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Report 542

Space allowance of young goats during transportation to slaughter.

welfare of goats on the road

December 2011

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Abstract
Research was performed during long distance road transportations of young goats (6-8 weeks). Effects of three space allowances on physiological responses (blood parameters, heart rate and body temperature) were measured.

Keywords
Young goats, road transport, heart rate, blood parameters, body temperature, loading density

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Titel
Space allowance of young goats during transportation to slaughter.

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Samenvatting
Onderzoek tijdens lange afstand wegtransport van jonge geiten (6-8 weken oud). Enkele fysiologisch responsen (hartslag, lichaamstemperatuur en bloedparameters) werden gemeten bij drie verschillende beladingsdichtheden

Trefwoorden
Jonge geiten, wegtransport, hartslag, bloed parameters, lichaamstemperatuur, beladingsdichtheid.

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Space allowance of young goats during transportation to slaughter.

Beladingsdichtheid tijdens het wegtransport van jonge geiten.

V.A. Hindle, H.G.M. Reimert, J.T.N. van der Werf, E. Lambooij

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Voorwoord

In het kader van beleidsondersteunend onderzoek van het ministerie van Economische zaken, Landbouw en Innovatie is additioneel financiën vrijgemaakt voor een studie naar het welzijn van jonge geiten tijdens wegtransporten vanuit Nederland naar de slacht in het buitenland.

Samenvatting

Consumenten vragen een betere behandeling van dieren in de gehele productieketen, dus inclusief het transport van dieren. De condities tijdens transport en het welzijn van getransporteerde dieren staan steeds meer ter discussie. Parlementariërs en beleidsmedewerkers van verschillende overheidsorganisaties willen condities tijdens transport verbeterd hebben om aan de vraag van de burger te voldoen.

De interesse in Nederlandse zuivelproducten van geiten is stijgende met als gevolg een stijgend aantal geboren geitenbokjes. Om te voorkomen dat geitenbokjes op het bedrijf massaal gedood zouden moeten worden heeft de sector een plan van aanpak opgesteld. Een onderdeel hiervan was om het totaal aantal bokjes te beperken en een zo'n groot mogelijk aantal dieren in NL af te mesten en te slachten waarna het vlees geëxporteerd zou kunnen worden. Helaas is er onvoldoende capaciteit voor het slachten van deze bokjes en vervolgens gaat er ook nog een slachthuis dicht. Dit betekent dat een groot aantal van deze bokjes levend naar Spanje en Frankrijk worden getransporteerd. Dit staat haaks op de wens van de overheid om lange transporten van slachtdieren te beperken tot maximaal 8 uur.

De dierenartsen van de Voedsel en Waren Autoriteit stellen vraagtekens bij de huidige Europese norm van geiten met een gewicht tot 35 kg 0,2 m^2/dier nodig hebben, dus 5 bokjes/m^2. Wanneer de bokjes 9/10 kg, dus < 35 kg is dus de norm: 5 dieren/m2 op grond van het dierenwelzijn. Op grond van de transportverordening mag de beladingsgraad van jonge geitenlammeren minder dan 0,2 m^2/dier bedragen indien de leeftijd, de grootte van de dieren, de weersomstandigheden en de lengte van de reis hiertoe aanleiding geven. Op basis van de grootte van de dieren zou afwijking van de beladingsgraad kunnen worden gerechtvaardigd. Echter de lange transporttijd, de mindere fysieke conditie van jonge dieren en de weersomstandigheden tijdens de zomermaanden in Spanje zijn destijds aanleiding geweest deze hogere beladingsgraad niet toe te staan. Deze overweging is gemaakt met in achtneming van de overwegingen van het EFSA rapport (SCAHAW, 2002).

Het principe dat dieren adequate ruimte hebben, kunnen staan en liggen in hun natuurlijke positie in hun thermische comfort zone en zonder beschadigingen en lijden met voldoende hoogte in het compartiment is vastgelegd in de EU-regelgeving. De Transportverordening 1/2005 vereist onder andere dat er voldoende ruimte boven de dieren dient te zijn om voor een adequate ventilatie boven de dieren te zorgen wanneer deze in hun natuurlijke houding rechtop staan zonder dat zij gehinderd worden in hun natuurlijke bewegingen. Het EFSA rapport maakt ook melding van het feit dat dieren in staat moeten kunnen zijn om hun evenwicht te bewaren zonder in contact te hoeven komen met hun soortgenoten. Daarnaast is het voor het welzijn van het dier noodzakelijk dat de binnentemperatuur van het vervoerscompartiment niet buiten de grenswaarden van de comfort zone van de te vervoeren diersoort komt. De grenswaarden van de comfort zone van jonge dieren liggen dichter bij elkaar dan die van volwassen dieren. Het is belangrijk dat de technische voorzieningen in het compartiment de comfort zone kunnen handhaven.

Dit rapport bevat de bevindingen van een studie naar verschillen in gedrag- en fysiologische responsen van jonge geiten (8-10 kg lichaamsgewicht, max. 8 weken oud) tijdens het transport. De dieren werden vervoerd met 0.2, 0.13 of 0.1 m^2 leefruimte per dier (oftewel beladingsdichtheden van 5, 7.5 of 10 dieren /m^2) gedurende drie ritten. Hierbij betrokken zijn gespeende geiten na 5-6 weken melkvoeding via een lammerbar. Deze dieren zijn met een vrachtauto vanaf een verzamelpunt in het zuiden van Nederland naar een slachthuis in Noord Spanje (ca. 1400 km) getransporteerd.

Bij het verzamelpunt werden voor het laden, 6 dieren geselecteerd per beladingsdichtheidsgroep. Bij elke rit kwam elke beladingsdichtheid voor. Van elk van deze dieren werden het lichaamsgewicht en temperatuur gemeten, waarna bloedmonsters uit de halsader werden genomen. Bij 3 van deze geselecteerde geiten werd een ECG (hartfilm) logger in een hesje om de borst geplaatst. Elk groep van 6 dieren werd gehuisvest in een van de drie beladingsdichtheden. De locatie van de groepen werd per rit gerouleerd over de drie compartimenten van de onderste laag van het aanhanger van de vrachtauto. Bij aankomst werden de beladingsgroepen (van 6 dieren) apart gehuisvest in de wachtruimte van het slachthuis

Na het uitzetten werd de logger unit verwijderd en bloedmonster genomen en het temperatuur en lichaamsgewicht opgemeten.

Het gedrag werd digitaal vastgelegd via twee (breed beeld) camera's geplaatst tegenover elkaar in elk compartiment gedurende de rit. De bezetting van de ruimte door de geiten werd geanalyseerd. Opvallend, was dat alle dieren stonden bij het vertrek. Op geen enkele moment ging alle dieren tegelijk liggen, onafhankelijk beladingsdichtheid. De beschikbare ruimte wordt volledig gebruikt (staand of zittend) bij

10 geiten per m^2. Bij de laagste beladingsdichtheid kropen de dieren dichter bijeen. Bij de middelste bezettingsgraad verspreidden de geiten zich over het compartiment. De beladingsdichtheid had geen effect op het gedrag en de fysiologische parameters gemeten tijdens het transport. Hartslag varieerde tussen 120 – 190 slagen/min tijdens de ritten in maart en april. Tijdens de rit in mei werd een lagere hartslag (100-160 slagen/min) geregistreerd. Het bleek onmogelijk effecten van beladingsgraad op hartslag te onderscheiden gedurende deze ritten met jong geiten.
Een students t-test werd gebruikt om de bloedanalyse data statistisch in 2 ritten voor en na transport te toetsen. De uitkomsten wijzen op significante (P<0.001) toenames in Hb, Ht, Na+ en Cl- en ook BE (P= 0.002) en een significante reductie in sO_2 (P=0.007).
De geiten (8-10 kg) verloren gemiddeld 0.4 kg lichaamsgewicht en hun lichaamstemperatuur was 0.2 ^{o} C lager.

Conclusies

- Geitenbokjes (8 – 10 kg) verliezen ongeveer 0.4 kg en dalen 0.2^{o}C in temperatuur tijdens een transport van 20 uur van verzamelplaats tot slachthuis.
- Er komen geen duidelijke verschillen in beladingsdichtheid naar voren in gedrag en fysiologische waarden.
- Tijdens het transport kruipen de dieren tegen elkaar aan bij de lagere bezettingen. Bij de hoogste bezetting is de bewegingsruimte per dier (te) beperkt, omdat de ruimte vol is.
- De bloedwaarden duiden op een indikking van het bloed t.o.v. de begin waarde op de verzamelplaats

Aanbevelingen

- Duidelijke verschillen in gedrag en fysiologische waarden zijn bij geitenbokjes (8 – 10 kg) getransporteerd met verschillende beladingsgraden niet aangetoond. Wel is het compartiment met een bezetting van 10 dieren/m^2 vol, waarmee een maximumgrens is bereikt en de aanbeveling is iets lager te zitten e n wel 9 dieren/m^2
- Aangezien de dieren een gebrek krijgen aan vocht wordt aanbevolen het vocht op een andere manier te verstrekken.

Summary

In response to consumer demand the Dutch government is addressing several issues concerning welfare of animals in the chain of production.
A particular case in point is the increasing demand for Dutch dairy products from goats. However, this has produced a surplus young male goats. In order to avoid a mass on-farm slaughter of unwanted goats the industry has initiated a plan of action. This plan envisages a curtailment of the numbers of male goats and introduction of a policy to rear as many goats as possible for slaughter in The Netherlands with eventual export of the meat and meat products. At present a large number of male goats are transported live to be slaughtered upon arrival in France and Spain. This practice is directly contrary to the governments wishes to restrict live animal transportation. A recent review of EU directive 1/2005 recommends journey times for several species including goats of up to 8 hours (EFSA,2011).
The Competent Authority is concerned about the authenticity of the present European standards for the transportation of goats. Current EU standards state that goats up to 35 kg bodyweight have sufficient space with an allowance of 0.2 -0,30 m^2/animal, or approximately 5 goats/m^2, irrespective of animal size. However, in terms of the decree on transportation of live animals the space allowance for young male goats may be less than 0,2 m^2/animal depending on age, body size, weather conditions and the length of the journey. Adjustments based on the size of the animals to be transported appear justifiable, but long journey times, physical restraints of young animals and the extremes of summer weather conditions in Spain have restricted acceptance of higher loading densities. These restrictions have been introduced according to an EFSA report (SCAHAW, 2002).
A recent EFSA review (EFSA, 2011) states that sufficient space should be provided inside each compartment to ensure that there is adequate ventilation above the animals when stood in their natural position, without hindering their movement.
An animal's ability to cope during transportation are dependent upon maintenance of its comfort zone. During transport goats in particular are suspect to social (i.e. mixing with strange, unknown animals) and other forms of stress (e.g. rough handling) (EFSA, 2011). Individual behavioural differences that develop on-farm are related to reactions during transportation. Behavioural (over-reaction to normal stimuli) and clinical changes (increase in respiration and heart rate) can lead to exhaustion (Broom & Johnson, 1993). Loading on to the vehicle increases risk of injury or wounding, caused by forcible contact in the loading runs of by fighting or springing up against their contemporaries, causing stress prior to transportation. Stress affects energy use and body temperature resulting in an increase in respiration and evaporation. Eventually defecation may increase resulting in bodyweight losses up to 10% in goats (Richardson, 2002).
Transporters and traders in livestock, believe that the EU decree on livestock transportation offers scope for increasing stocking density above the standard of 5 animals per m^2 . The research reported here is an initial appraisal of EU approved space allowances for young goats. Goats involved had been weaned and removed to a rearing farm where they were lambar-fed for the initial 5-6 weeks and then transported (c. 1400 km) from a central assembly point to the slaughter plant in Spain.
This report documents a study of the differences in behaviour and physiological responses to travelling conditions observed during transportation of young goats (8-10 kg bodyweight, max. 8 weeks old) at space allowances of 0.2, 0.13 and 0.1 m^2/ animal (equivalent to loading densities of 5, 7.5 or 10 animals /m^2, respectively) during three journeys.
Prior to loading at the assembly point 6 goats were selected per space allowance group an each individual was weighed, rectal temperature measured and three of the six were fitted with a purpose made ECG logging device. Each group of 6 was allocated to one of three compartments on the lower deck of a three-tiered trailer. Position of loading density was rotated for each journey. Upon arrival at the slaughter plant each treatment group was unloaded into a separate holding pen. The ECG logging device was deactivated and removed, a blood sample was taken, rectal temperature measured and each animal weighed.
Behavioural responses were monitored by two video wide lens cameras fitted directly facing each other in each compartment. This allowed for continual registration throughout the journey from moment of loading until the last animal had vacated the trailer. Positioning of the cameras allowed only for a side view of the compartment which restricted determination of individual behaviour but did allow an assessment of the space occupied.
Exceptionally, it was only at the beginning of transportation that all lamb goats were standing . During the journey it was observed that not at any time were all goats lying down independent of the loading density. However, occupation of the compartment was seen to differ with loading density, the available area is fully utilized at a loading density of 10 goats per m^2. Independent, of whether they were

standing or lying down. Goats transported at a low density tended to group to the front or rear of their compartment in close proximity to adjacent groups, while goats in the high density group filled the compartment. Goats housed at medium density were spread sporadically throughout the compartment.
The HR levels and patterns observed here displayed variable patterns, HR ranged between 120 – 190 bpm during the trips performed in March and April while the range observed during the last journey was slightly lower (100-160 bpm). No distinction could be made as to effect of treatment on HR during transportation.
Blood parameter data was analysed using a t-test of variables from samples taken prior to departure paired with those from samples taken after arrival at the slaughter plant, Results indicated significant ($P<0.001$) increases in Hb, Ht, Na+ and Cl- measurements and BE ($P= 0.002$) and a significant decrease in sO_2 ($P=0.007$) levels.

Conclusions

- Young male goats (8-10 kg) lost an average 0.4 kg in bodyweight and their body temperature fell by 0.2 ^{o} C during transportation by road for approximately 20 hours from assembly point to slaughterhouse.
- Loading density did not appear to have any distinctive effects on animal behaviour or those physiological parameters that were measured.
- During transportation the goats tended to huddle together at lower loading densities. Goats transported at the highest density (10/m^2) appeared to be restricted in their movement due to the limited amount of free floor space.
- Blood parameter measurements indicate a thickening of the blood during transportation from the assembly point, symptomatic of dehydration stress.

Recommendations

- There were no indications of obvious differences in behaviour and physiological parameters of young goats (8-10 kg) when transported at the loading densities applied during his study. However, loading at 10 animals/m^2 is considered to be very full indicating that a limit has been reached and it is therefore recommended that young goats be transported at a slightly lower loading density of 9 animals/m^2.
- The goats also displayed signs of dehydration although water was made available. It is advised that water should be supplied using a drinking system to which the animals are accustomed.

Contents

1 Introduction

Consumers and public organisations alike are constantly increasing their demands for improvements in the rearing and handling of animals within the food production chain. These demands include concerns about conditions during the transportation of production animals. Parliamentarians, policy makers and various governmental organisations are aware of the fact that something has to be done to address these public concerns.
Demand for Dutch dairy products from goats is growing, which consequently results in surplus amounts of “Billy” or male goats. In order to avoid a mass on-farm slaughter of Billy goats the industry has initiated a plan of action. This plan envisages a curtailment of the numbers of male goats and introduction of a policy to rear as many goats as possible for slaughter in The Netherlands with eventual export of the meat and meat products. Unfortunately, there is insufficient slaughter capacity and yet another slaughterhouse is expected to close shortly. Consequently, a large number of male goats are transported live to be slaughtered upon arrival in France and Spain. This practice is directly contrary to the governments wishes to restrict live animal transportation. A recent review of EU directive 1/2005 recommends journey times for several species including goats of up to 8 hours (EFSA,2011).
The Competent Authority is concerned about the authenticity of the present European standards for goats. According to present EU standards, goats weighing up to 35 kg have sufficient space with an allowance of 0.2 -0.3 m^2/animal, or approximately 5 Billy goats/m^2 (EC regulation, 2004) Therefore, if the goats weigh between 9-10 kg (< 35 kg) the standard is 5 animals/m^2 to ensure animal welfare standards. However, in terms of the decree on transportation of live animals the space allowance for young male goats may be less than 0,2 m^2/animal depending on age, body size, weather conditions and the length of the journey. Adjustments based on the size of the animals to be transported appear justifiable, but long journey times, physical restraints of young animals and the extremes of summer weather conditions in Spain have restricted acceptance of higher stocking densities. These restrictions were made in accordance with considerations made in the EFSA report (SCAHAW, 2002).
Additionally, a recent EFSA review (EFSA, 2011) emphasizes (chapter II, Means of transport, sub section 1.2, page 69) that sufficient space should be provided inside the compartment and at each level to ensure that there is adequate ventilation above the animals when stood in their natural position, without hindering their movement.
An animal’s ability to cope is considered to be correlated with its response to transportation and conditions affecting its comfort zone. During transport goats in particular are suspect to social stress (i.e. mixing with strange, unknown animals) and other forms of stress (e.g. rough handling) (EFSA, 2011). Individual behavioural differences that develop during rearing on-farm are related to reactions during transportation, such as herding and mixing of animals. During stress the hormones of the hypothalamic-pituitary-adrenal axis (glucocorticoids) and the autonomic nervous system (ANS) (para- and sympathetic nervous system; catecholamines) are activated. This results in unusual behaviour (over-reaction to normal stimuli) and clinical changes (increase in respiration and heart beat rates), resulting in exhaustion (Broom & Johnson, 1993). Prior to departure the animals are loaded on to the vehicle with increased risk of injury or wounding. This is mainly due to forcible contact against the sides of the loading runs but once in the compartment they can fight or spring up against their contemporaries, causing stress prior to transportation. Stress affects energy use and body temperature resulting in an increase in respiration and evaporation. Additionally, defecation increases resulting in loss of bodyweight. Withholding of feed together with dehydration can result in up to 10% loss in live weight in goats (Richardson, 2002).
Animal husbandry systems are based on behavioural characteristics and encouragement of residence. Transportation of animals should be subjected to the most stringent rules and long journeys to slaughter should be avoided or limited to an absolute minimum.
Those posed with this problem, in particular transporters of goats and traders in livestock, believe that the EU decree on livestock transportation offers scope for increasing stocking density above the standard of 5 animals per m^2 . This research was intended as an initial appraisal of EU approved space allowances for young goats. These goats had been weaned and removed to a rearing farm where they were fed with a lambar for the initial 5-6 weeks of their lives and transported from a central assembly point over a distance of approximately 1400 km for slaughter.
This report documents a study of the differences in behaviour and physiological reactions to travelling conditions observed during transportation of young goats (8-10 kg liveweight, max. 8 weeks old) at space allowances of 0.2, 0.13 and 0.1 m^2/ animal (equivalent to loading densities of 5, 7.5 or 10 animals /m^2, respectively) during three journeys.

2 Materials and Methods

2.1 Experimental design

Transport of live goats was envisaged in co-operation with traders and a commercial transport company. Data was used from three commercial journeys with goats from an assembly point in The Netherlands (Eindhoven) to a slaughter facility in Spain (Barcelona), a distance of approximately 1400 km. These journeys were performed in spring (April – May) 2011. The goats were transported in a three-tier vehicle with each deck divided into three compartments. Monitored animals were placed in the three compartments of the lower deck of the trailer and transported at one of the following stocking densities: 5 (low), 7.5 (medium) or 10 (high) animals per square meter. These stocking densities were rotated per compartment for each trip. The dimensions of the floor space per compartment varied slightly as follows (l x b): front 2.7 m x 2.4, middle 2.85 x 2.4 and rear 2.7 x 2.4m.
Drinking water was available via a nipple system in lairage (assembly point) and during transportation. Immediately before loading 18 goats were selected at random, weighed and blood samples were taken from the jugular vein. Rectal temperature was measured using a standard mercury (Hg) thermometer.

2.2 Animals

All animals (Dutch Dairy goats) used were young male goats (6-8 weeks old) intended for commercial slaughter in Spain (Barcelona). These goats were surplus to demand on-farm and were reared on a lambar from birth with milk. Milk was withdrawn 2 hours prior to transportation from the rearing farm to the assembly point. The goats were housed for 2-6 hours at the assembly station and had access to water only.

2.3 Behaviour

Animal behaviour was recorded throughout each journey with cameras fitted with wide-angle lens and stored on digital recorders for analysis at a later date, after completion of all the journeys. Cameras were fitted in the three compartments on the lower deck of the vehicle. The two cameras in each compartment were placed on each side of the compartment directly facing each other in an attempt to cover the activity of the animals throughout the whole compartment, or as much as possible.
Video recording started from the moment that the first animals entered the compartment until unloading.
Basis for behaviour analysis was an ethogram containing the following characteristics:
Standing: animals supports its own weight on three or four legs.
Lying down : animal prostrate on belly or side. Sometimes on top of a companion animal.
Sitting: animals sits on rump and supports front half with front legs. Rump placed on floor of compartment or on top of a companion animal (only observed incidentally).
Agonistic behaviour (e.g. butting, displacement, threats) was observed incidentally.

These parameters were analysed from the moment the compartment was closed until the end of the recording. Behavioural characteristics were analysed from the first 15 minute period real time until the last 15 minute segment real time i.e.: during periods of 15 minutes (0, 15, 30, 45 every hour). These activities were scored as follows:

1. Count or estimation of numbers of goats standing
2. Estimation of the of the numbers of animals in an area expressed as percentage of total compartment area that was occupied during the period analysed.
3. Estimation of the largest area that wasn't occupied during the period expressed in relation to total compartment area.

Recordings from each camera were synchronized per compartment to compensate for so-called "blind" areas (close to or under a camera, outside the range of the lens angle) not completely covered by each camera.
For practical reasons, derivative measure for the area occupied (as percentage of total compartment space) was defined as the smallest imaginary square that could be drawn around all animals, including the corner that was nearest to the animals. Derivative measure for the unoccupied area (as percentage of total compartment space) was defined as the largest imaginary square that could be drawn around free space, including the corner furthest away from the animals. Therefore, occupied and unoccupied space as defined here do not necessarily add up to 100% of compartment space.

2.4 Heart activity, body weight and body temperature

Prior to each trip 9 of the selected goats were equipped with ECG electrodes. In order to secure placement of monitoring equipment a specially designed jacket was made for use in this experiment (figure 1). The jacket was fitted prior to loading. Firstly, the test goats were shaved (figure 2) to allow close fitting of the jacket and ensure good contact with the pad electrodes used for placement of the sensor leads. Before placement of the electrodes the area was rinsed with water, dried and cleaned with 70% alcohol. Surgical glue was applied to secure the pad electrodes to the surface of the skin (figure 3). Electrodes were placed caudal to the olecranon on both sides of the breast. The earth electrode being placed dorsally to the electrode on the right side of the breast. The sensor leads were attached to a data logger (Lowe et al, 2007) which was housed in a stainless steel container and secured in a pouch on the back of the goat (figure 4). Logging started immediately after fitting the data logger and was terminated upon arrival in the reception pen in the slaughterhouse. Three of the 9 goats fitted with ECG equipment were allocated to each compartment in the lower deck of the vehicle. After transport the similar procedure was performed and the jackets including electrodes removed.

Figure 1: Goat ready for transport equipped with heart rate logger in specially made jacket.

