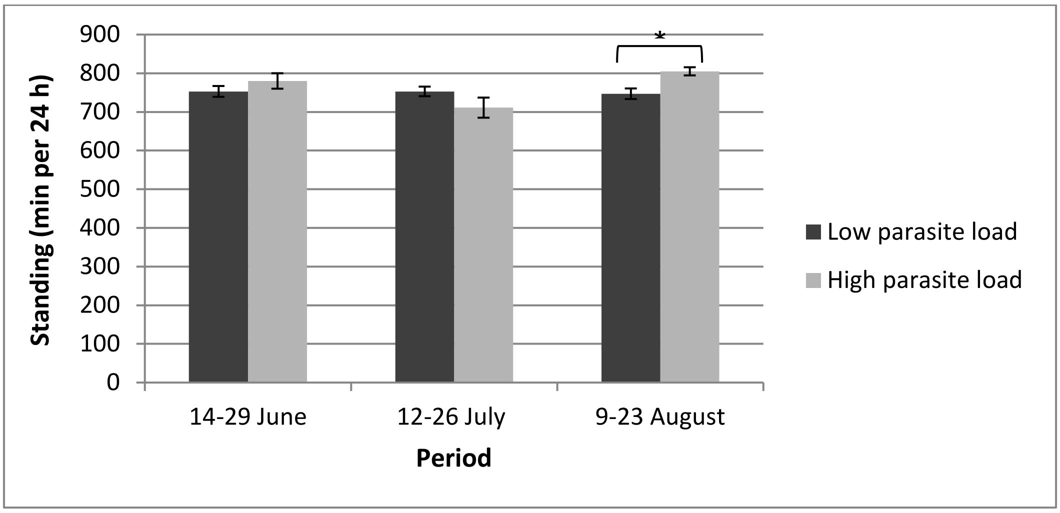


Figure 9. Mean duration of standing in minutes per 24 h (± SE) in steers with high vs. low parasite load at pasture at three different periods (n=10 steers/treatment, * P ≤ 0.05).

Number of steps taken

The number of steps taken during three different periods (14-29 June, 12-26 July and 9-23 August) are shown in figure 10. There was a significant effect of period on number of steps taken ($P < 0.0001$, $F_{2;\, 32.4} = 49.02$) where the number of steps taken was significantly higher in 14-29 June compared to 12-26 July and in 14-29 June compared to 9-23 August. The number of steps taken was also higher in 12-26 July compared to 9-23 August (fig 10). There were also significant interactions between period and treatment ($P = 0.0003$, $F_{2;\, 32.4} = 10.41$). Steers with low parasite load were more active due to the significantly higher number of steps taken in 14-29 June ($P = 0.0344$) and 12-26 July ($P = 0.0456$). There were however no significant differences in 9-23 August.

There was a tendency of a correlation between number of steps taken and the daily weight gain ($P<0.1$, $r = 0.42$) during 14-29 June. There was however no significant correlation during 12-26 July and 9- 23 August.