Body temperature was measured as rectal temperature and ECG traces were analysed as heart rate in beats per minute. (Labchart7 Pro, V7.1.2, AD Instruments, Cologne, Germany).
All selected goats were weighed using a digital balance (Mettler) prior to preparation for blood sampling and logger fitting. All treatment animals were weighed upon arrival in the collection pen at the slaughterhouse.

Figure 2; Preparation of skin area for application of electrode pads.

Figure 3: Placement electrode pad.

Figure 4: Goat fitted with logger in specially designed pouch.

Figure 5: Goats in lairage prior to transport

2.5 Blood parameters

Figure 6 :Blood sampling.

Blood samples were taken from 18 goats in all which meant that 36 samples were taken during each journey. Samples were taken (figure 6) prior to fitting of the logging equipment and after arrival at the slaughterhouse in Barcelona prior to removal of the logging device. Analyses of the blood samples was performed immediately after sampling using an ABL80 Flex (Radiometer Medical ApS Brønshøj, Denmark).

Blood samples were analysed for :
pH (acidity or alkalinity values; expressed as H+ -ion concentration)
pCO_2 (pressure of carbon dioxide: expressed as mm Hg)
pO_2 (pressure of oxygen: mmHg)
sO_2 (saturation levels of oxygen: %)
BE (base excess value: mmol/L)
Hb (Haemoglobin levels: g/dL)
Ht (Haematocrit levels: %)
Glu (Glucose levels: mmol/L)
Na (Sodium ion concentration: mmol/L)
CL (Chloride ion concentration: mmol/L)
K (Potassium ion concentration: mmol/L)
Ca (Calcium ion concentration: mmol/L)

2.6 Temperature and humidity in compartment

Ambient temperature and relative humidity were recorded for each compartment. A hotdog (thermohygrometer; type: ATV; Merk Atal) was suspended from the ceiling in the centre of each compartment enabling continual measurement of temperature and relative humidity throughout the journey.

2.7 Ethics

Use of a limited number of goats for measurement and observation during commercial journeys from a collection point in the South of the Netherlands to the slaughterhouse in the North of Spain was approved beforehand by the Ethics Committee on use of Animals for Experiments (DEC) of Wageningen UR, Livestock Research (Lelystad, the Netherlands).

2.8 Data analysis

Changes in rectal temperature and bodyweight were analysed using the ANOVA option in the statistical package GenStat for Windows (GenStat, 2011). Blood parameters before and after transport were analysed as a paired students t-test.

3 Results

3.1 Experimental design

The goats used in this study were all transported on the lower deck of the trailer at three different space allowances, allocated per journey to different compartments (Table 1). All animals arrived safely at the destination, i.e. no deaths occurred during transportation.

Table 1: Duration (arrival – departure time), placement (front, middle, rear), stocking densities (10, 7.5 or 5 goats /m2) and total numbers transported. Each trip started between approximately 10.00 and 11.00 am.

Trip[1]	Duration	Front	Middle	Rear	Goats
			Compartment		
			Stocking density (goats/m^2)		
	hrs		Numbers per comp.		Total freight
1	18:18	5	7.5	10	684
		32	46	65	
3	19:40	7.5	10	5	563
		43	68	32	
4	18:25	10	5	7.5	654
		65	34	43	

[1]: second trip aborted after police compounded the vehicle at the French-Spanish border.

3.2 Body temperature and weight

Table 2. Allocated stocking density (goats/m^2) per transport. Overview of average (S.D.) rectal temperatures (^{o} C) and average (S.D.) body weight (kg) of 6 goats per compartment prior to loading (Dept.) and after unloading (arrival).

trip	Compartment	Stocking Density[1]	Rectal Temperature Dept.	Arr.	Body weight Dept.	Arr.
1	Front	5	39.2(0.6)	38.9(0.7)	8.8(1.0)	8.6(1.0)
	Middle	7.5	39.4(0.2)	39.2(0.5)	8.4(1.0)	8.1(0.9)
	Rear	10	39.4(0.6)	39.1(0.3)	8.4(0.7)	8.2(0.7)
Overall average			39.3(0.5)	39.1(0.5)	8.5(0.8)	8.3(0.8)
3	Front	7.5	39.8(0.3)	39.5(0.2)	8.1(1.1)	7.5(1.0)
	Middle	10	39.6(0.2)	39.6(0.3)	8.4(1.0)	8.0(1.0)
	Rear	5	39.8(0.2)	39.6(0.3)	9.0(0.6)	8.5(0.6)
Overall average			39.8(0.3)	39.6(0.3)	8.5(1.0)	8.0(0.9)
4	Front	10	39.4(0.4)	39.3(0.4)	9.1(1.2)	8.5(1.2)
	Middle	5	39.6(0.4)	39.3(0.5)	8.8(1.0)	8.5(0.8)
	Rear	7.5	39.6(0.3)	39.3(0.3)	8.9(1.5)	8.6(1.5)
Overall average			39.5(0.4)	39.3(0.4)	8.9(1.2)	8.5(1.1)

[1] stocking density of 5, 7.5 and 10 animals per square meter equivalent to space allowances of 0.2, 0.13 and 0.1 square meter per animal respectively.

3.3 Compartment temperature and humidity

Conditions at departure were within seasonal ranges for the area. Temperature at departure averaged 15 (± 2) °C and relative humidity was between 63 -73 % as average over the three trips monitored. Conditions upon arrival were between 10-15 °C and relative humidity was 50-60 %.

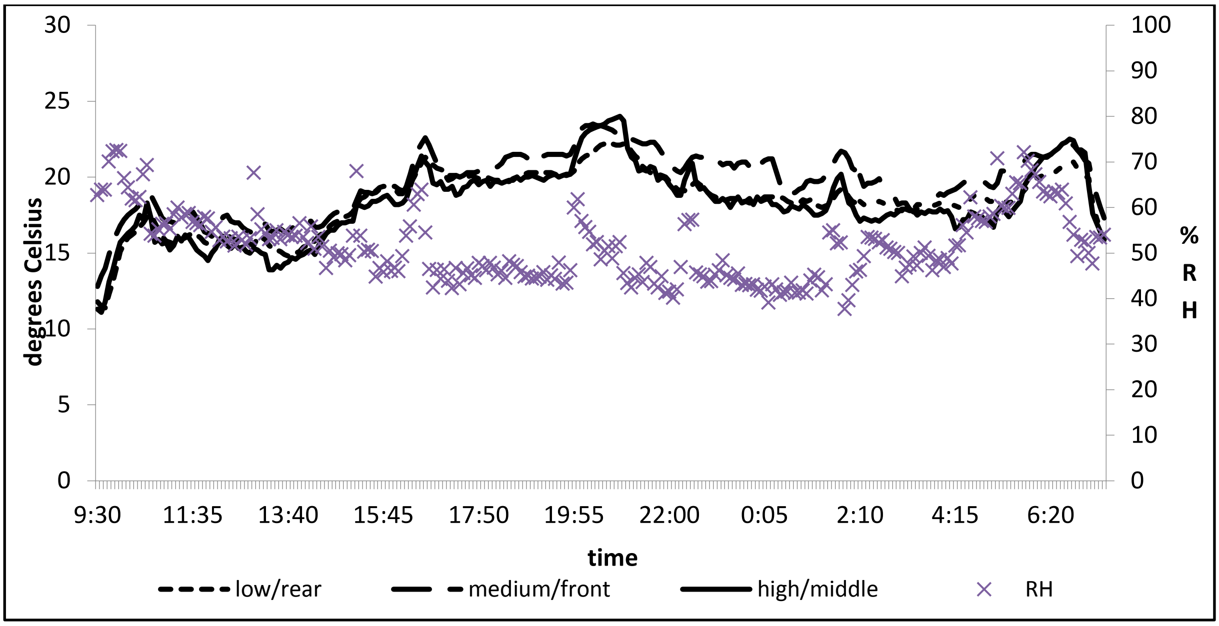


Figure 7: Ambient temperature per compartment and relative humidity measured continually during transportation of goats from The Netherlands to Spain on 4-5 April 2011.

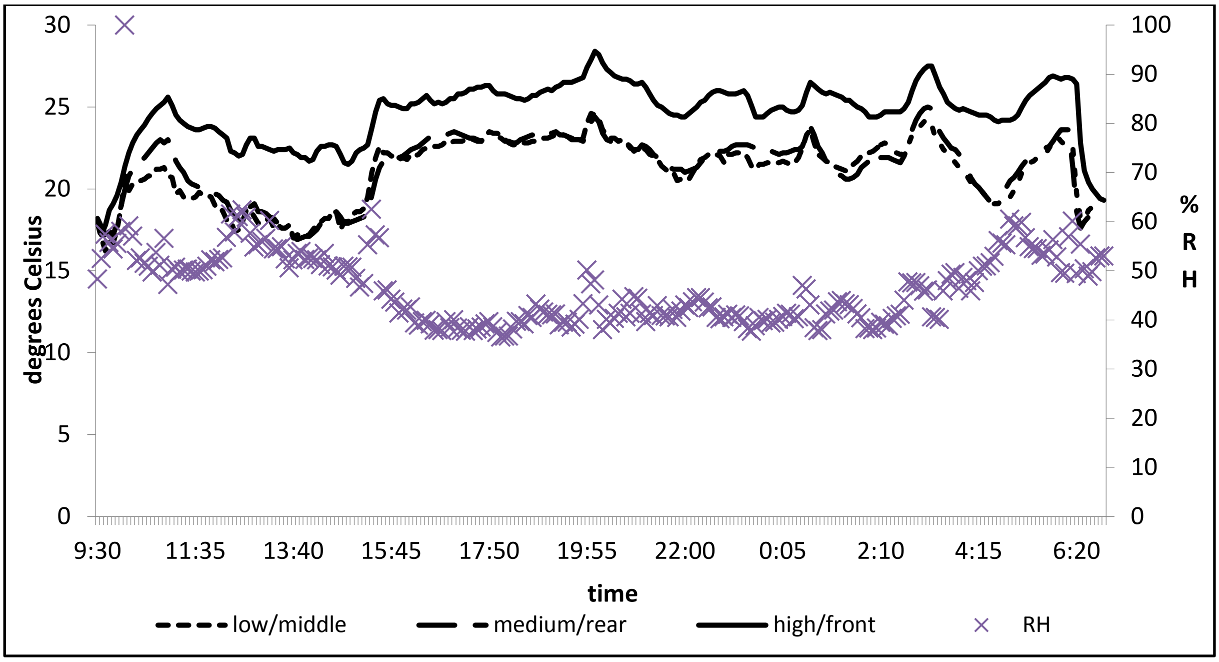
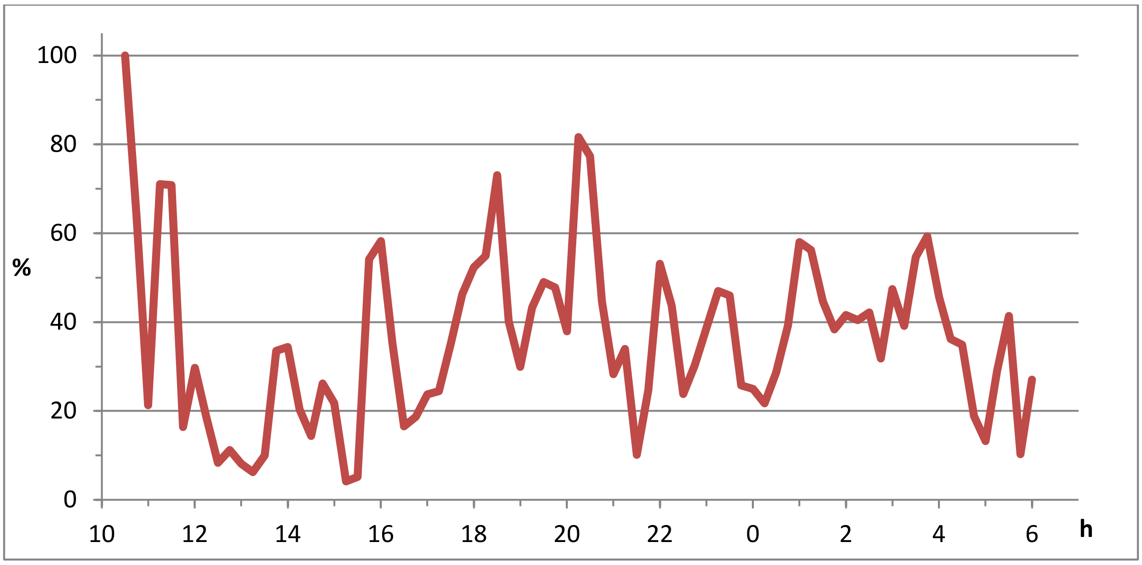


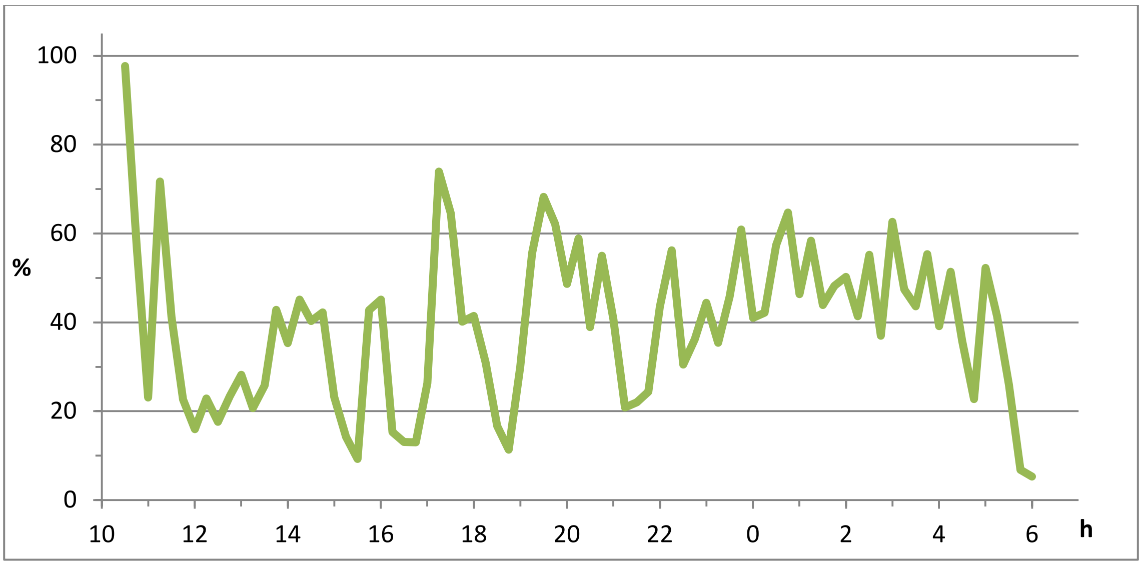
Figure 8: Ambient temperature per compartment and relative humidity measured continually during transportation of goats from The Netherlands to Spain on 16-17 May 2011

3.4 Behaviour

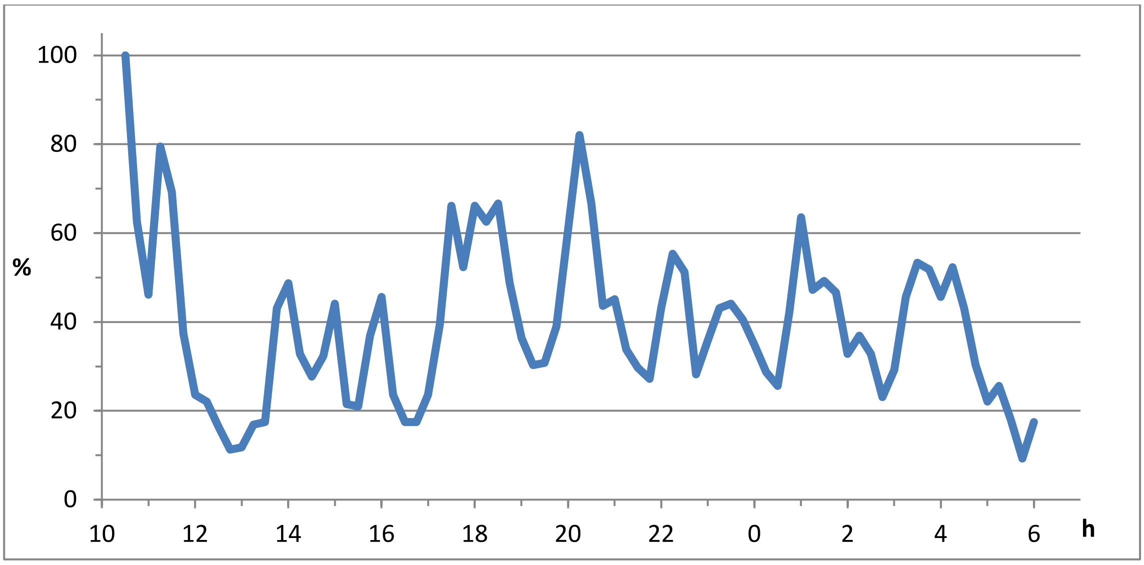
Each recording was analysed in 15-min segments during which counts were made of the numbers of goats standing, results depicted in figure 9 for low (a = 5/m^2), medium (b= 7.5/m^2) and high (c=10/m^2) stocking densities respectively. In order to assess the area occupied an estimate was made of the total available floor space (length x width of visible area) that was occupied, shown in figure 10 for low (a), medium (b) and high (c) stocking densities respectively. At the same time an estimate was made of the available free floor space expressed as a percentage of the visible area, results shown in appendix 3.
Surprisingly, it was only at the beginning of transportation that all goats were standing. During the journey it was observed that not at any time were all goats lying down independent of the loading density. (Figure 9). However, occupation of the compartment was seen to differ with loading density, the available area is fully utilized at a loading density of 10 goats per m^2 (Figures 10 c). Independent of whether they were standing or lying.
As a result of the restricted height (low ceiling)positioning of the cameras restricted the view of the animals, observation of agonistic behaviour was unsatisfactory.



a

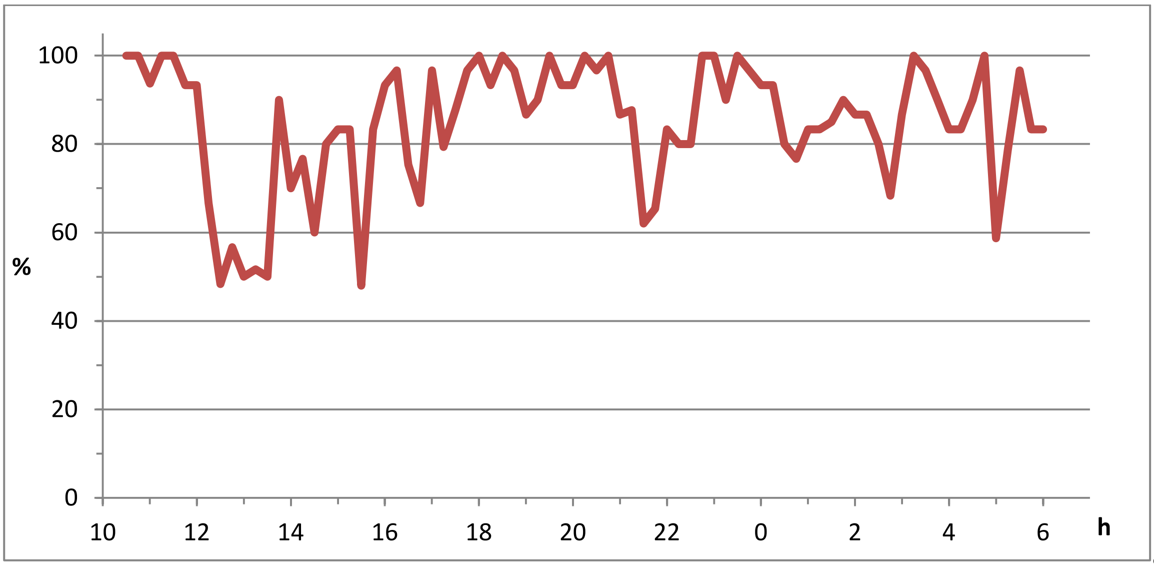


b

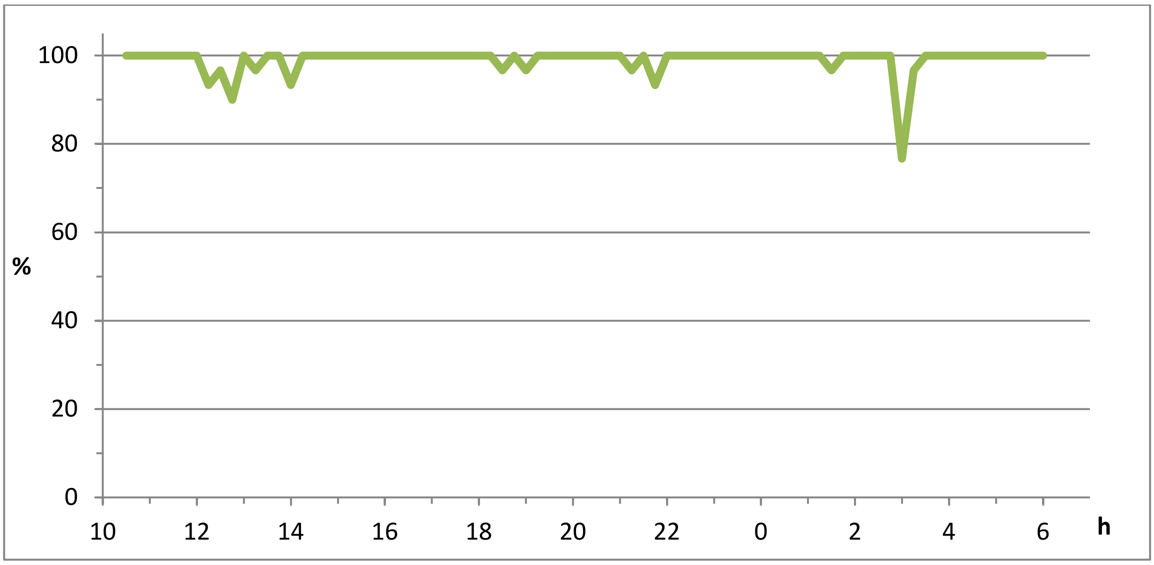


c

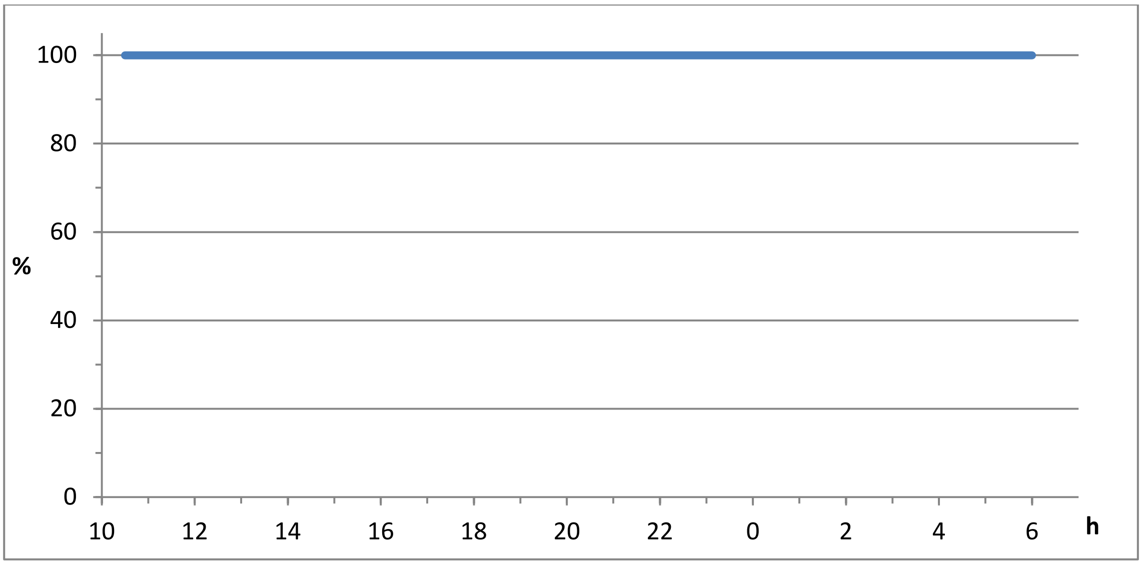
Figure 9: Percentage of goats standing during transportation (average of three trips): a) low density (5/m2); b) medium density (7.5/m2) and c) high density (10/m2).



a



b



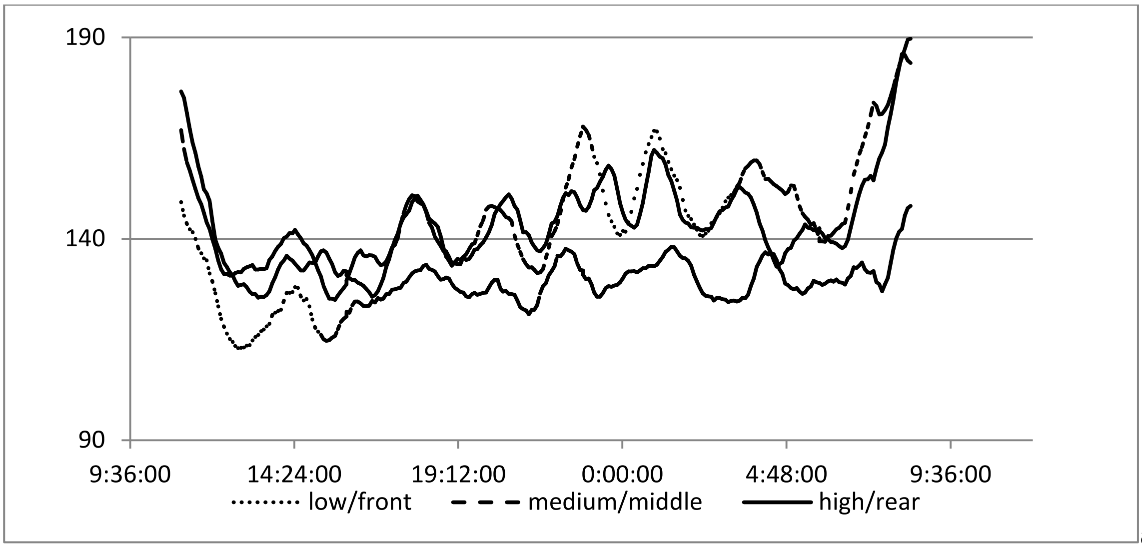
c

Figure 10: Percentage space occupied during transportation (average of three trips):
a) low density (5/m^2); b) medium density (7.5/m^2) and c) high density (10/m^2).

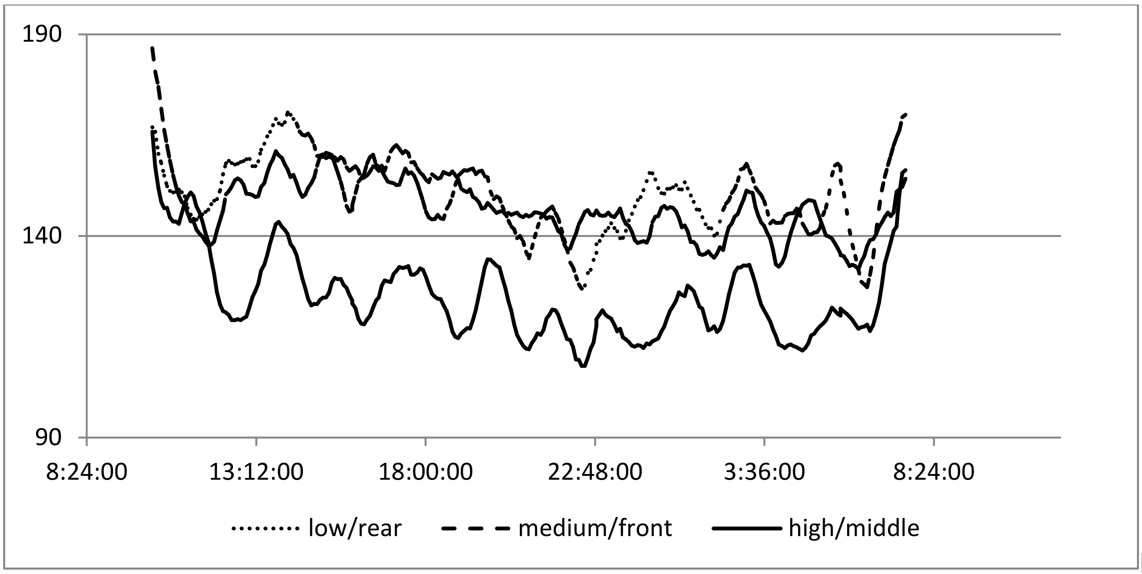
Goats transported at a low density tended to group to the front or rear of their compartment in close proximity to adjacent groups, while goats in the high density group filled the compartment. Goats housed at medium density were spread evenly throughout the compartment, most of the time making full use of the available floor space.

3.5 Heart activity

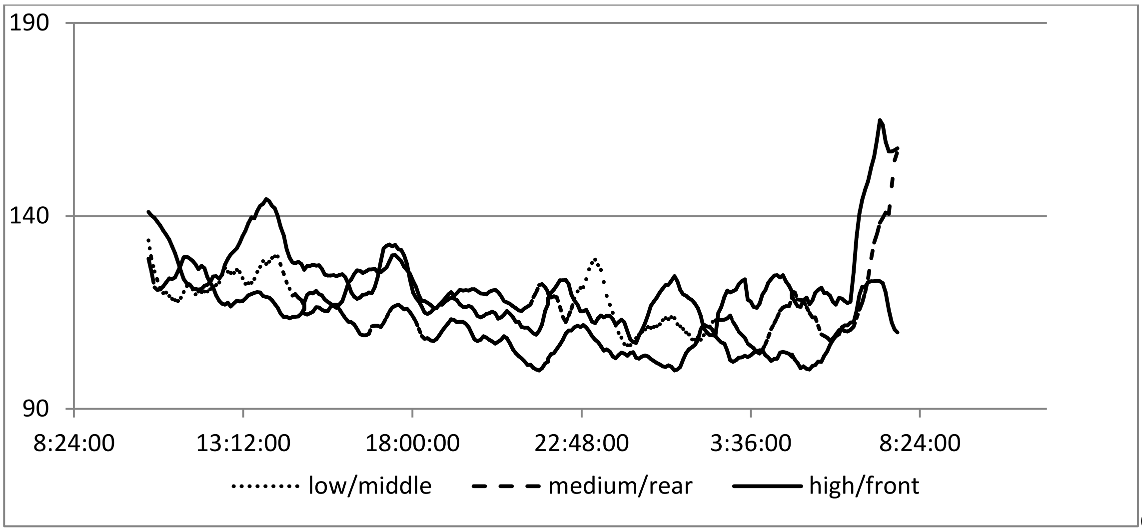
Figures 11 a, b, c show the trends, based on 10 minute moving averages in the heart rates measured with the ECG data loggers. Heart rate trends are illustrated for goats at high (10/m^2: solid line), medium (7.5/m^2: dashed line) or low (5/m^2: dotted line) stocking density per (front, middle or rear) compartment.



a



b



c

Figure 11: Heart rate (BPM) trends of young goats measured at different loading density (low, medium, high) or compartment (front, middle, rear) during trip 1 (a), trip 3 (b) and trip 4 (c)

3.6 Blood parameters

Table 3 provides an overview of the results from the blood sample analyses taken during trips 1 and 4. Since no data is available from the other trips undertaken the dataset is imbalanced and does not allow a complete analysis of variation. Therefore, the available data was analysed on the basis of a t-test of variables from samples taken prior to departure paired with those from samples taken after arrival at the slaughter plant. Results indicate significant ($P<0.001$) increases in Hb, Ht, Na^+ and Cl^- measurements and BE ($P=0.002$) and a significant decrease in sO_2 ($P=0.007$) levels.

Table 3 : Blood parameters (mean ± SD) measured in samples taken before departure and after unloading at slaughterhouse during 2 trips.

		Trip 1			Trip 4					
Stocking density (n/m^2)		10	7.5	5	10	7.5	5			
numbers of goats monitored		6	6	6	6	6	6			
compartment		rear	middle	front	front	rear	middle	departure	arrival	P
pH	Departure	7.36(0.04)	7.37(0.05)	7.35(0.02)	7.40(0.02)	7.42(0.03)	7.38(0.04)			
	Arrival	7.37(0.06)	7.38(0.02)	7.37(0.02)	7.41(0.02)	7.40(0.04)	7.40(0.03)			
								7.38(0.04)	7.39(0.04)	0.229
pCO_2	Departure	44.3(2.25)	41.0(4.73)	43.8(2.86)	40.5(1.38)	38.5(1.76)	41.7(2.16)			
mmHg	Arrival	49.0(7.97)	44.7(4.27)	44.7(0.82)	40.3(3.33)	39.5(2.88)	41.5(2.59)			
								41.6(3.24)	43.3(5.12)	0.017
pO_2	Departure	29.5(2.59)	36.8(20.43)	33.2(4.31)	28.0(2.97)	26.7(2.66)	28.5(2.59)			
mmHg	Arrival	26.5(0.84)	27.2(4.26)	29.2(4.79)	27.5(3.02)	26.7(4.55)	27.0(4.73)			
								30.4(8.89)	27.3(3.77)	0.026
sO_2	Departure	53.0(4.99)	58.7(19.85)	59.9(8.62)	52.6(6.60)	51.1(6.52)	52.6(5.21)			
%	Arrival	46.3(3.97)	48.7(10.89)	52.7(8.95)	51.9(9.01)	49.0(11.39)	49.9(12.65)			
								54.6(9.9)	49.7(9.40)	0.007
BE	Departure	-0.65(2.84)	-1.32(1.99)	-1.57(0.83)	0.45(1.35)	0.80(1.37)	-0.28(2.55)			
mmol/l	Arrival	1.98(1.50)	1.12(1.22)	0.60(1.80)	0.67(1.49)	-0.27(3.04)	0.95(0.95)			
								0.43(2.01)	0.84(1.80)	0.002
Hb	Departure	8.70(0.77)	8.20(0.78)	9.03(0.81)	7.58(0.66)	6.77(1.96)	7.48(1.33)			
g/dl	Arrival	8.98(0.52)	9.27(0.83)	9.52(0.42)	8.70(0.19)	8.30(2.21)	8.30(0.69)			
								7.96(1.31)	8.85(1.07)	<0.001
Ht	Departure	27.0(2.28)	25.5(2.26)	28.0(2.37)	23.7(1.97)	21.2(5.81)	23.3(4.03)			
%	Arrival	27.8(1.60)	28.7(2.42)	29.5(1.22)	27.0(0.63)	25.8(6.59)	25.8(2.04)			
								24.8(3.94)	27.4(3.19)	<0.001
Glucose	Departure	3.87(0.93)	4.07(1.13)	3.65(0.33)	3.35(0.79)	3.37(1.00)	3.18(0.87)			
mmol/l	Arrival	4.22(0.37)	4.13(0.65)	4.5(0.79)	3.28(1.10)	2.52(1.17)	3.47(0.59)			
								3.6(0.87)	3.7(1.03)	0.57
Na	Departure	145(2.1)	145(1.2)	146(2.0)	142(0.5)	142(1.9)	144(1.0)			
mmol/l	Arrival	147(2.6)	149(2.1)	148(2.6)	146(1.9)	144(2.5)	145(1.2)			
								144(2.1)	146(2.7)	<0.001
Cl	Departure	109(2.3)	110(2.8)	110(1.7)	109(2.1)	107(1.4)	109(1.2)			
mmol/l	Arrival	112(2.3)	113(3.1)	112(2.9)	110(3.6)	109(2.8)	110(2.4)			
								109(2.0)	111(2.9)	<0.001

4 Discussion

According to earlier studies transportation is a source of emotional and physical stress affecting goat welfare (Richardson, 2002; EFSA 2011). Different phases of transportation i.e. loading, unloading, stopping and starting can be particularly stressful.

Various changes in physiological factors including body weight, body temperature, blood parameters and heart function have been advocated by various researchers as reliable indicators of animal welfare status during transportation (EFSA, 2011). Weight loss is seen to indicate compromised animal welfare conditions of transport often in relation to dehydration (Warriss, 1998). According to the traders the anticipated weight loss from farm to slaughter is on average approximately 8%. Changes in body weight observed during this study could not be associated with effects from treatment densities or placement in the vehicle (Table 2). Although most of the goats monitored lost between 0.1-0.6 kg during the journeys, with one outstanding exception (loss of almost 2.5 kg) in April. There were also two animals that actually displayed a slight gain in weight (0.1 kg), for which the reason is unclear. Overall average bodyweight loss (±0.4 kg) was approximately 4% which is lower than the 10% reduction advocated as critical by Kannan et al., 2000 or the 11.9% bodyweight loss reported by Minka & Ayo (2007). However, both of these studies were performed under extremely warm ambient conditions in Africa. The 4% bodyweight loss from our study would appear favourable in relation to estimates in agreement with estimates from European studies from Plyaschenko and Sidorov, 1987 (referred to by Minka & Ayo, 2007). Who predicted weight losses of 0.5% per hour for transportation of livestock in general during transports across Europe.

Rectal temperature is considered to be a reliable, relatively accurate on-the-spot diagnostic parameter alongside blood parameters, providing insight into the adaptability of domestic livestock to various environmental factors but particularly to transportation stress (Vihan & Sahni 1981, Ayo et al, 1998, Minka & Ayo, 2007). In our study rectal temperature decreased slightly (±0.3 degrees) during transportation (table 2) yet remained within a range (38.9 - 39.8^{o} C) similar to previous investigations (Minka and Ayo, 2007).

Mortality rates are also considered to be influenced by transport conditions (More and Brightling, 2003), losses being reported at 1.4% under certain circumstances. However, no fatalities were registered during any of our journeys. Deaths during transit have been reported during earlier studies and often been linked to the capability or fitness of the animals to travel. Fitness often being associated with the preceding treatment (rearing and husbandry) of the animals in question. In our study these extremely young goats (6-8 weeks old) were weaned at birth on-farm and transferred to be lambar reared on milk until transported to an assembly point for onward transportation to point of slaughter. These animals were all considered fit to travel.

Conditions within the vehicle of transport are also of importance. Compartment temperature, relative humidity and ventilation (automated or not) are critical to the comfort of the animal. In goats, the thermoneutral zone is 12–24 ºC (Nikitchenko et al., 1988) and the upper limit of heat tolerance is between 35 to 40 ºC (Appleman and Delouche, 1958). Transportation during thermally stressful hot-dry seasons may overtax their homeostatic control mechanisms (Igono et al., 1982; Minka and Ayo, 2007) and may have longer-term negative effects on health status and productivity (Ayo et al., 2006). During our study, conditions of temperature and relative humidity within the compartment remained well within the boundaries of animal comfort (figures 7 and 8). Although, it remains uncertain whether or not the automated ventilation in the vehicle was ever activated.

Overcrowding will exacerbate heat stress. Animals standing with their necks extended and with open-mouthed breathing indicate severe heat stress. Loading density or space allowance is critical to the animals perception of freedom of movement. Goats behave differently to sheep with goats establishing a stable hierarchical order (Barroso et al, 2000) maintained by agonistic and affiliate social behaviour. Disruptions to any established group i.e. by mixing prior to or during transportation can lead to excessive agonistic behaviour (Addison and Baker, 1982; Andersen and Bøe, 2007). This may lead to acts of aggression such as biting, kicking, butting or threatening displays involving interactions of chasing and fleeing (Alvarez et al., 2007). These activities have been seen to decrease dramatically after 24 hours (Alley and Fordham, 1994). However, during transportation the establishment of new hierarchal structures could aggravate behavioural patterns in dominant animals increasing bouts of aggression and increasing injuries (Ayo et al, 2006). Observation of the recorded behaviour during our trips was limited to analysis of the area occupied and the frequency of standing, or lying down. Incidences of aggression were perceived to be limited (occasional incidences of butting or threatening). The establishment of the dominance order in goats is influenced by individual characteristics, such as aggressiveness, age, size, body weight, breed, sex, parentage, experience, the presence of horns and horn length (Miranda de la Lama et al., 2010). In situations where individual distances are reduced, goats have fewer opportunities to perform butting activity, and biting as was observed in earlier studies (Tolu and Savas, 2007).

Space allowance appeared to influence occupation of the available floor space. Figures 9 and 10 indicate that more animals remain standing and occupy more floor space at higher densities indicating that it is highly probable that loading 10 young goats per square meter was restrictive to their freedom of movement.

Das et al. (2001) observed that during a 50-minute journey by road most goats frequently adopted a standing orientation parallel to the truck's direction of travel (24 min) followed by diagonal orientation (12 min) and perpendicular orientation (9 min). The goats never orientated themselves opposite to the truck's direction of travel. During transportation, goats changed their orientation frequently, apparently to maintain balance, suggesting they are restless. During the journeys performed in this study the goats were observed to huddle together at the lower loading densities but were probably incapable of this at the highest loading density as little free floor space was available.

Should these conditions of transportation have been stressful then it has been suggested that certain blood parameters can be seen as indicators of (di)stress.
The levels of cortisol and glucose responses to stressor treatment are greater in older goats (Kannan et al., 2003). Behaviours such as freezing, vocalisation, kicking, struggling and escape attempts observed in goats during transportation are behavioural indicators of discomfort (Kannan et al., 2002). Heart rate is also an important physiological on the spot indicator of animal health status and their adaptability (Minka and Ayo, 2009). Heart rate can decrease when animals are frightened but an increase in HR is associated with disturbing situations. An increase in HR of 1.6 times base rate was observed in pigs climbing a ramp (Van Putten and Elshof, 1978) and also occurs prior to a flight response. Baldock and Sibly (1990) registered basal heart beat levels for sheep. Heart rate is considered a useful measure of welfare for short-term stressors such as during handling, loading and incidences during transportation. Some adverse conditions may result in a prolongation of elevated levels. Parrot et al.,1998a showed that HR of sheep during loading to increase from 100 – 160 bpm lasting for at least 15 minutes. Furthermore, elevated HR was seen to last for nine hours during transportation (Parrott et al, 1998b) The HR levels and patterns observed here (figure 11) displayed variable patterns, HR ranged between 120 – 190 bpm during the trips performed in March and April while the range observed during the last journey was slightly lower (100-160 bpm). Patterns were similar with apparently large increases at loading and unloading. The HR pattern for the high density group displayed an obviously lower level in HR placed in the middle compartment during trip 3. Patterns varied least during trip 4. No distinction could be made as to effect of treatment on HR during transportation.

Certain blood parameters are considered good indicators of animal health status and welfare. Kannan et al. (2000) reported that plasma glucose concentrations remained elevated for about 3 h in Spanish goats after 2 h transportation, whereas Nwe et al. (1996) observed a similar trend in Japanese native goats after 6 h transportation. When animals are transported they are to a certain extent deprived of water. This can be assessed by measurement of the osmolarity of blood (Broom et al.,1996). If food is restricted the reserves are rapidly exhausted and various changes in metabolites become apparent. Haematocrit (Ht) levels are altered during transport. During handling and transportation the proportion of red blood cells may increase (Parrott et al.,1998b). However, if the animal is challenged for longer periods these levels may decrease dramatically (Broom et al,1996). Although the blood analyses during our study were limited there are indications (table 3) that samples taken upon arrival after travelling for approximately 20 hours, displayed significant increases in Hb (±0.9 g/dl), Ht (±2.6%) and BE (also Na and Cl concentrations) levels. There was no indication of significant increases in glucose levels. However, these increases in Ht and BE (Na and Cl) together with a slight (± 0.5kg) loss in body weight would seem to be symptomatic of dehydration. Oxygen saturation levels (sO_2) fell by approximately 5%-points during transport on trips 1 and 4.

However, any new environment during pre-slaughter holding and social isolation may be a stronger stressor than feed and water deprivation for goats (Richardson, 2002). Several studies have confirmed differences between sheep and goats in their water consumption and water conservation capacities. Mutton Merino lambs had a 49% higher water intake per kg mass gain than Boer goats (Ferreira et al., 2002). Higher water turnover rates were also found in sheep compared with goats kept under tropical conditions in Nigeria (Aganga et al., 1989). The lower water turnover rates in goats suggest that goats are better adapted to withstand dehydration than sheep under dry climatic conditions (Silanikove, 2000). Goats very rarely drink water during the pre-slaughter holding period. However, withholding of feed coupled with dehydration can cause live-weight shrinkage as high as 10% in the summer (Richardson, 2002). The estimated weight loss (±4%) during our study was, although not desirable, less excessive than in other reported cases. It is also considered that such young animals may have had difficulty identifying or using the drinking water supplied via nipple drinkers. Restricted space of movement at the highest stocking density may have hindered access to the drinking nipples.

5 Conclusions and recommendations

Conclusions

Young goats (8-10 kg) lost an average 0.4 kg in bodyweight and their body temperature fell by 0.2 ^{o} C during transportation by road for approximately 20 hours from assembly point to slaughterhouse.
Loading density did not appear to have any distinctive effects on animal behaviour or those physiological parameters that were measured.
During transportation, goats tend to huddle together at lower loading densities. At 10 goats per square metre the animals appear to be restricted in their movement due to the limited amount of free floor space.
The HR levels and patterns observed here displayed variable patterns, HR ranged between 120 – 190 bpm during the trips performed in March and April while the range observed during the last journey was slightly lower (100-160 bpm). No distinction could be made as to effect of treatment on HR during transportation.
Blood parameter measurements indicate a thickening of the blood during transportation from the assembly point.

Recommendations

There are no indications of obvious differences in behaviour and physiological parameters of young goats (8-10 kg) when transported at the loading densities applied during his study. It was evident that when loading at 10 animals/m^2 the compartment is very full indicating that a limit has been reached and it is therefore recommended that young goats be transported at a slightly lower loading density of 9 animals/m^2.
The goats displayed signs of dehydration although water was made available. It is advised that drinking water should be supplied in an alternative manner to nipple drinkers particularly when the animals have been accustomed to a lambar system.

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Appendices

Appendix 1 Bodyweight

Changes in bodyweight, calculated as the difference between weight after arrival with that measured prior to departure, are illustrated in figures A, B, C performed in March, April and May respectively. Changes are given for individual goats indicating compartment (rear, middle or front) placement and stocking density (high=10, medium=7.5 or low=5).