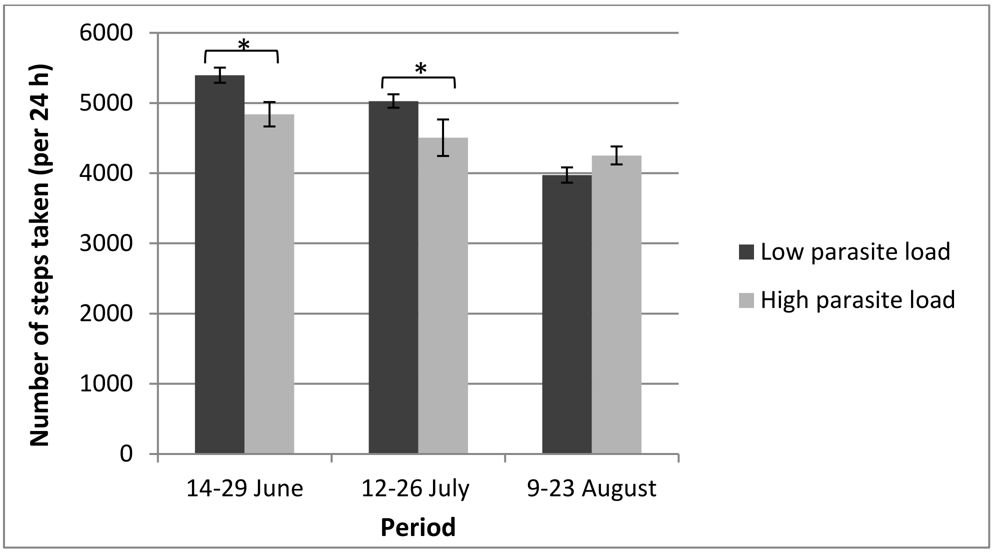


Figure 10. Average number of steps taken per 24 h (± SE) in steers with high vs. low parasite load at pasture at three different periods (n=10 steers/treatment, * $P \leq 0.05$).

Number of lying bouts

The number of lying bouts during three different periods (14-29 June, 12-26 July and 9-23 August) are shown in figure 11. There was a significant effect of period on number of lying bouts ($P= 0.0022$, $F_{2; 31.7} = 7.49$). The number of lying bouts was significantly higher in 14-29 June compared to 9-23 August and in 12-26 July compared to 9-23 August (fig 11). There were also significant interactions between period and treatment ($P< 0.0001$, $F_{2; 31.7} = 16.11$). During 12-26 July the average number of lying bouts was significantly higher in steers with high parasite load ($P= 0.0058$) in comparisons with steers with low parasitic load (fig 11). There is however one individual that distinguish from the rest in the group of steers with high parasitic load and thereof the large differences between the treatments in this period. There were however no significant differences between treatments in the other two periods.

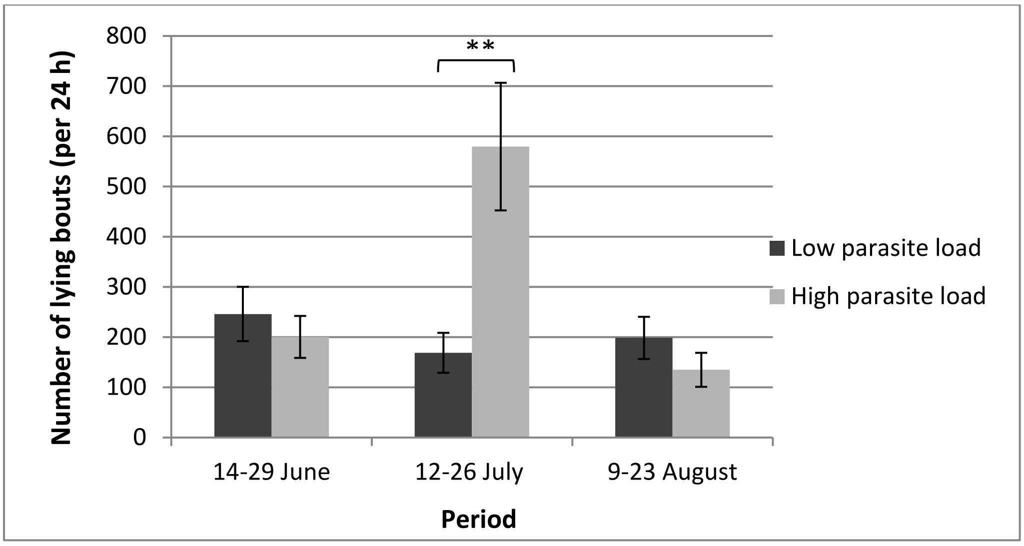


Figure 11. Average number of lying bouts per 24 h (± SE) in steers with high vs. low parasite load at pasture at three different periods (n=10 steers/treatment, ** $P \leq 0.01$).

Behavioural observations

Because the whole group was observed there are no individual data on the behaviours and therefore no statistical analysis could be done. Steers with low parasite load appeared to stand less and lie more than steers with high parasite load. These animals also appeared to walk less (fig 12).

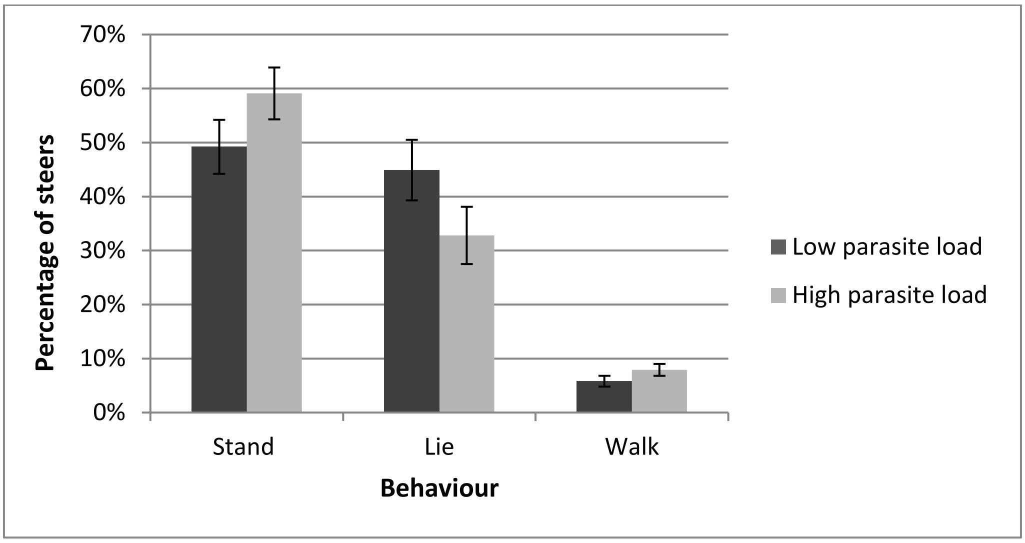


Figure 12. The mean percentage (± SE for different observation days) of steers with either high or low parasitic load that spent time on standing, lying and walking during the pasture period during direct observations 60 minutes during day time (n=1 group/treatment).

Steers with high parasite load appeared to graze more and ruminate less in comparison with the steers with low parasite load. Steers with low parasite load appeared however to be more active performing other behaviours, such as mounting etc. (fig 13).