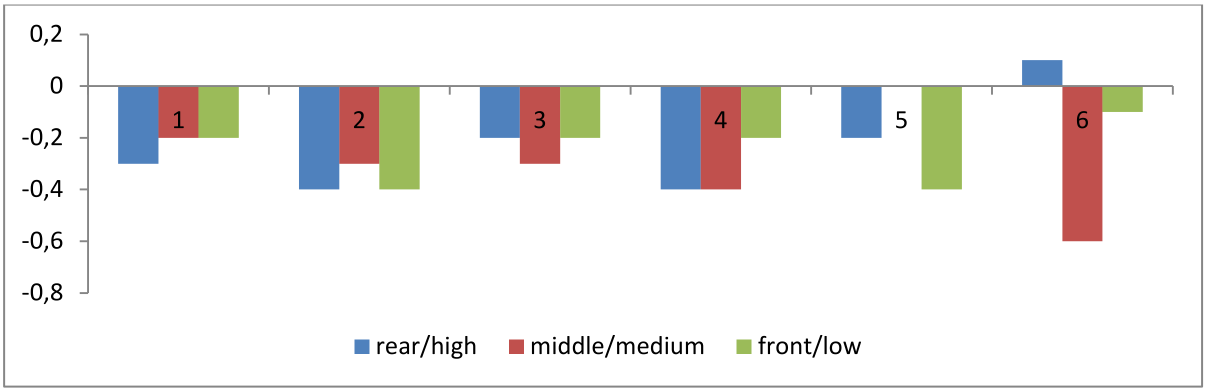


Figure A)

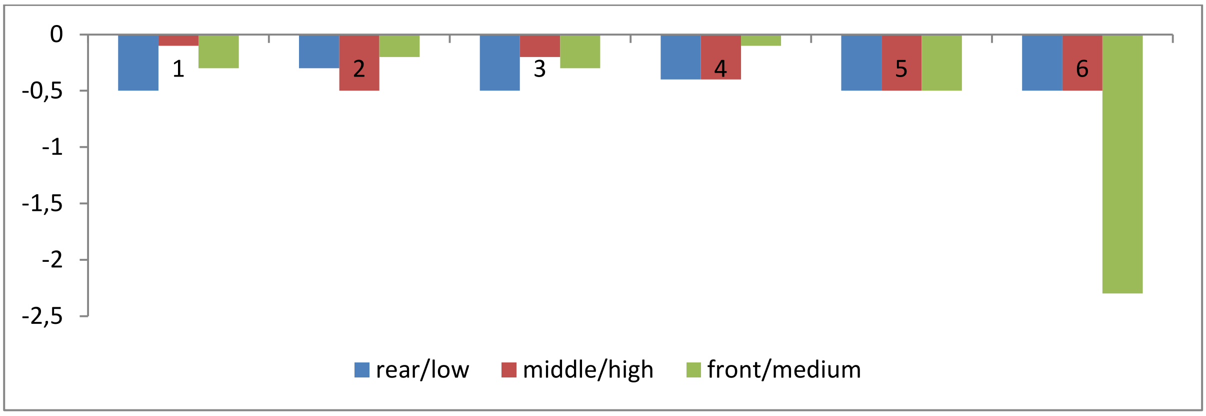


Figure B

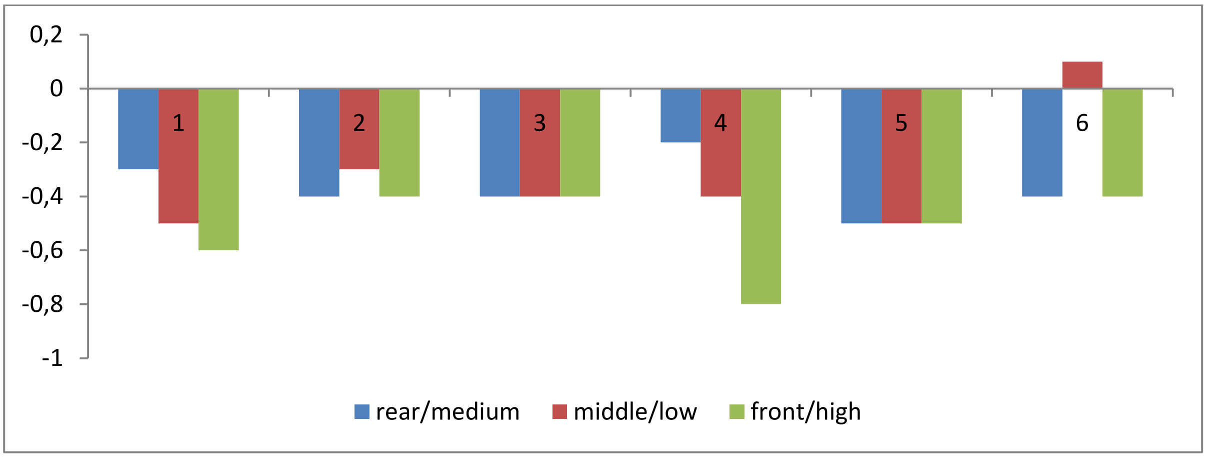


Figure C

Appendix 2 Body temperature

Changes in the rectal temperature, calculated as difference between measurement after arrival with temperatures measured prior to departure, illustrated in figures A, B and C for the trips in March, April and May respectively. Changes are given for individual goats indicating compartment (rear, middle or front) placement and stocking density (high=10, medium=7.5 or low=5 goats /m^2).

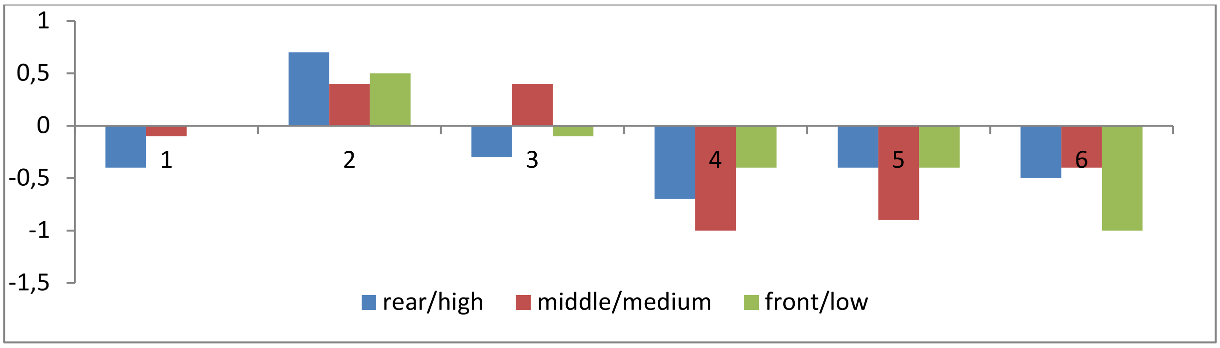


Figure A. Change in rectal temperature of young goats trip 1

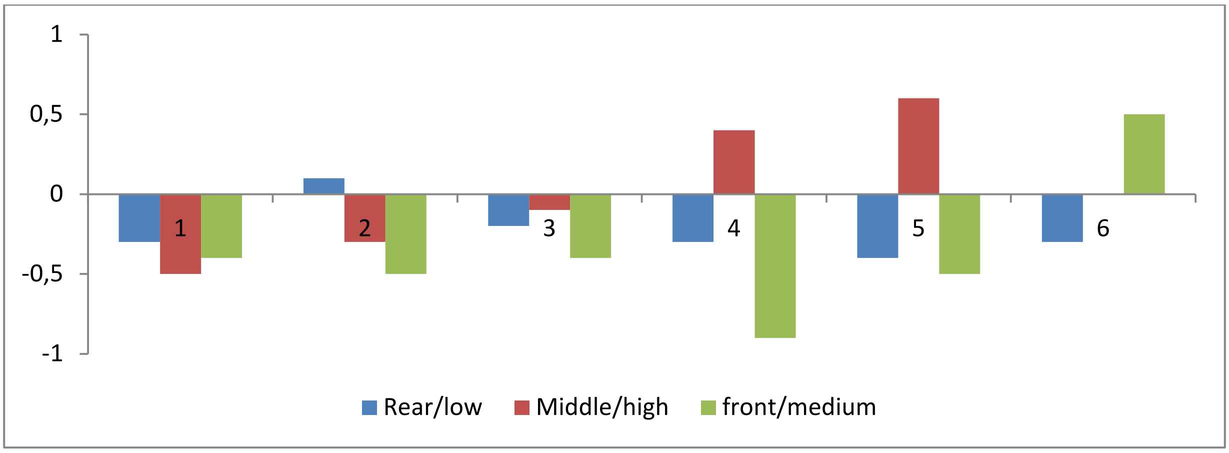


Figure B: Change in rectal temperature of young goats trip 2

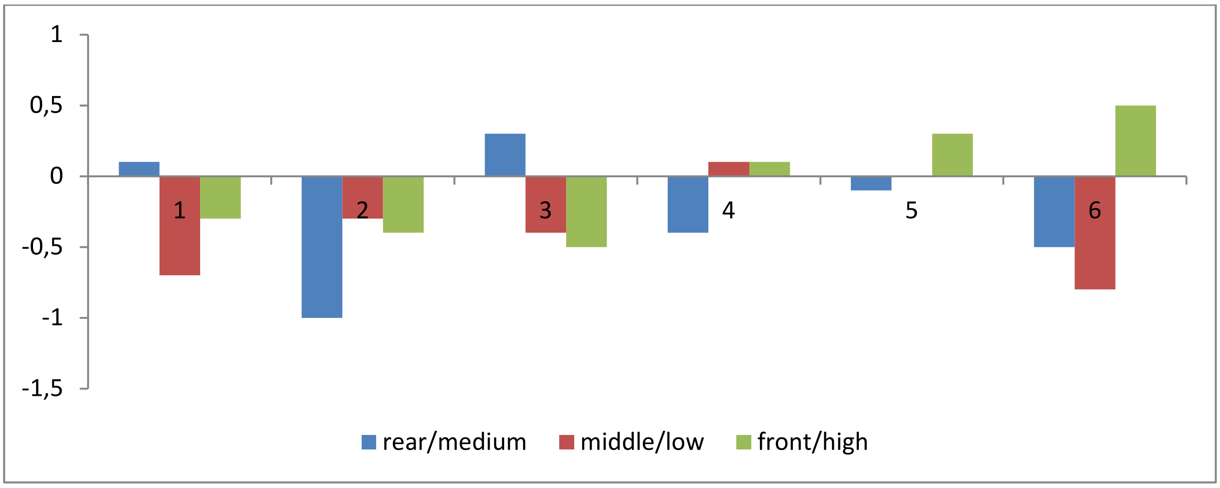


Figure C: Change in rectal temperature of young goats trip 3

Appendix 3

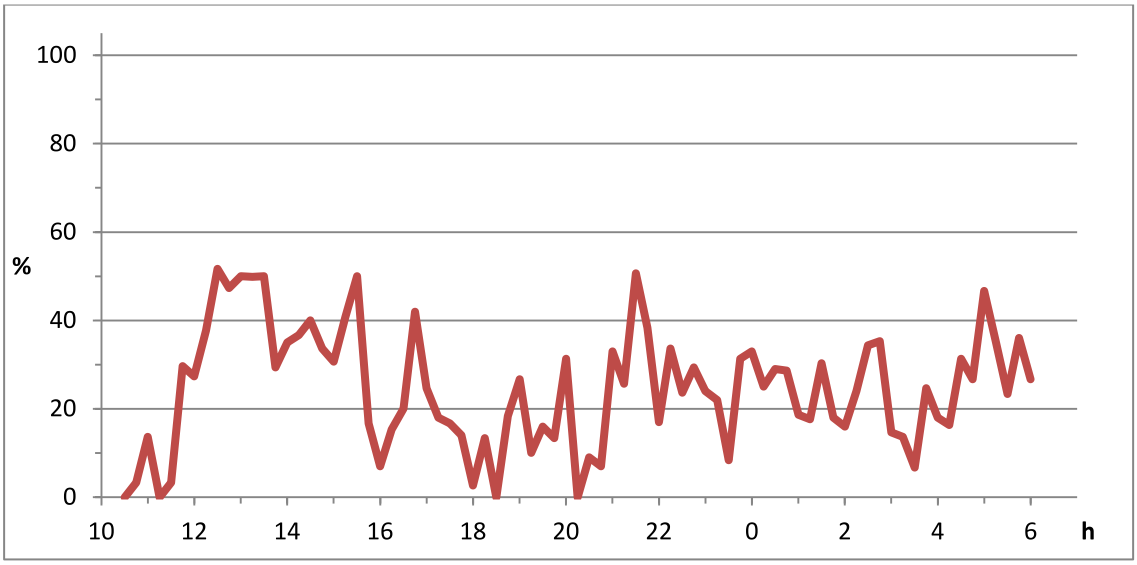


Figure appendix 3 a: Percentage free space (average of three trips) at 5 goats/m^2 density

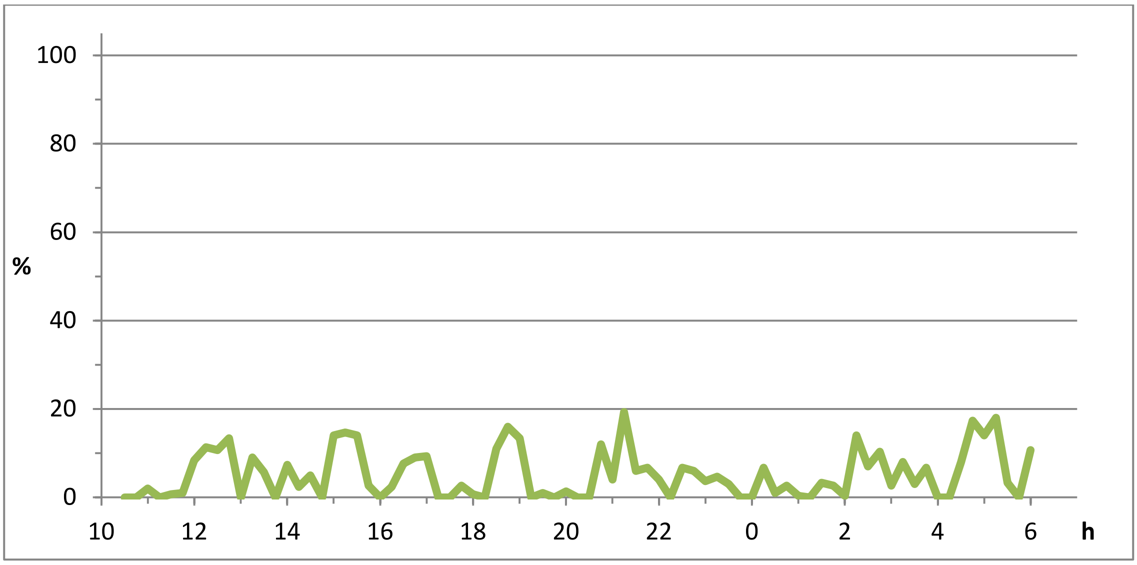


Figure appendix 3b: Percentage free space (average of three trips) at 7.5 goats/m^2

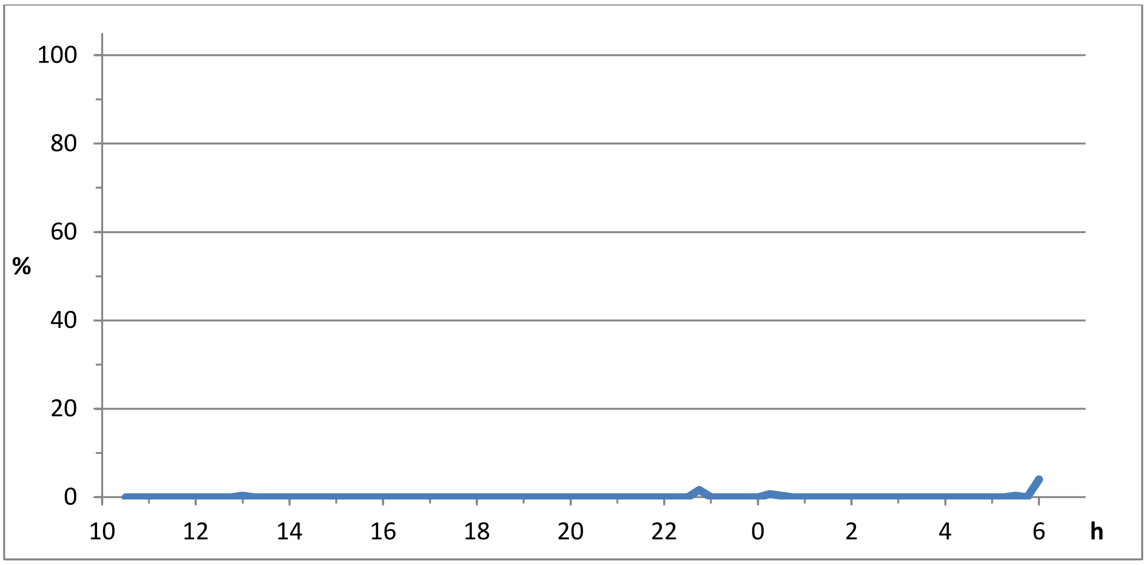
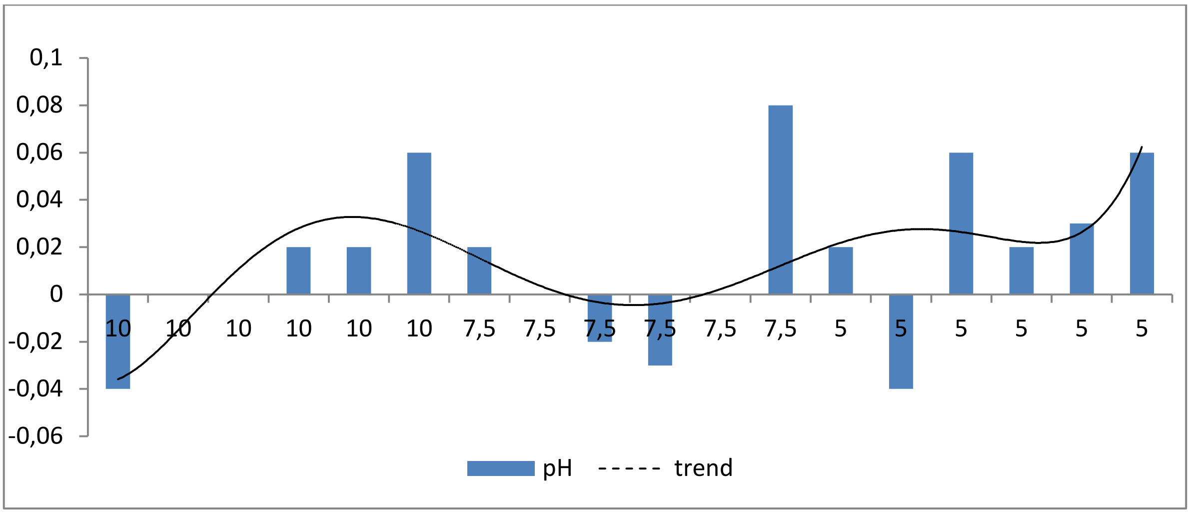


Figure appendix 3c: Percentage free space (average of three trips) at 10 goats/m^2

Appendix 4 Blood parameters

Blood pH:



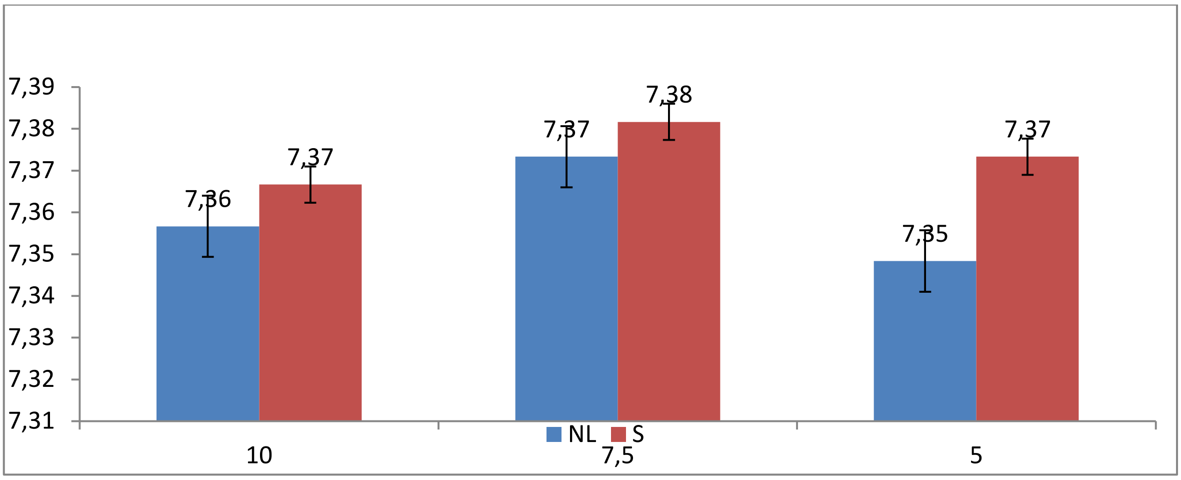
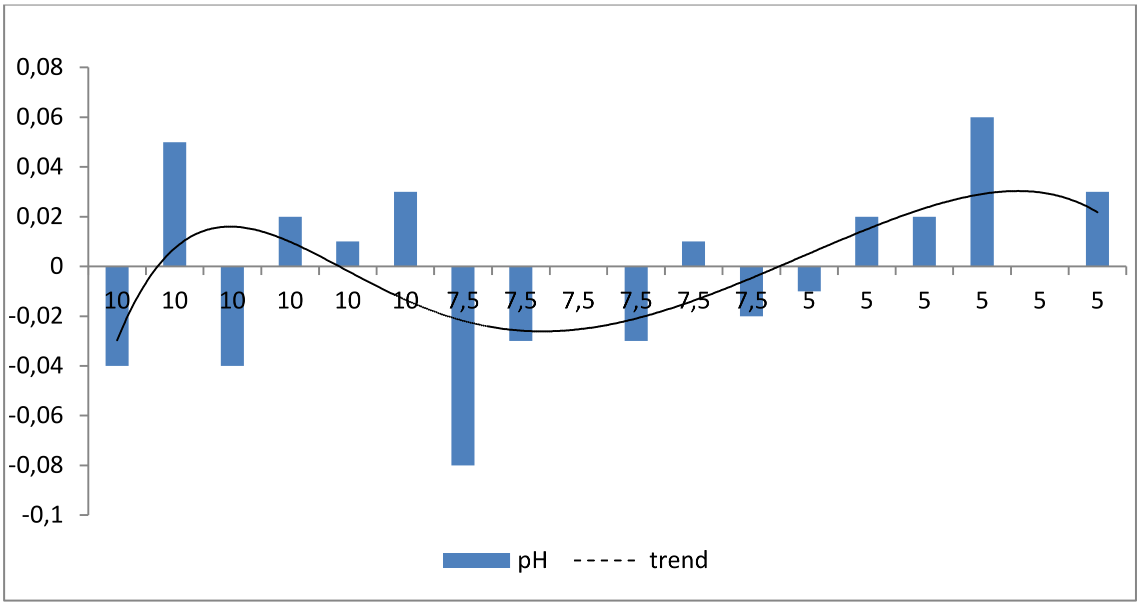


Figure appendix 4-1: Changes in pH levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 (a) per individual goat and group average (b) per loading density.