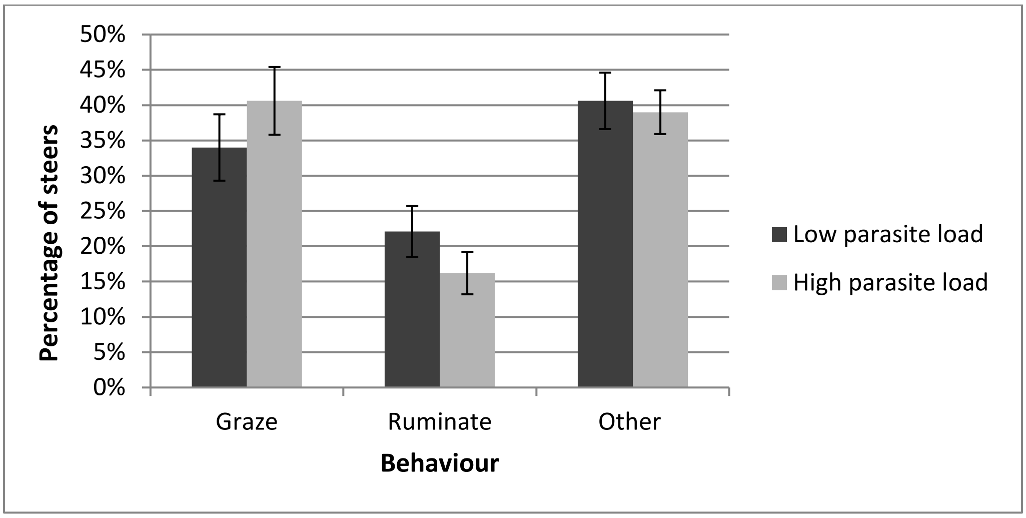


Figure 13. The mean percentage (± SE for different observation days) of steers with either high or low parasitic load that spent time on grazing, ruminating and other behaviours during the pasture period, during direct observations 60 minutes during day time (n=1 group/treatment).

Social behaviours such as sniffing and licking others appeared to occur more frequently in steers with high parasite load than in steers with low parasite load. For the behaviours sniff/lick itself, sniff/lick object and drink the mean values are very similar and the SE for the differences between observation days are overlapping so much that there does not seem to be any differences between high and low parasite load groups (fig. 14).

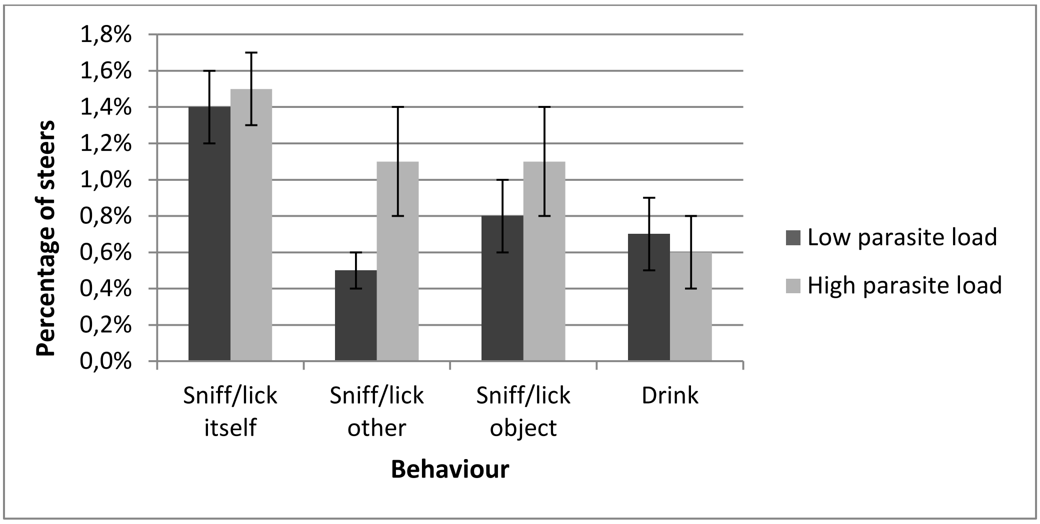


Figure 14. The mean percentage (± SE for different observation days) of steers with either high or low parasitic load spent time on sniffing/licking itself, sniffing/licking other, sniffing/licking object and drinking during the pasture period, during direct observations 60 minutes during day time (n=1 group/treatment).

Discussion

The major findings of this study were that gastrointestinal parasites in steers at pasture cause a reduced daily weight gain. The general activity was also found to be decreased in the parasitized steers per 24 h, but increased during day time.

Weight gain

The results from the present study confirm the predictions that the daily weight gain in steers infected with parasites (high parasite load) was lower compared to animals treated with anthelmintics (low parasite load). This is in agreement with earlier studies where weight gain in cattle has been documented to be negatively affected by gastrointestinal parasites. Helle and Tharaldsen (1976) reported a reduced weight gain in calves naturally infected with gastrointestinal parasites when grazed on contaminated pasture. Later on Fox et al. (1989) reported similar results where housed calves exhibited impaired growth due to parasite infections. Subsequently new studies have been performed where the effects of intestinal parasites on weight gain have been evaluated and where the weight gain in cattle have been shown to be reduced during grazing (Forbes et al., 2000; Merz et al., 2005; Szyszka et al., 2013). Based on these studies, the weight gain in steers infected with the parasite *O. ostertagi* and *C. oncophora* in this study was predicted to be reduced during the trial, and this was also confirmed by the results.

The daily weight gain was also found to be affected by different periods during the pasture. Steers treated with anthelmintics was found to have a significantly higher daily weight gain during the pasture periods 31 May-14 Jun, 29 Jun-12 Jul and 6-20 Sep than parasite infected steers. A possible reason for this might be the different life stages of the parasites and their increased nutritional demands (Kyriazakis et al., 1998) on infected animals. Despite the fact that there were no significant differences in the daily weight gain during the other periods the results showed that anthelmintic treated animals had an overall better growth than animals infected with parasites.

Since impaired growth is commonly associated with parasite infections it has been suggested that parasites contributes to a reduced daily grazing time and thus a reduced voluntary feed intake in cattle and other ruminants (Kyriazakis et al., 1998). Hence, a reduced feed intake might be a possible explanation to the reduced weight gain in the parasitized animals in the present study. Though this can only be speculated since the amount of feed intake or grazing time per 24 h was not measured in this study. Instead behavioural observations were performed on grazing behaviour where the total number of steers grazing in respective group was recorded. It was found that infected steers appeared to graze more during the one hour observation time during day time than anthelmintic treated steers. This result contradicts the result of Forbes et al. (2004). The authors of the previous study investigated the impact of anthelmintics on grazing behaviour and performance on cattle with subclinical parasitism. They found that the daily grazing time was significantly affected by anthelmintic treatment, where cows treated with anthelmintics grazed for approximately 47 minutes longer per day in contrast with non-treated cows (Forbes et al., 2004). In addition, the daily weight gain was improved due to the increased grazing time followed by the treatment with anthelmintics. Possible reasons for the different results regarding the grazing behaviour may be due to the choice of data collection method. However, in the present study behavioural observations were recorded with direct observations during selected weeks throughout the summer. This is an extremely subjective method, where the behavioural registrations might be delayed due to human mistakes. By monitoring the grazing behaviour with the use of 24 h video recording equipment or by using collars that can record grazing per 24 h the results would most probably have been different. However, the use of 24 h video recording equipment as an observation measurement in the present study would almost have been impossible, which is due to the large pasture areas and hence the need of multiple cameras placed on different places on the pasture. Therefore, it would not be viable to observe the grazing behaviours, or any other behaviour, with video recording equipment while on pasture, at least not on larger pastures. The use of a bite counter attached to a collar (Umemura et al., 2009) may be more useful as a method to register the grazing behaviour. This is due to the automatic register of jaw movements each 10 minutes which might provide trustworthy data. The hypothesis in the present study was however that the grazing events would decrease in parasitized animals, as suggested by Forbes et al. (2004, 2007) in grazing cattle infected with parasites. A decreased grazing time would have been consistent with an expected decrease in feed intake and consequently impaired growth in cattle infected with the parasite *O. ostertagi* (Fox et al., 1989).

Activity patterns

To the authors knowledge there are only a few studies that have been performed in order to investigate the impact of parasitism on activity patterns in cattle and other ruminants. The general activity level has however been found to decrease in animals due to parasite infections (Szyszka and Kyriazakis, 2013), which is in agreement with the results from the present study. It was found that both motion index and the number of steps taken were significantly affected by an interaction between period and the parasitic treatment. Anthelmintic treated steers were shown to have a higher motion index during 14-29 June in comparison with steers infected with parasites. The number of steps taken was also significantly higher during 14-29 June, but also during 12-26 July in the anthelmintic treated steers. This indicates that steers infected with parasites move less and consequently were more inactive than anthelmintic treated animals. However, the decrease in both motion index and number of steps taken was predicted due to one prior study where the activity level in general was found to be decreased in animals faced with a parasitic health challenge (Szyszka et al., 2013). There are also comparable data in pigs where the authors found that the total activity level was reduced with 34 % in pigs affected by acute parasitic disease (Reiner et al., 2009). Furthermore, the same authors found that while the general activity was reduced in infected pigs the duration of lying was increased. As there are so few studies that have looked at the activity level in animals with high parasite load it is good that this and the two published studies found similar results.