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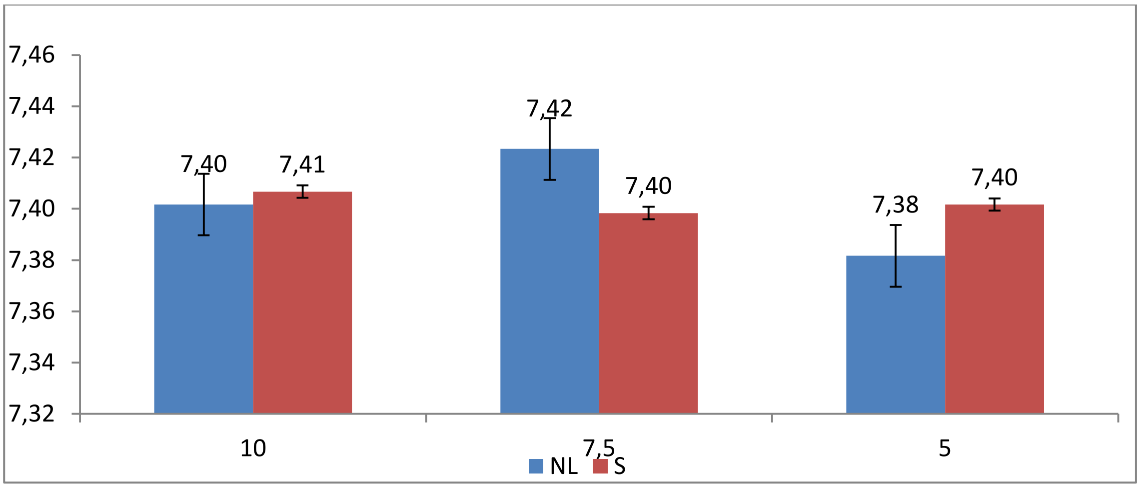
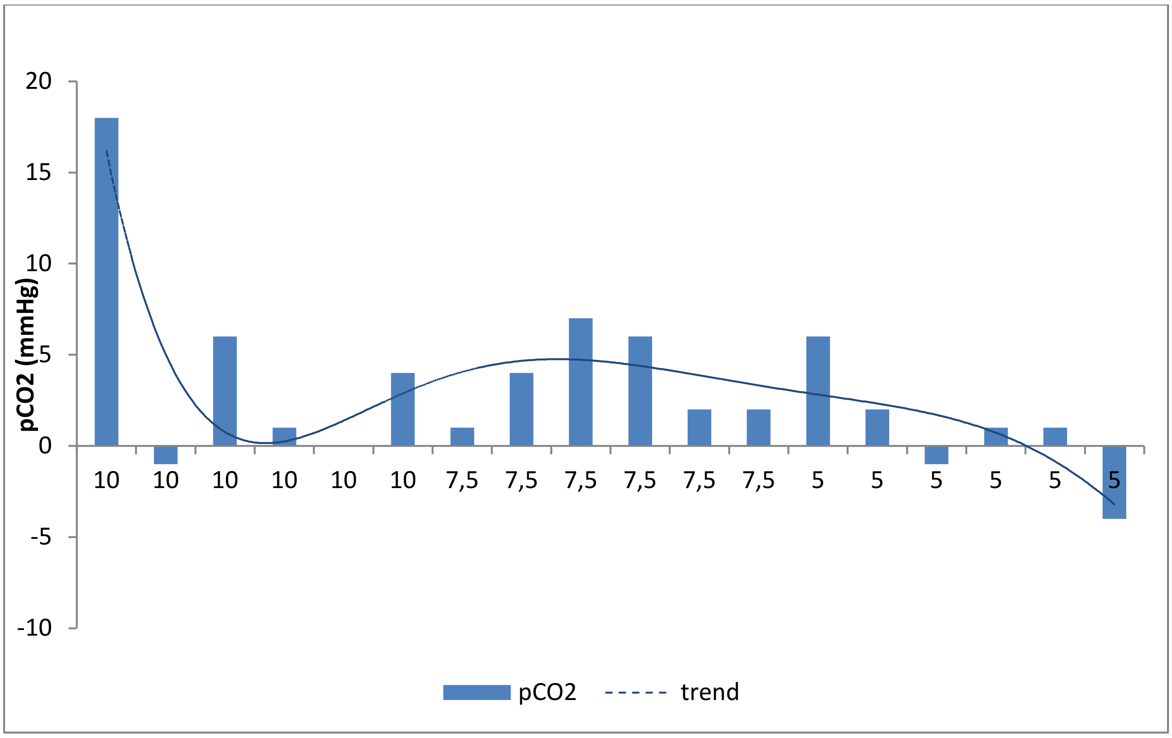


b

Figure appendix 4-2: Changes in pH levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 (a) per individual goat and group average (b) per loading density.



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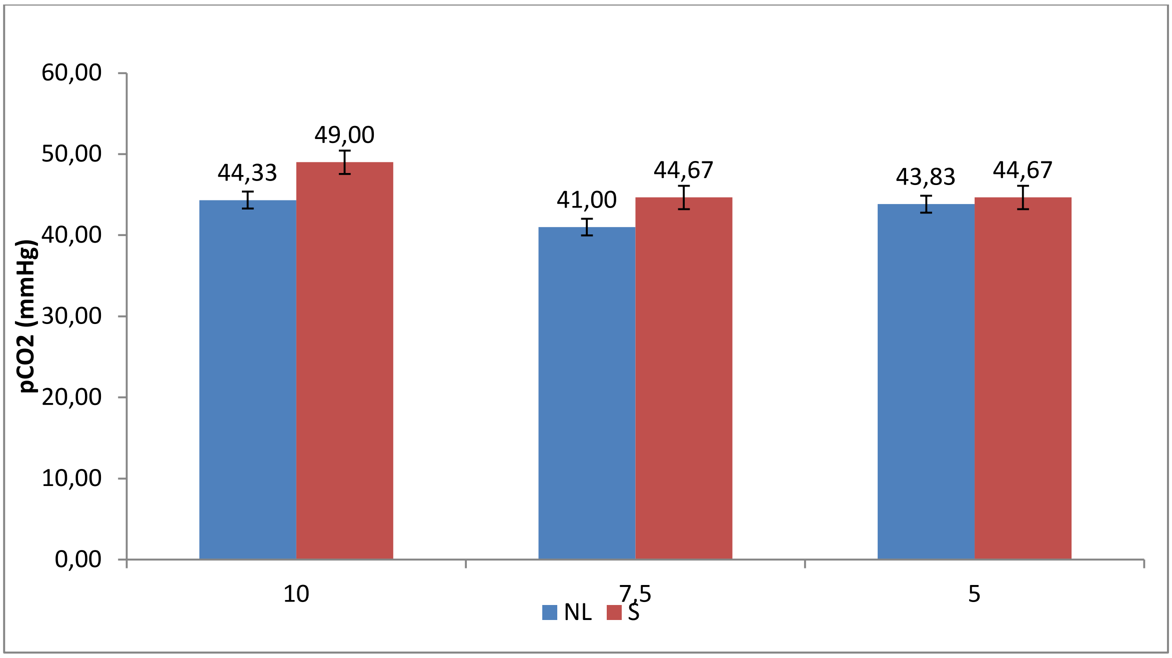
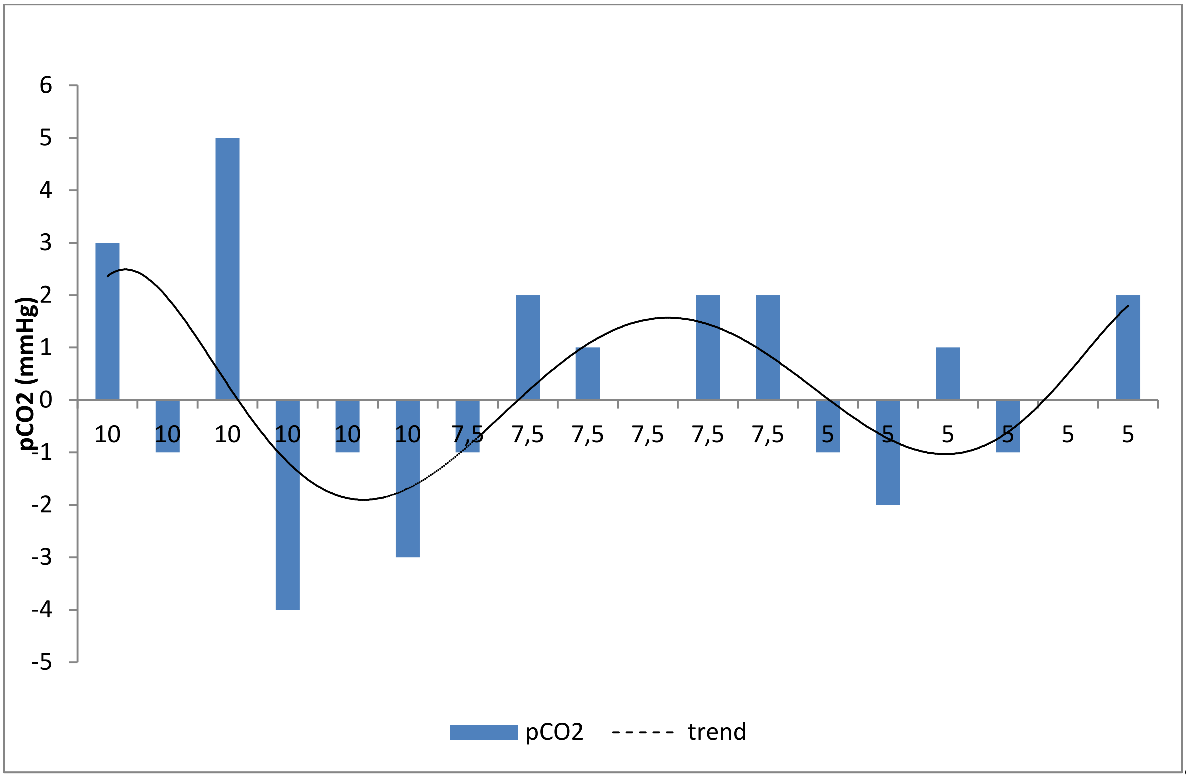


b

Figure appendix4-3: Changes in pCO_2 levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 (a) per individual goat and group average (b) per loading density.



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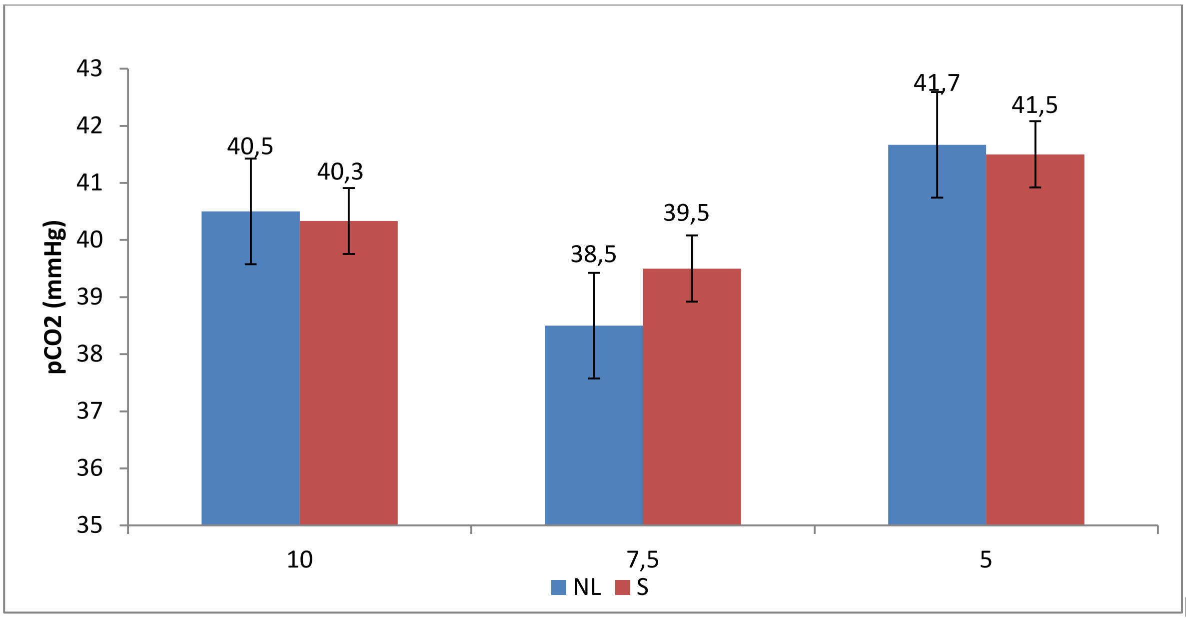
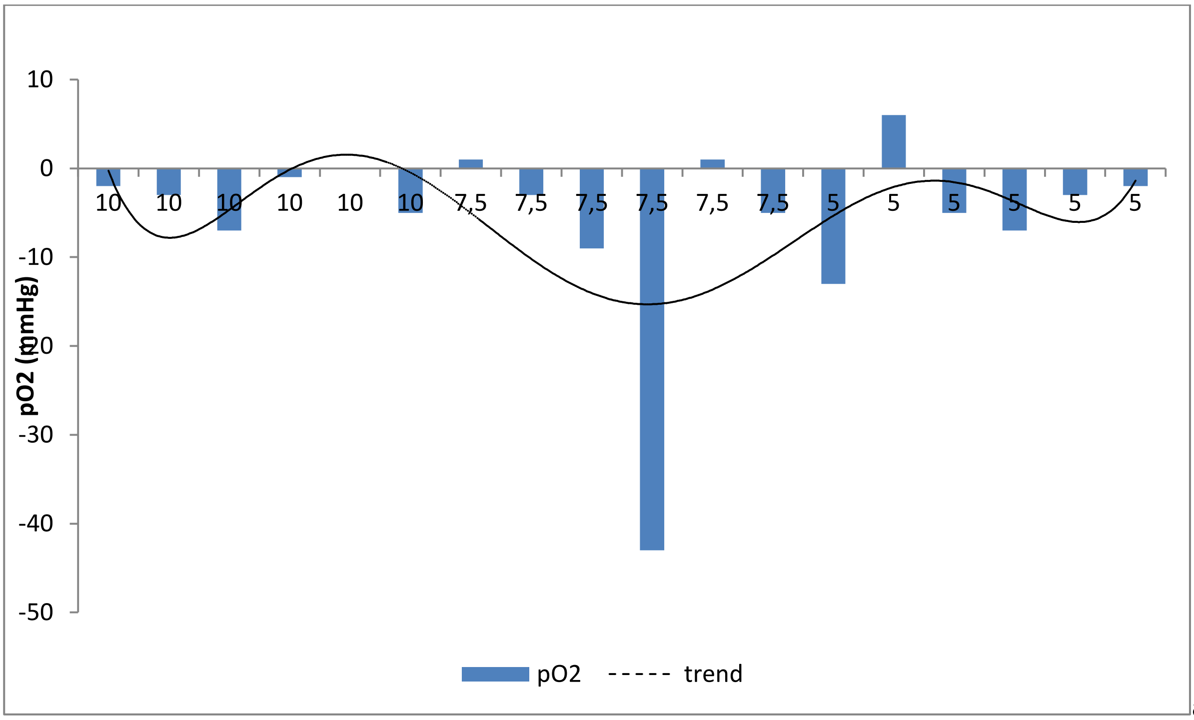


b

Figure appendix 4-4: Changes in pCO_2 levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per loading density.

Blood oxygen pressure (pO_2):



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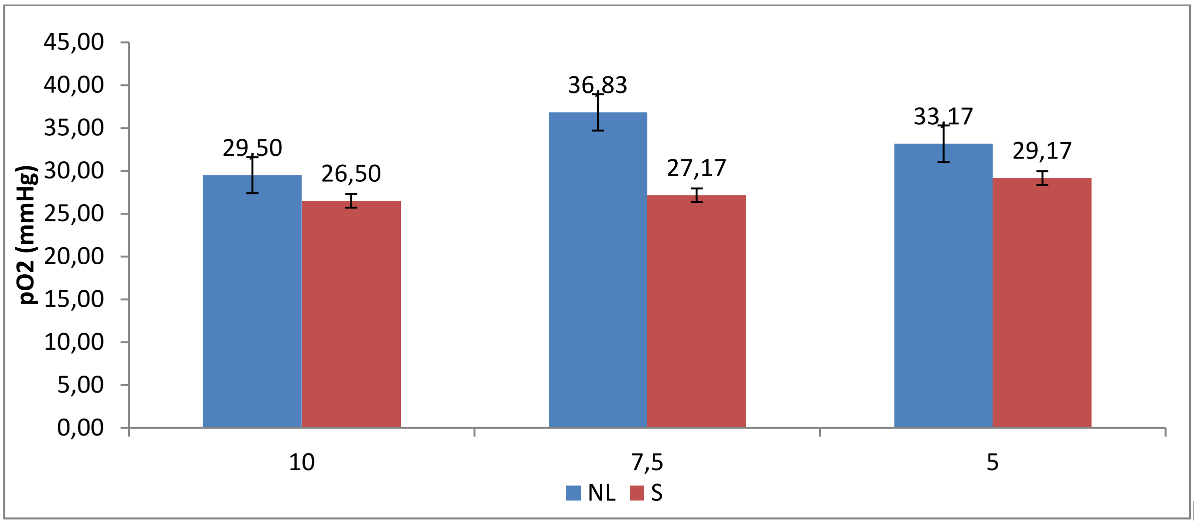
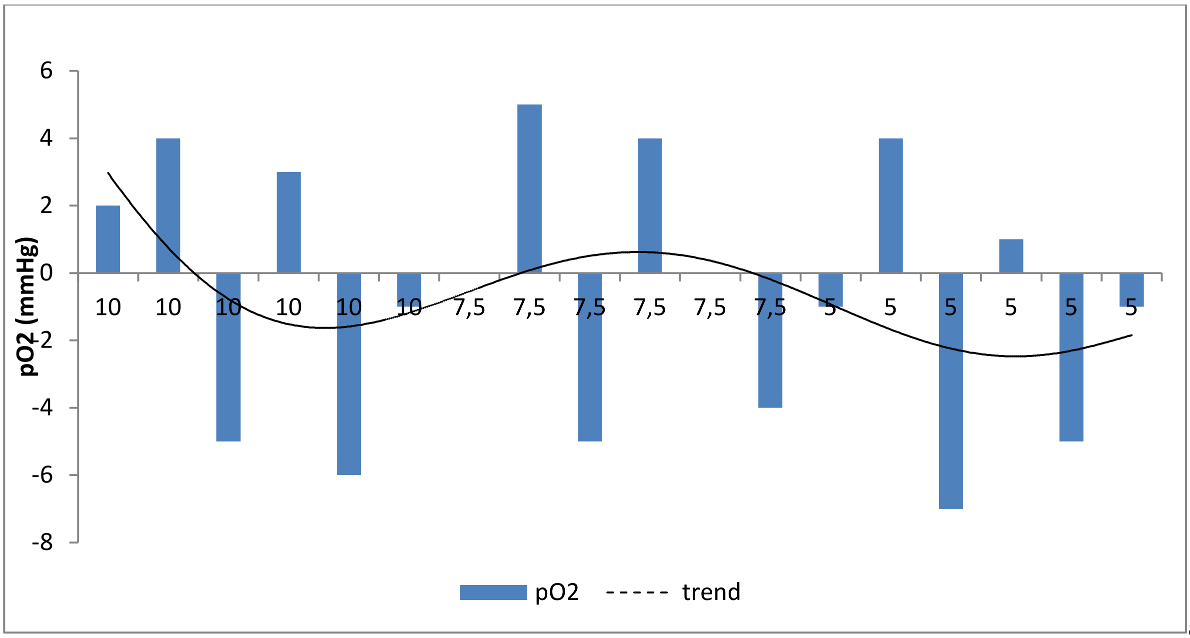


b

Figure appendix 4_5: Changes in pO_2 levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per loading density.



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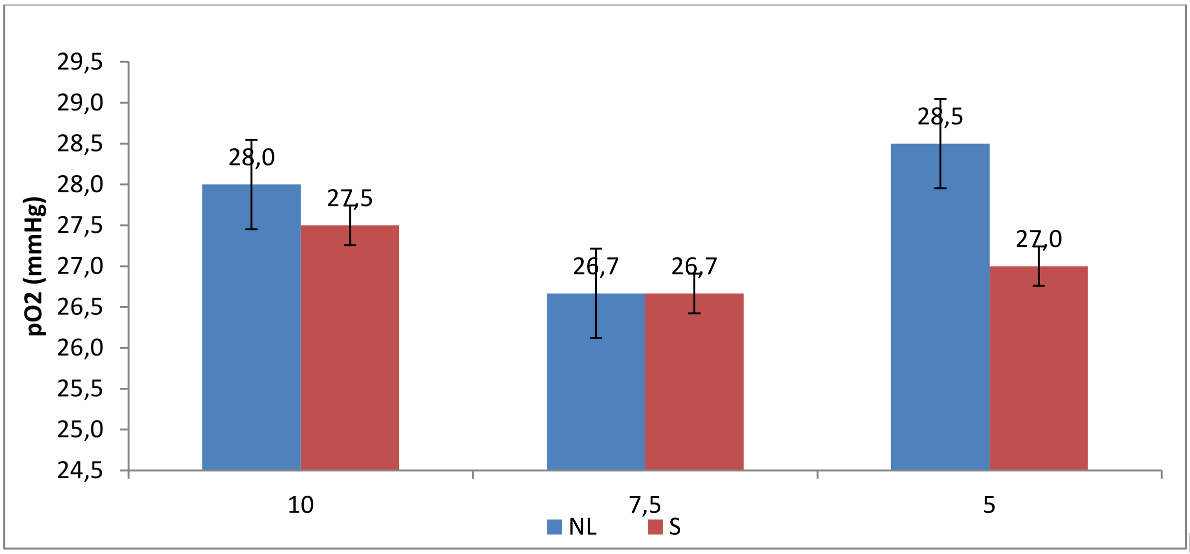
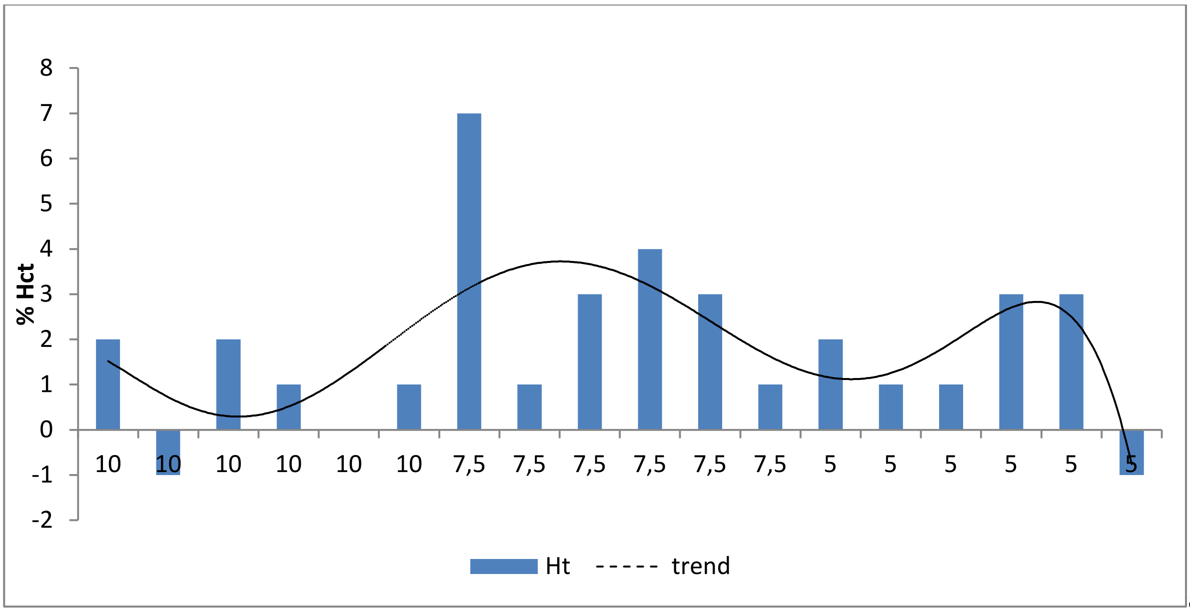


b

Figure appendix 4-6: Changes in pO_2 levels measured in blood samples taken on taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per loading density.