The present study showed that the duration of lying was lower in steers infected with parasites during 9- 23 August. Moreover, the duration of standing was found to be higher in the parasitized animals during the same period. Therefore the examination of the body postures showed that steers infected with parasites on average had longer standing episodes compared with the anthelmintic treated animals. These results were not expected since results from previous studies indicated that the decreased activity due to parasite infections normally is accompanied by longer duration of lying behaviour (Reiner et al., 2009; Szyszka et al., 2012, 2013). A decreased lying and standing frequency are also associated with parasitic challenges (Szyszka et al., 2012, 2013; Szyszka and Kyriazakis, 2013), which refer to a reduced transition between standing and lying postures. The results from the present study showed that anthelmintic treated steers had a lower number of lying bouts during 12-26 July than infected steers. Nevertheless, the significantly higher number of lying bouts that emerged in the parasite infected steers may be due to one individual whose collected data was considerably higher in comparisons with the data for the other individuals. This might have caused the large variation between infected and anthelmintic treated steers in the second period, and hence a possible results that would have agreed with the results suggested by Szyszka et al. (2012) who found that the lying and standing episode frequency was decreased with 15 % in parasitized bulls that had received a single dose with 200,000 L3 of the parasite *O. ostertagi*.

Even though there were no significant differences in the number of lying bouts during the two other periods the results indicated that infected steers in general appeared to have lower number of lying bouts than anthelmintic treated animals. This would also be consistent with the results from earlier studies (Szyszka et al., 2012, 2013; Szyszka and Kyriazakis, 2013).

The cause of the reduced activity is still unclear, but it has been suggested that it may arise when the animals tries to conserve energy by less movements (Szyszka et al., 2013), especially since parasitic challenges commonly is accompanied by a reduced feed intake (Kyriazakis et al., 1998) as discussed earlier. It has also been suggested that a decrease in the general activity may be due to the nature of the parasites. The reduced general activity might also be due to a fewer response that normally occurs in combination with parasite infections (Hart, 1990).

Behavioural observations

Behavioural observations was used in the present study in order to investigate if this might be a potential method to examine to what degree intestinal parasites affects the general behaviour of cattle on pasture. The activity in the current study was measured both by the use of IceTags and behavioural observations. The behavioural observations, i.e. grazing behaviour, can be performed either by the use of video recording equipment (Szyszka and Kyriazakis, 2013) or direct observations. In the current study direct observations was performed. To the authors knowledge there are no other study that have used direct observations to evaluate behavioural changes due to gastrointestinal parasites. This might be due to that data collected through direct observation are not that reliable as the data collected from video recording equipment or the use of IceTags. However, as discussed earlier video recording equipment are not viable to observe grazing behaviours, or any other behaviour, during pasture period. It may also be difficult to register the different behaviours, i.e. ruminating, when watching a video display. It may also be time consuming to analyze all the video material afterwards. Direct observations are however also time-consuming and it might be difficult to observe animals at distance in a pasture where the vegetation might be dense. On the other hand, if the direct observations are proper prepared, with a detailed description of the different behaviours and where an prior pilot study have been made in order to test the observation technique, the recordings may be highly useful. Moreover, the advantage with IceTags is that these not only measure the activity levels such as number of steps taken, but also the postures (Szyszka et al., 2012) which increase their appliance. IceTags are also a trustworthy measurement due to that data, as in the present study, is collected during 24 h for 13 days in a row. However, incorrect recordings can occur due to inaccurate estimations of the activity when the device is attached to the leg (Nielsen et al., 2010).