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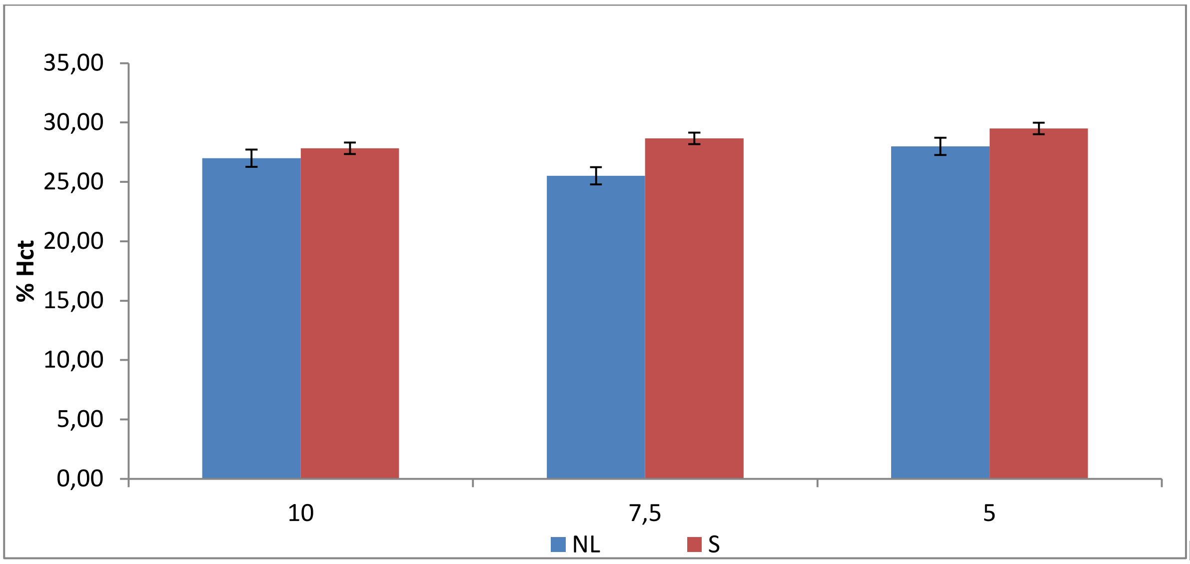
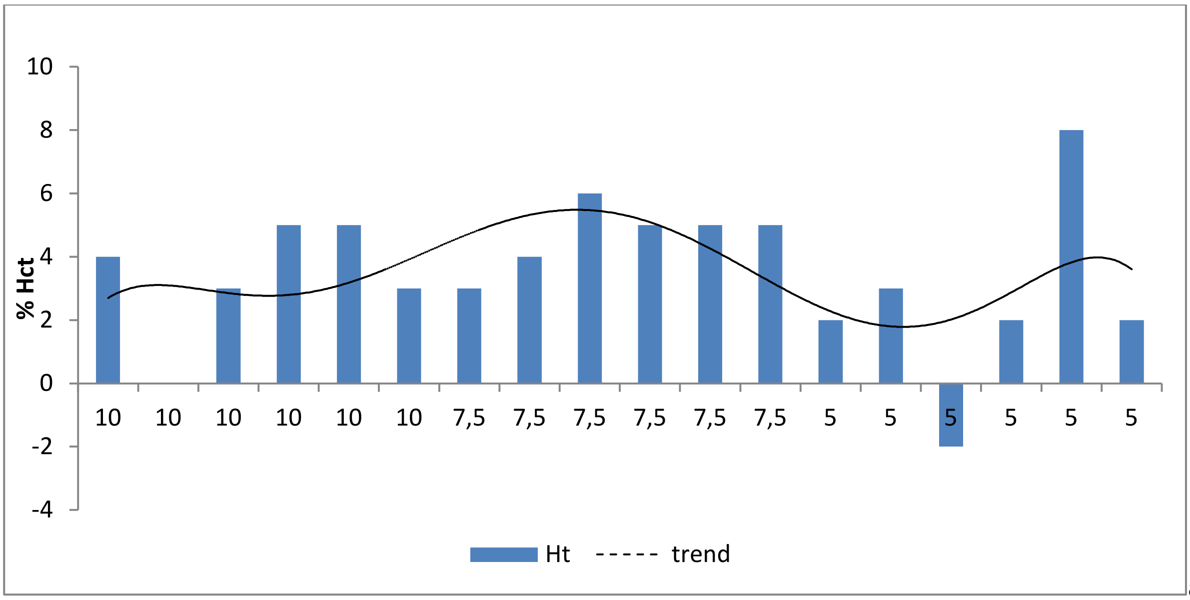


b

Figure appendix 4-7: Changes in haematocrit levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per stocking density.



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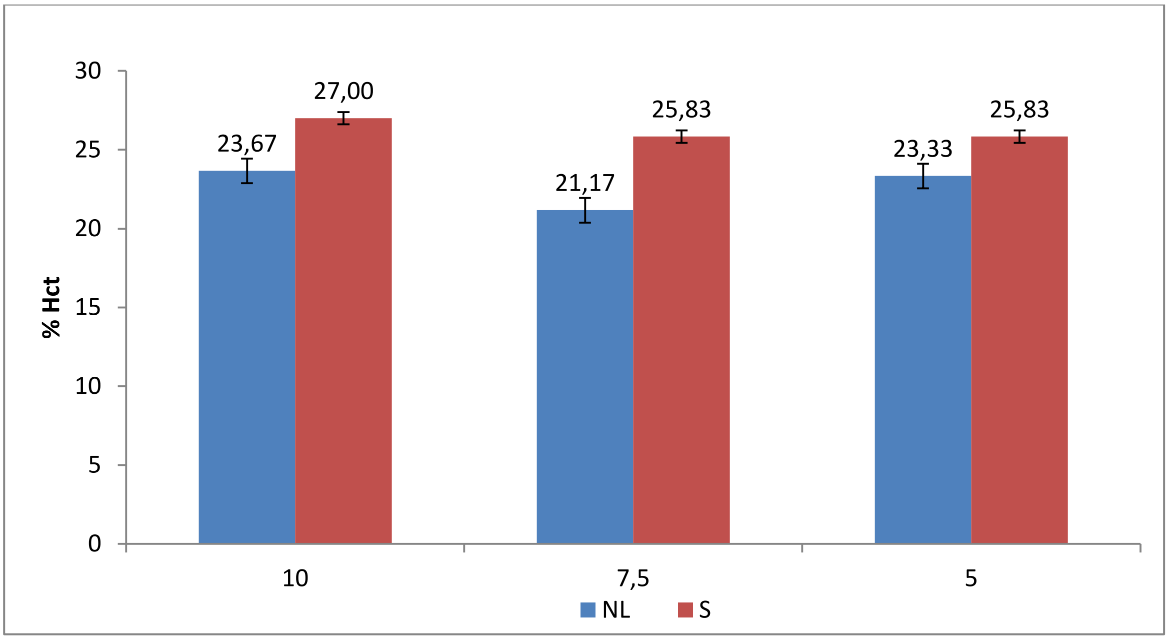

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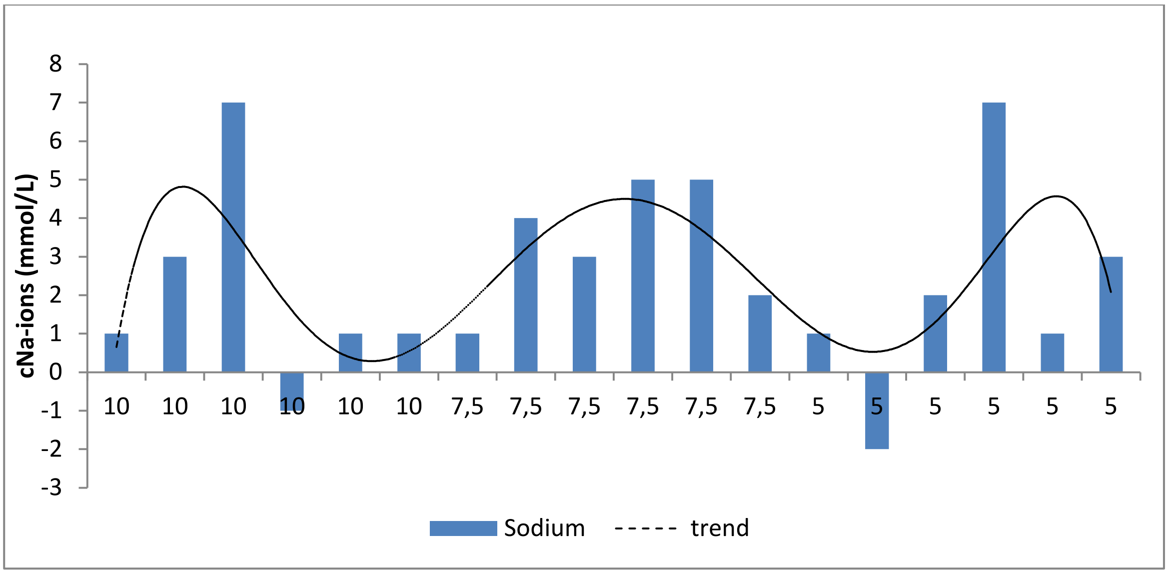
Figure appendix 4-8: Changes in haematocrit levels measured in blood samples taken on 16 May (NL) and 17 May (S) per individual goat (a) and group average (b) per stocking density.



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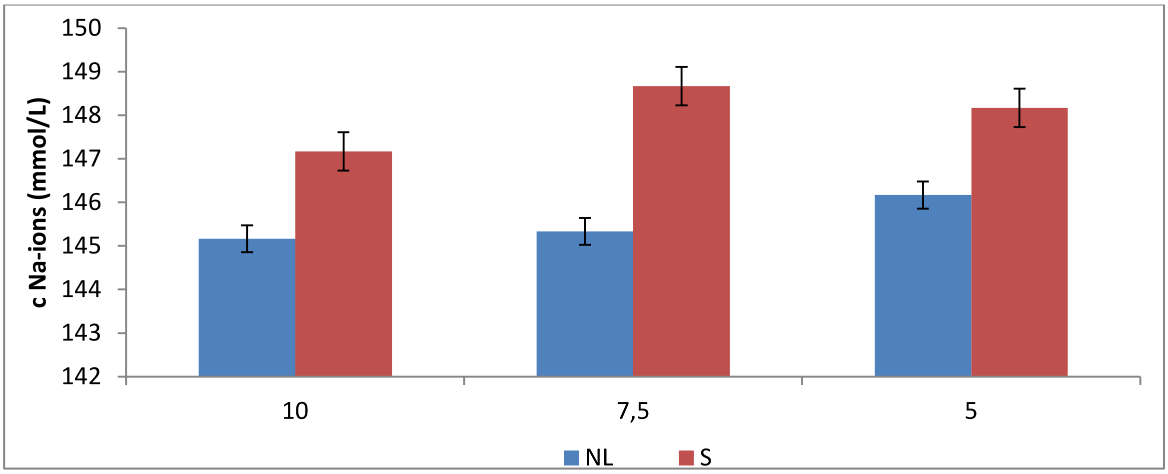
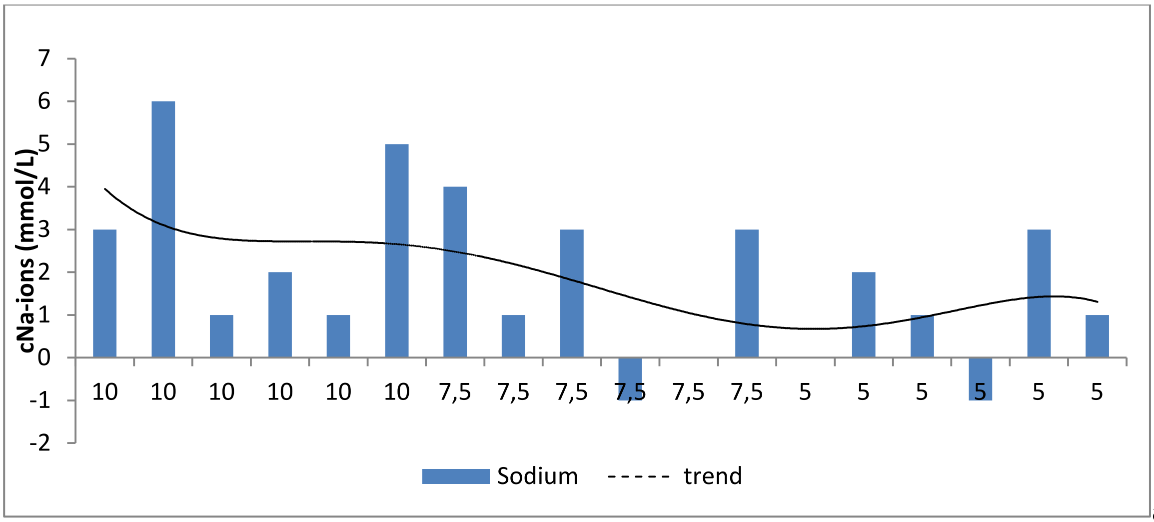


b

Figure appendix 4-9: Changes in sodium levels measured in blood samples taken on 21 March (NL) and 22 March (S) per individual goat (a) and group average (b) per stocking density.



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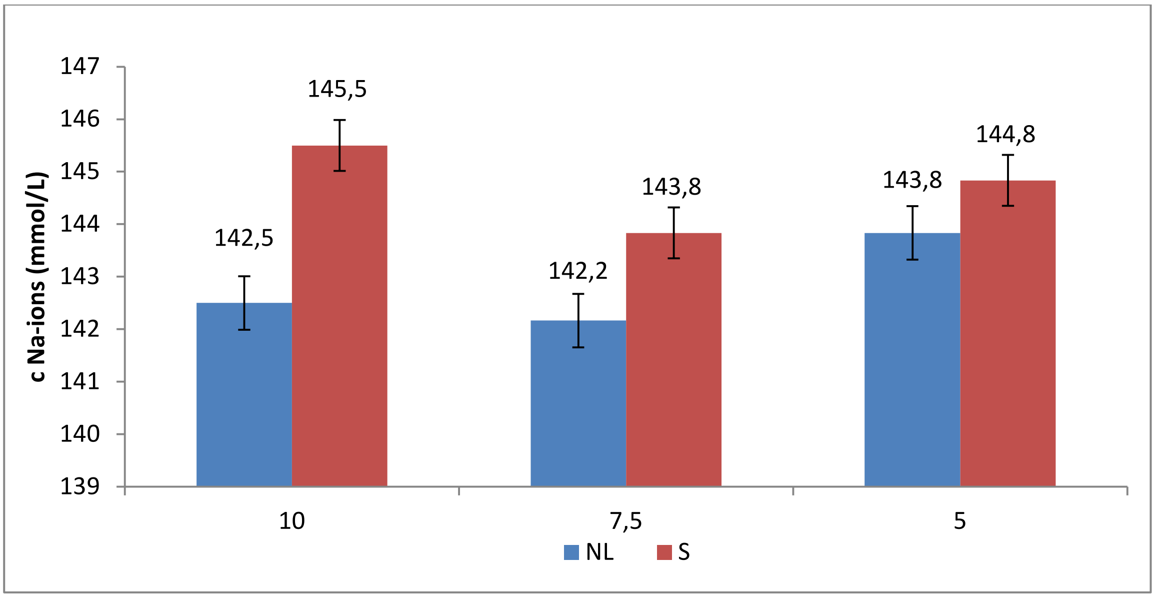
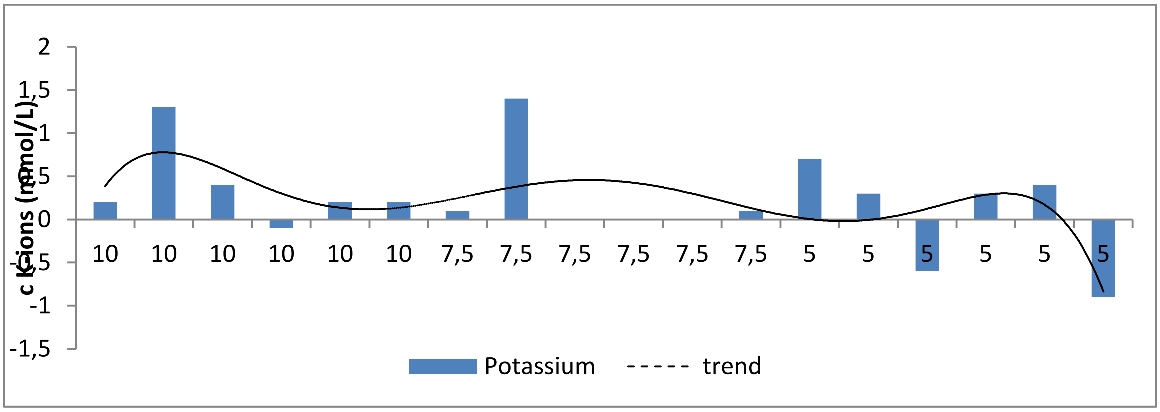


b

Figure Appendix 4-10: Changes in sodium levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.



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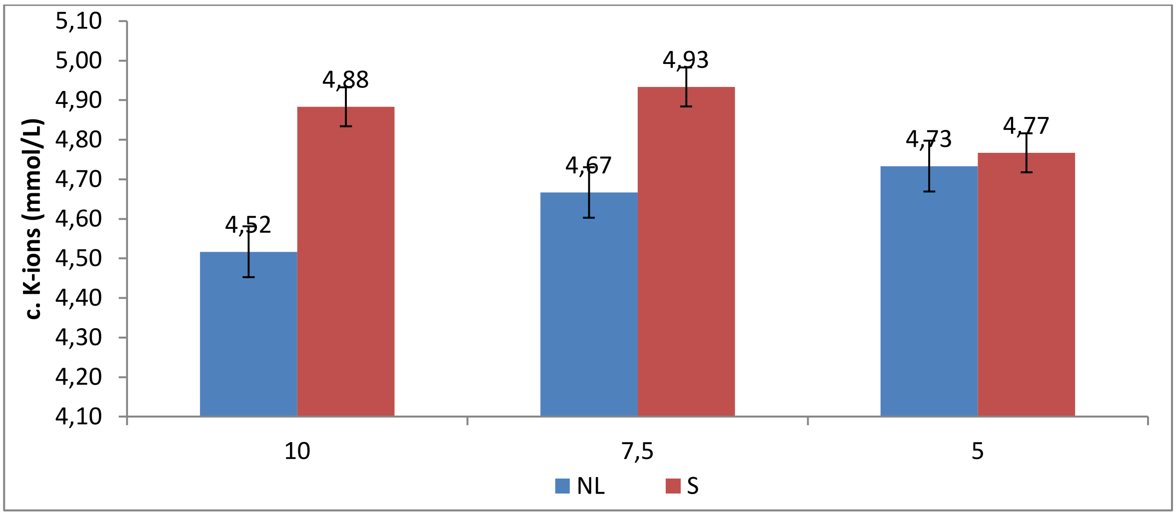
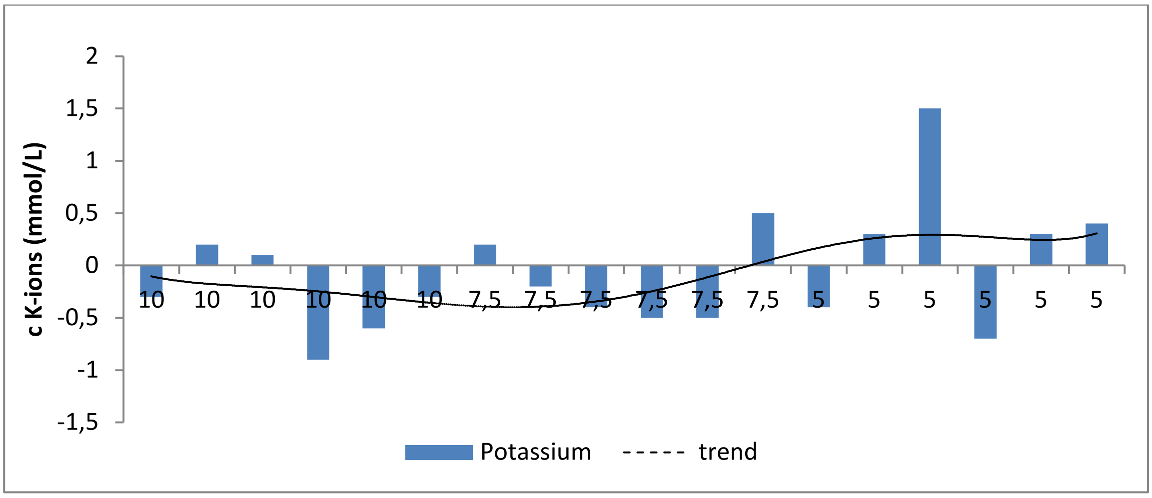


b

Figure appendix 4-11: Changes in potassium levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per stocking density.