The results from the behavioural observations showed that steers infected with parasites appeared to walk more compared with the anthelmintic treated animals. The reason for this can be due to the choice of weeks and the time of the day to perform the observations. The reason for having the observations mainly between 13.00 and 15.00 was because the steers were predicted to be more active in the afternoons. This contradicts with the results received from the IceTags, as discussed in the former chapter, and additionally to the results from previous studies where the activity level, as mentioned before, was found to be decreased due to parasite infections (Reiner et al., 2009; Szyszka et al., 2012, 2013). The postures were however similar between the different data collection methods on activity level, where infected steers tended to stand more and lie less.

Social behaviours such as allogrooming are an important feature in cattle due to the communicative function with other individuals (Laister et al., 2011). When an animal is faced with a health challenge the social behaviours in general are reduced (Hart, 1988). The present study showed the opposite where the parasitized steers appeared to perform more social behaviour than the anthelmintic treated animals. The social behaviour measured in this study were mainly sniffing and licking of another individual, which is equated with allogrooming. However, for the behaviours sniff/lick itself, sniff/lick object and drink the mean values are very similar and the SE for the differences between observation days are overlapping so much that there does not seem to be any differences between high and low parasite load groups. Even though it did not appeared to be any apparent differences for the behaviours sniff/lick itself, sniff/lick object and drink between steers with high and low parasite load, behaviours such as social behaviours and drinking in general are decreased (Hart, 1988), which may be a result of a parasitic health challenge.

Factors that might have contributed to the different results between the present study and previous studies might be environmental factors, such as the automatic scales that were placed on the pasture, the weather, but also the manual weighings where the animals were brought into the stables. These factors might have contributed to a changed behaviour and hence a different results than previous studies.

Future studies

There were some disturbances during the study that could have affected both the behaviour and weight gain of the steers. The disturbances refer to the required deworming of two steers, and to the problem with downloading of the activity patterns from two of the IceTags. These values were therefore treated as missing values which may have affected the overall results. To what extent or if the results may have been affected will remain unclear. Nevertheless, the results obtained from the current study still points out the important knowledge that gastrointestinal parasites have a negative impact on both weight gain and activity patterns in cattle.

Even though infections caused by gastrointestinal parasites have been found to be the most prevalent cause of impaired productivity (Schutz et al., 2012), there are still only a few studies that have investigated the negative impacts caused by these parasites, especially on the activity patterns. By examine the temporary changes in the behaviour of cattle these results may be useful guidelines in the future in order to diagnose gastrointestinal parasites (Szyszka et al., 2013). Further effort should therefore be made in order to gain more knowledge about how these parasites affects the behaviours.

In the current study grazing behaviour was only observed through direct behavioural observations and these indicated that the grazing behaviour was increased in parasitized animals. This may be due to the increased nutritional demands on the host animal since it seems natural that an increased demand regarding the nutrition would lead to an increased grazing behaviour in order to compensate for the parasitic presence. It would therefore be interesting to investigate what this increased grazing behaviour in the parasitized animals may be due to, even though previous studies found the opposite (Fox et al., 1989; Taylor et al., 1989; Kyriazakis et al., 1998; Forbes et al., 2004; Szyszka et al., 2013).

Conclusion

The current study revealed that gastrointestinal parasites cause a reduced daily weight gain in steers with high parasite load. The daily weight gain was also found to be influenced by the different pasture periods, where steers with low parasite load had a higher daily weight gain during 31 May-14 Jun, 29 Jun-12 Jul and 6-20 Sep. Gastrointestinal parasites also cause a decreased general activity level per 24 h in steers with high parasite load. The general activity was nevertheless increased during day time in infected animals. The results regarding the activity patterns were however different depending on data collection method where the results from the IceTags demonstrated a decreased general activity in parasitized animals while the behavioural observations instead showed an increase in the general activity level in the parasitized animals.

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