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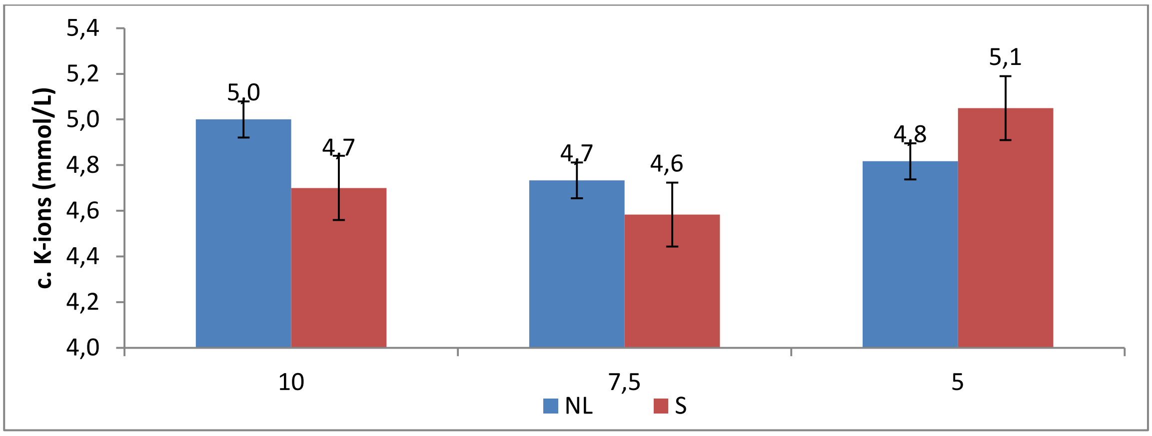
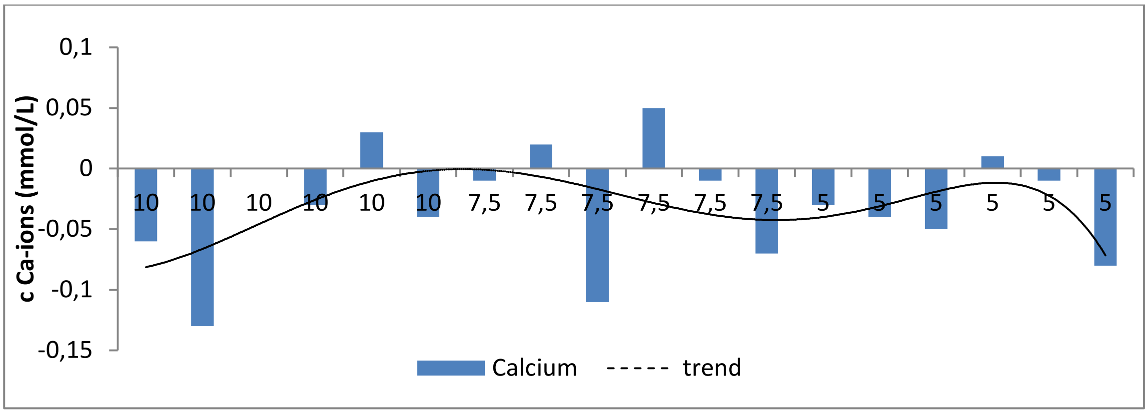


b

Figure appendix 4-12: Changes in potassium levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.



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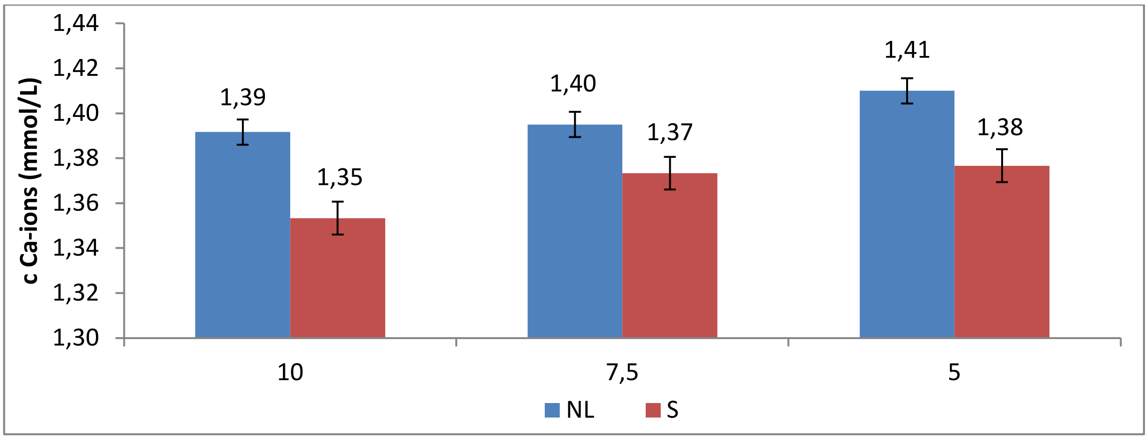

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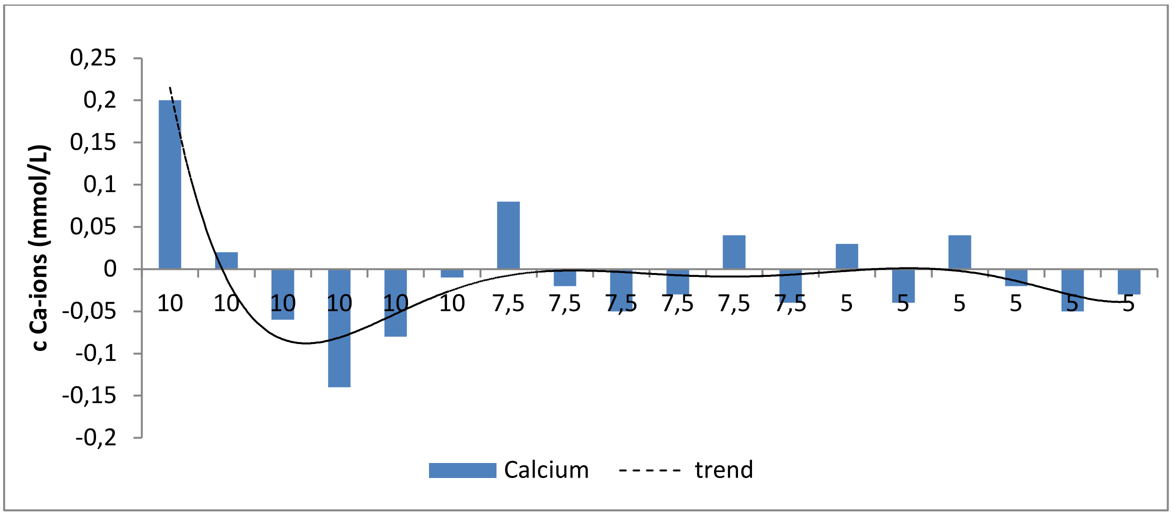
Figure appendix 4-13: Changes in calcium levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per stocking density.



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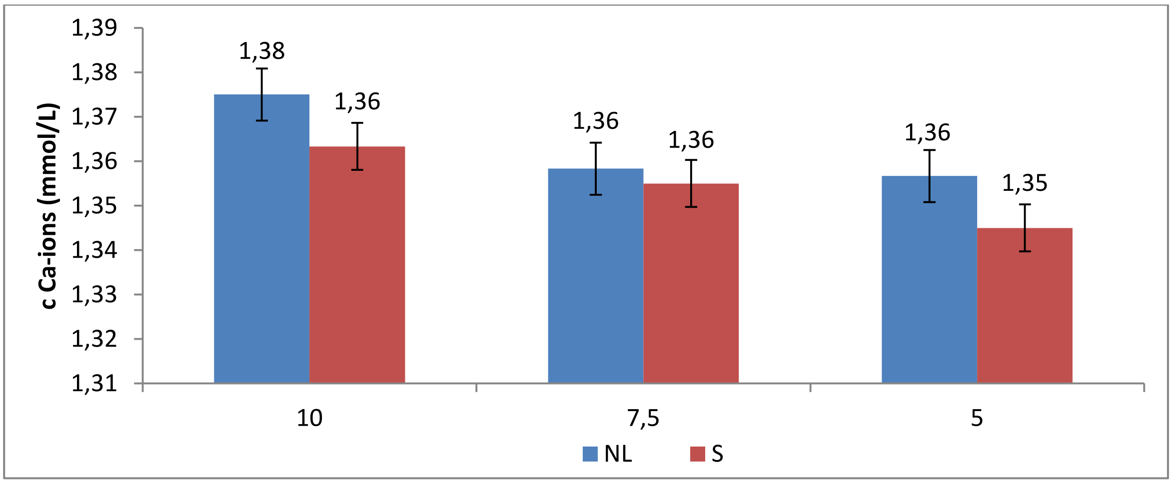
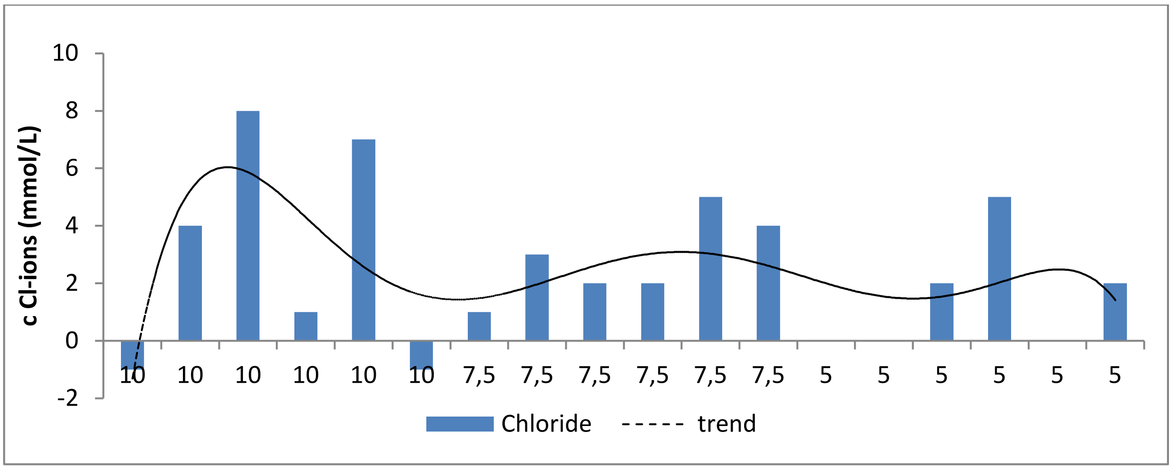


b

Figure appendix 4-14: Changes in calcium levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.



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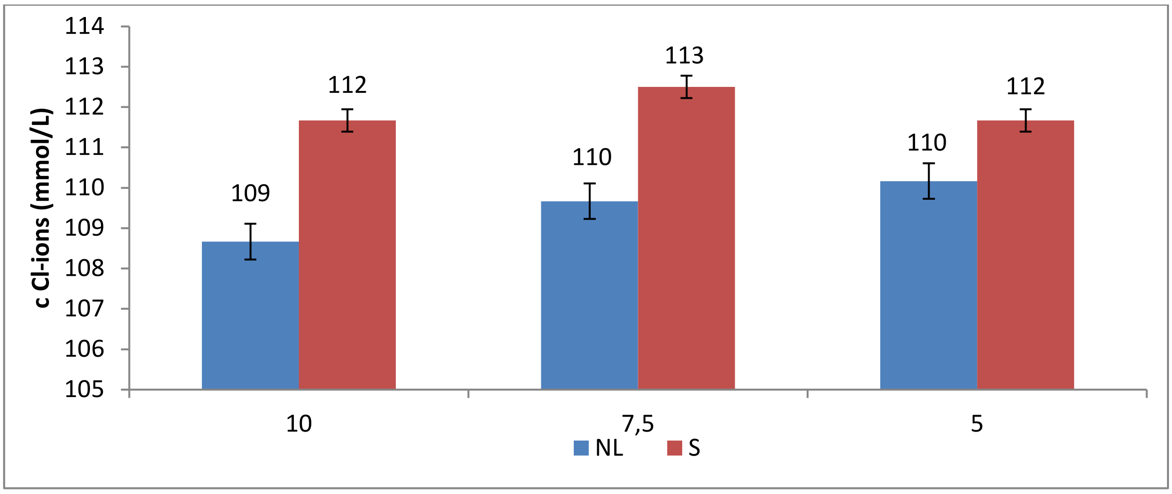
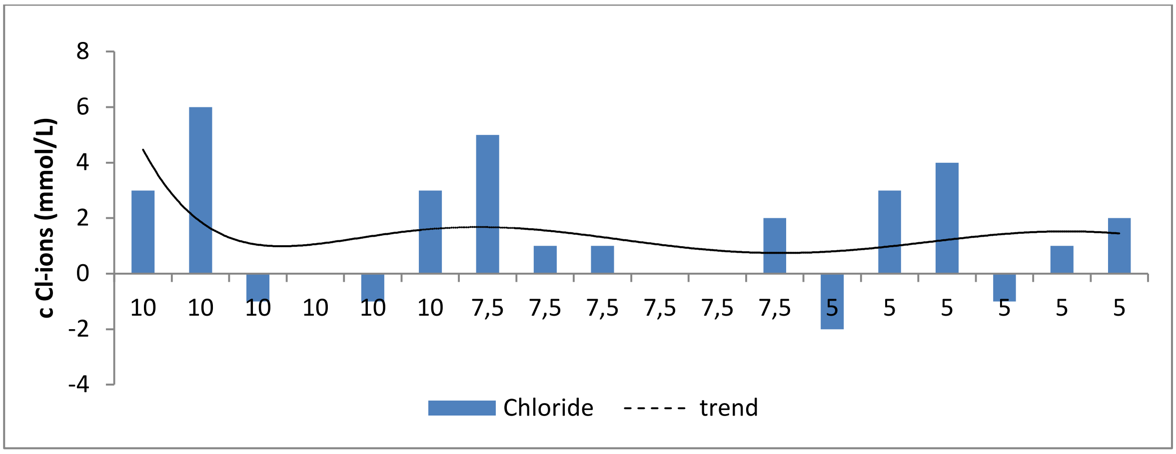


b

Figure appendix 4-15: Changes in chloride levels measured in blood samples taken on 21 March (NL) and 22 March (S) per individual goat (a) and group average (b) per stocking density.



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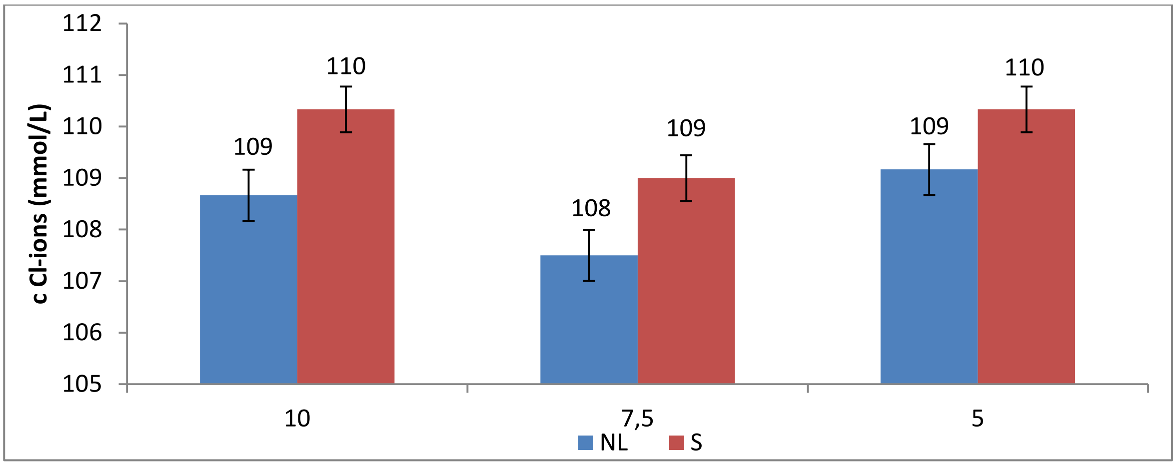

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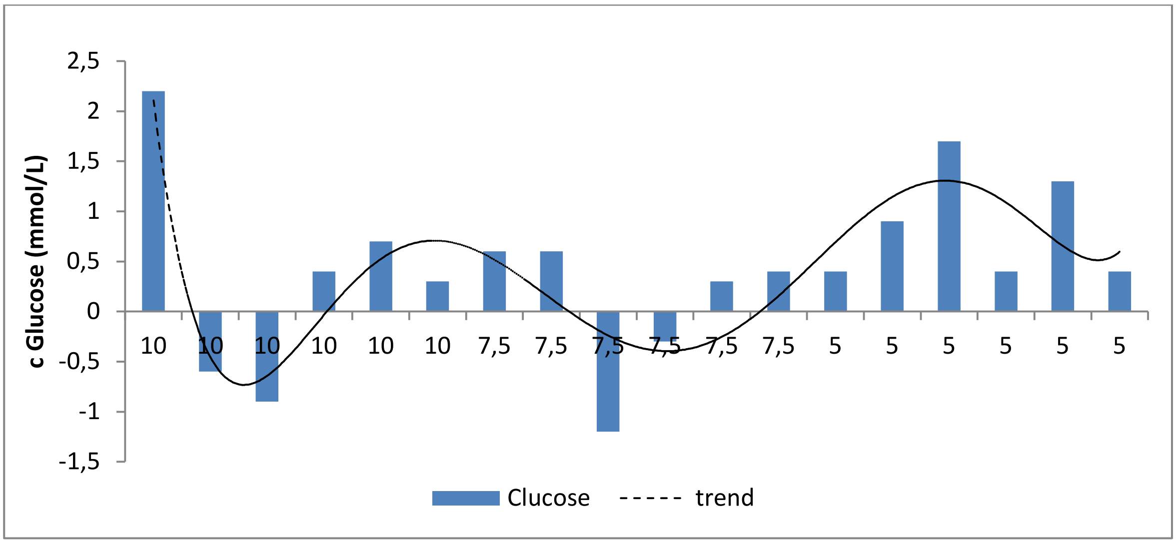
Figure appendix 4-16: Changes in chloride levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.



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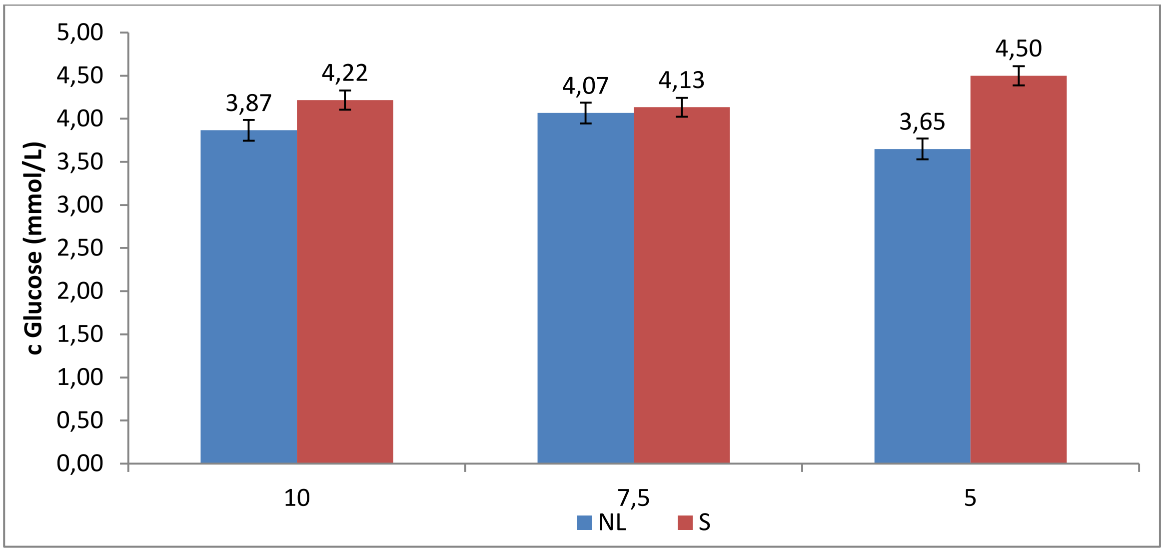
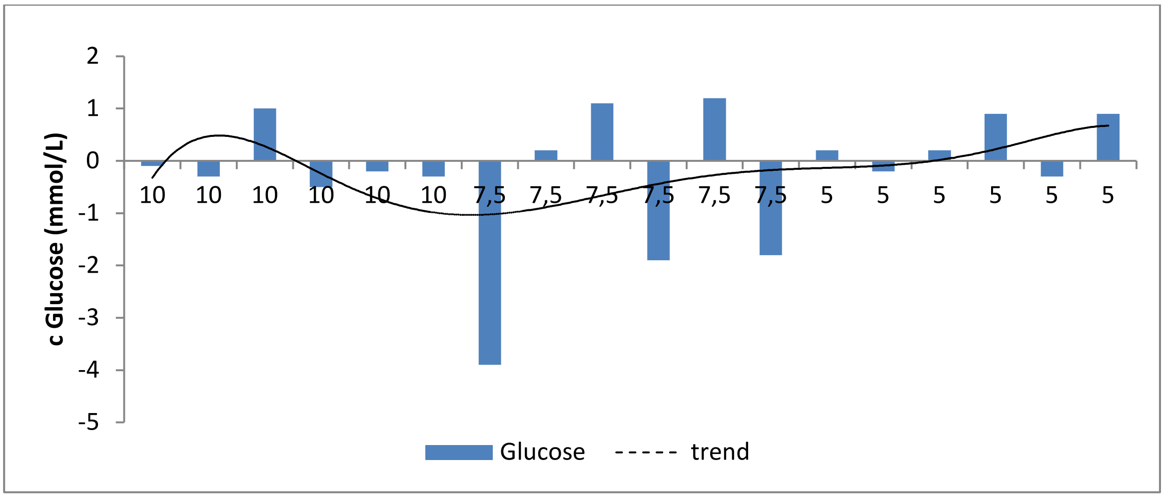


b

Figure appendix 4-17: Changes in glucose levels measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per stocking density.



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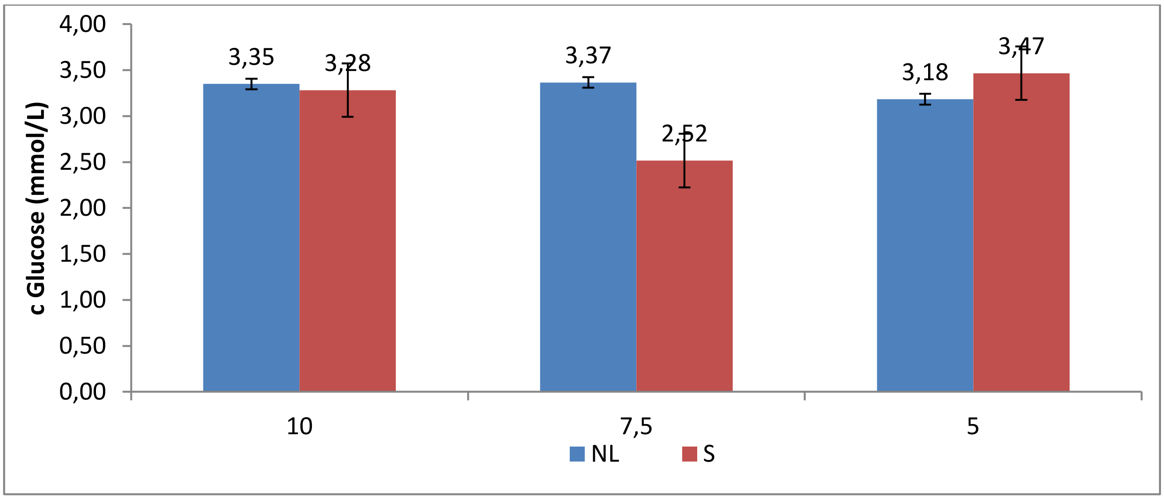
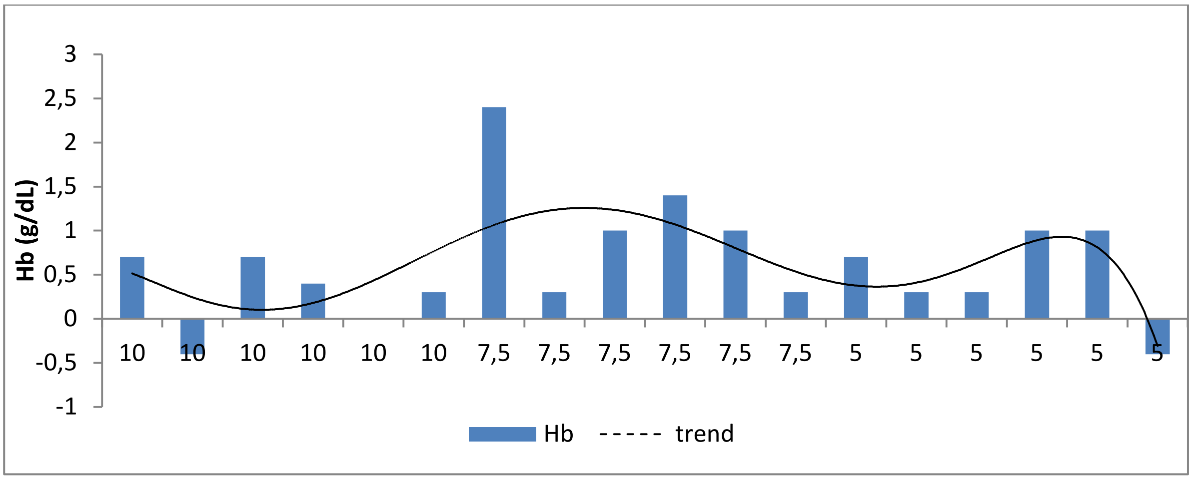


b

Figure appendix 4-18: Changes in glucose levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.



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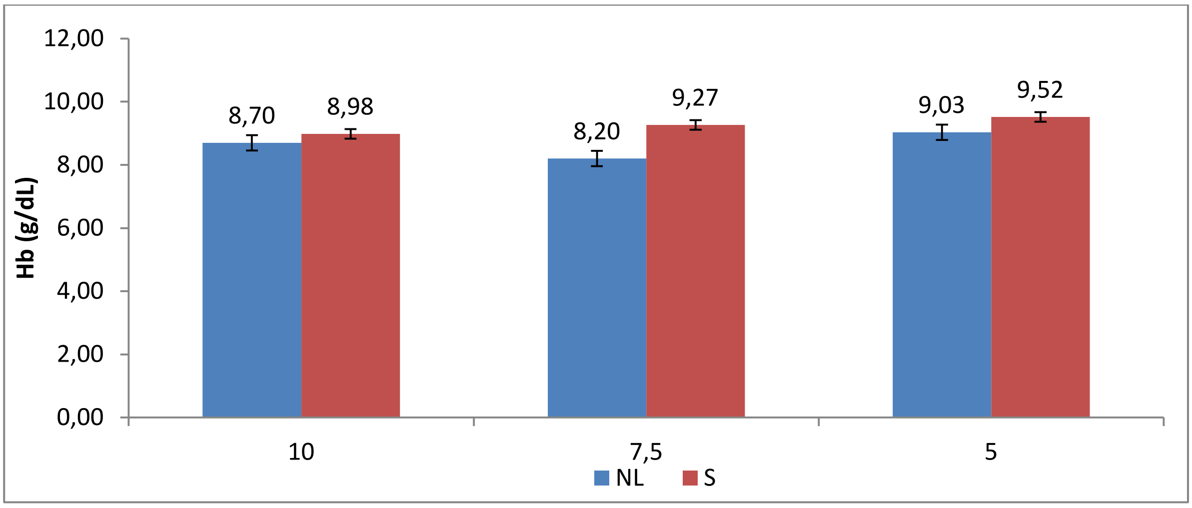
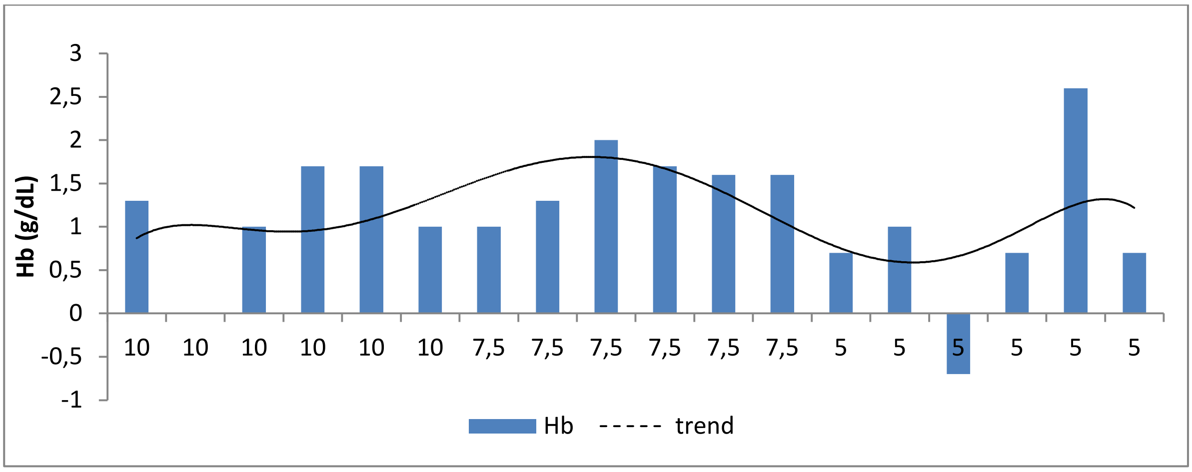


b

Figure appendix 4-19: Changes in haemoglobin levels measured in blood samples taken on 21 March (NL) and 22 March (S) per individual goat (a) and group average (b) per stocking density.



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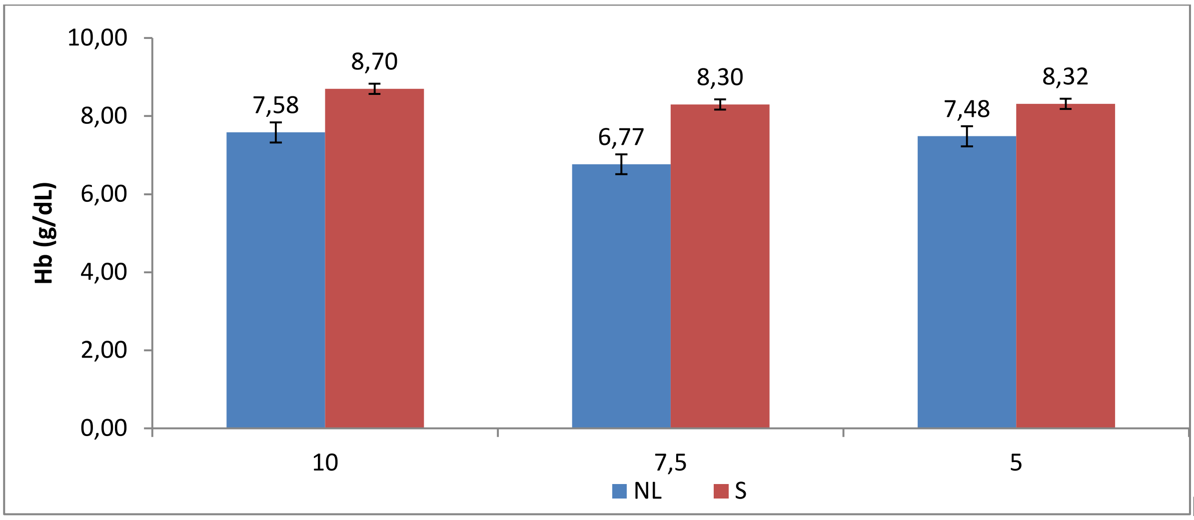


b

Figure appendix 4-20: Changes in haemoglobin levels measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.

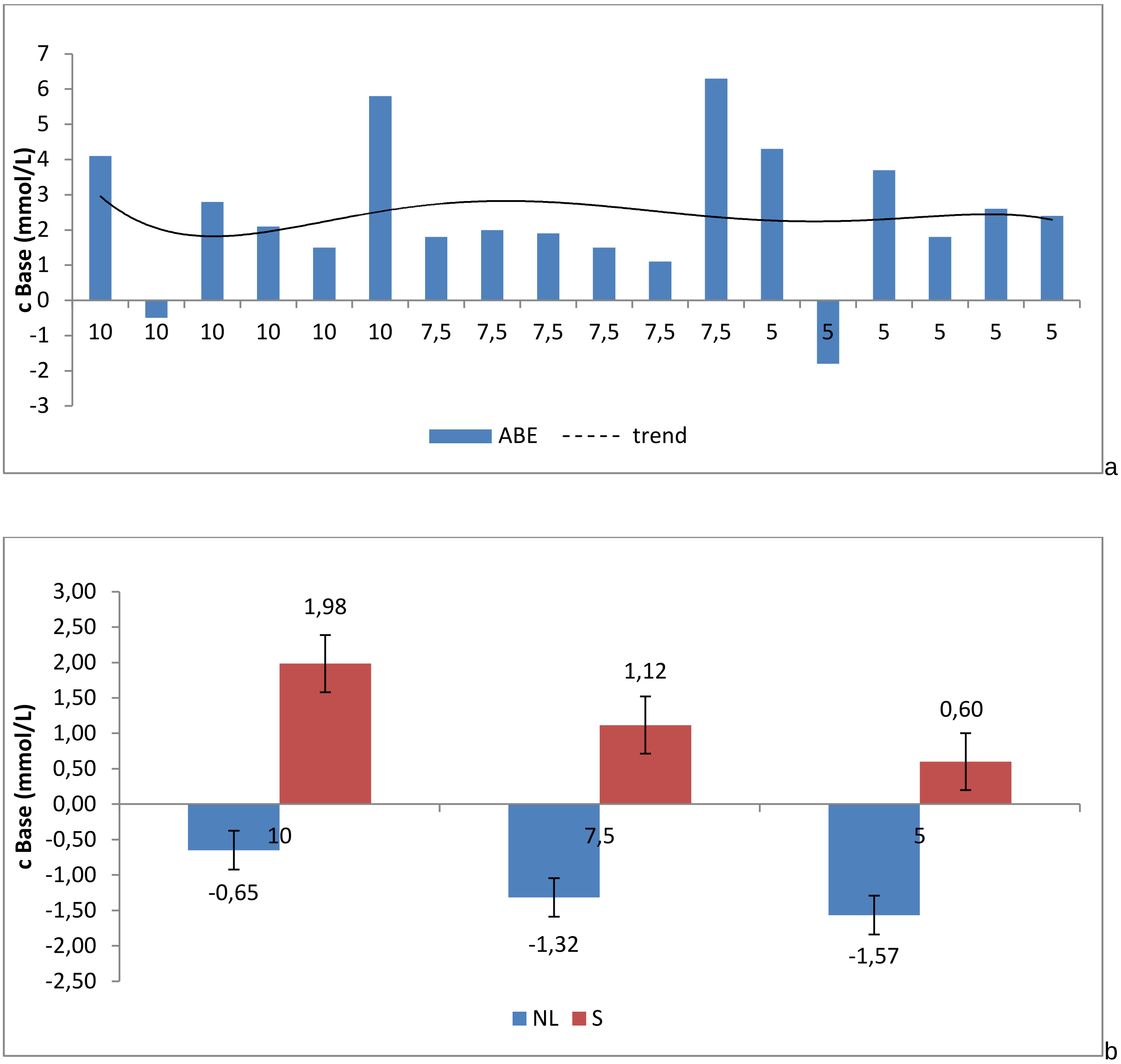
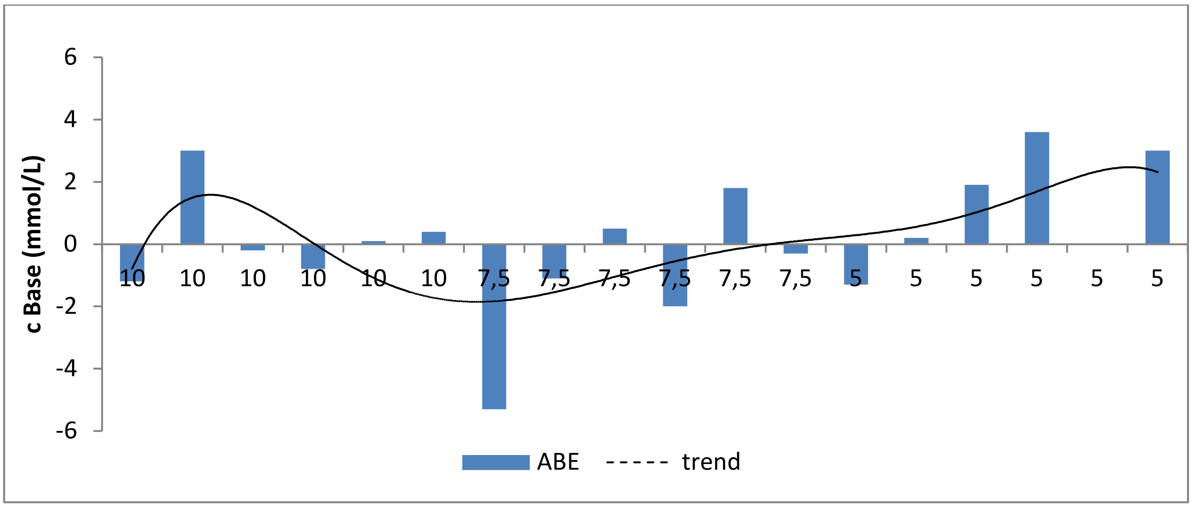


Figure appendix 4-21: Changes in Actual Base Excess measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per stocking density.



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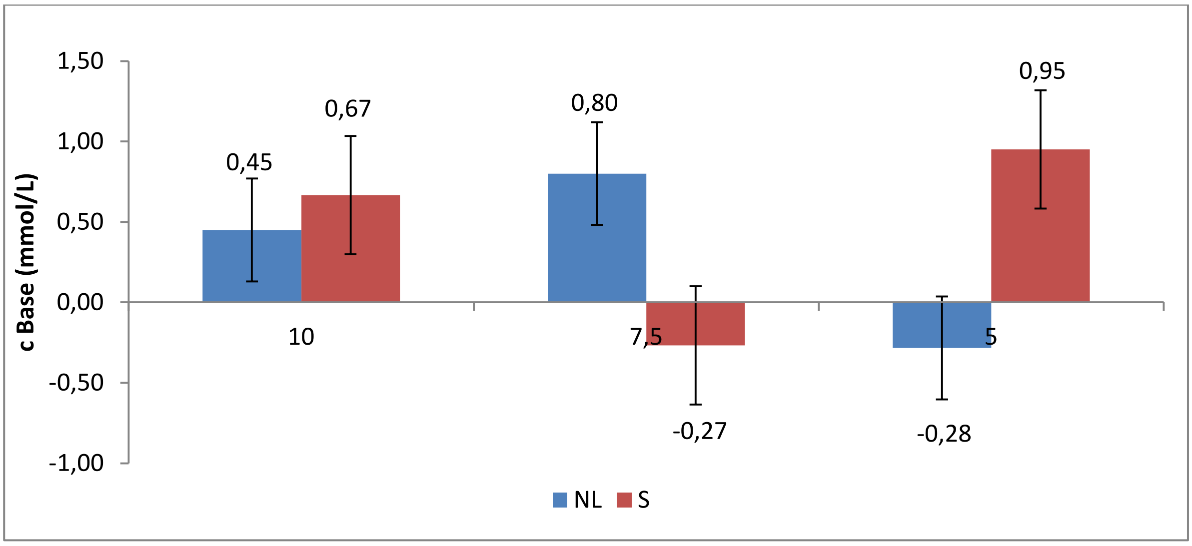
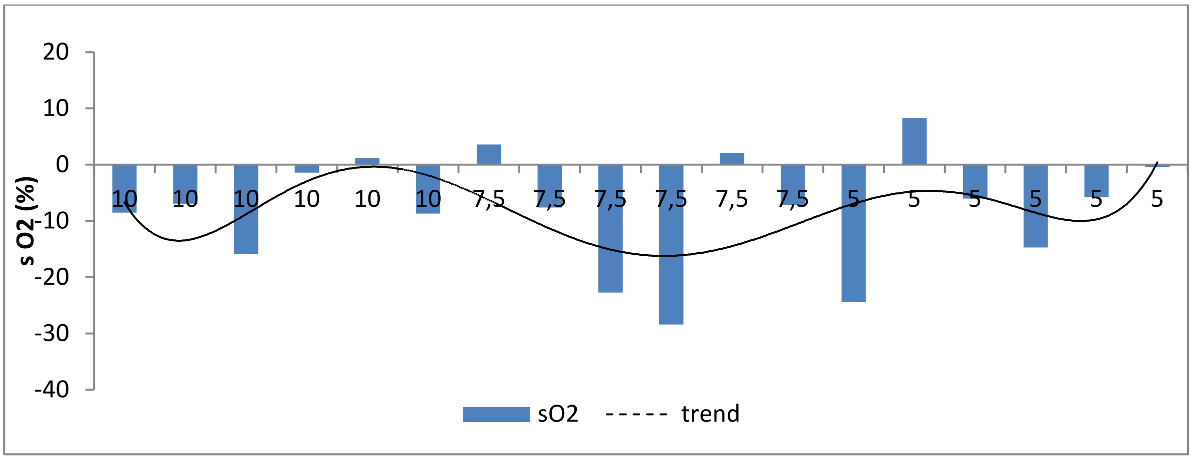
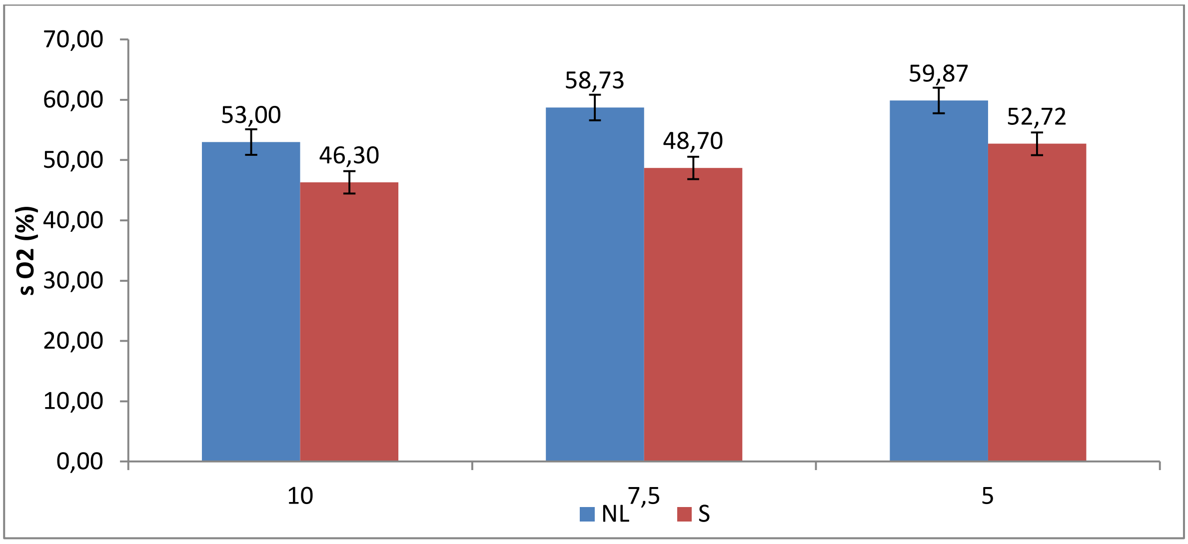


b

Figure appendix 4-22: Changes in Actual Base Excess measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.

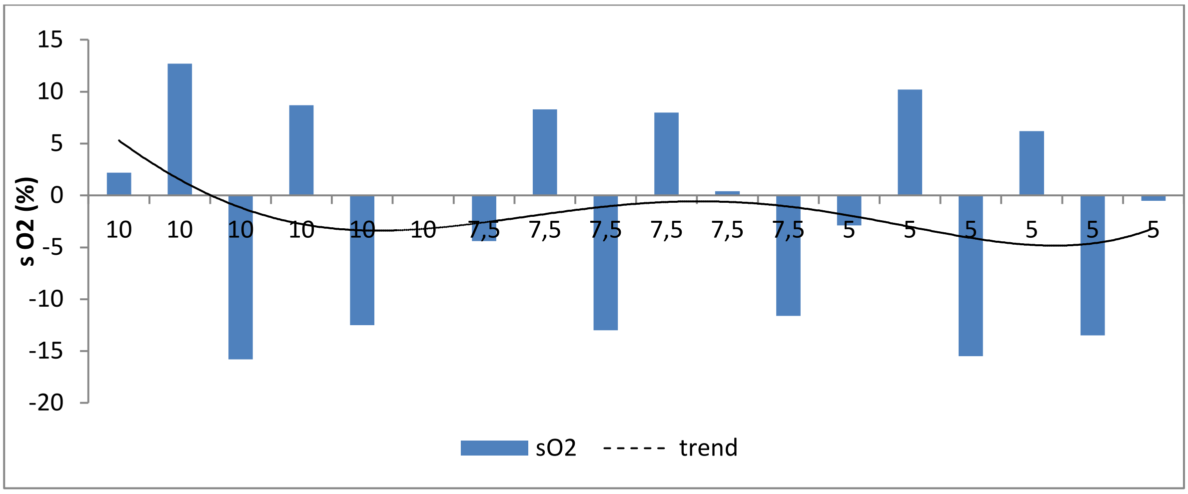


a

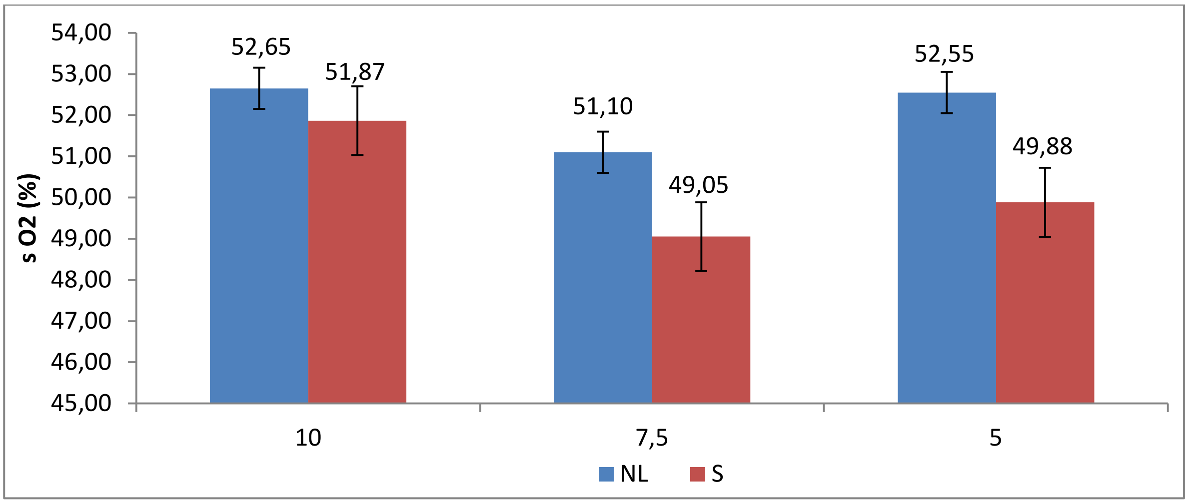


b

Figure appendix 4-23: Changes in oxygen saturation percentage measured in blood samples taken on 21 March (NL) and 22 March (S) per individual goat (a) and group average (b) per stocking density.



a



b

Figure appendix 4-24: Changes in oxygen saturation percentage measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.

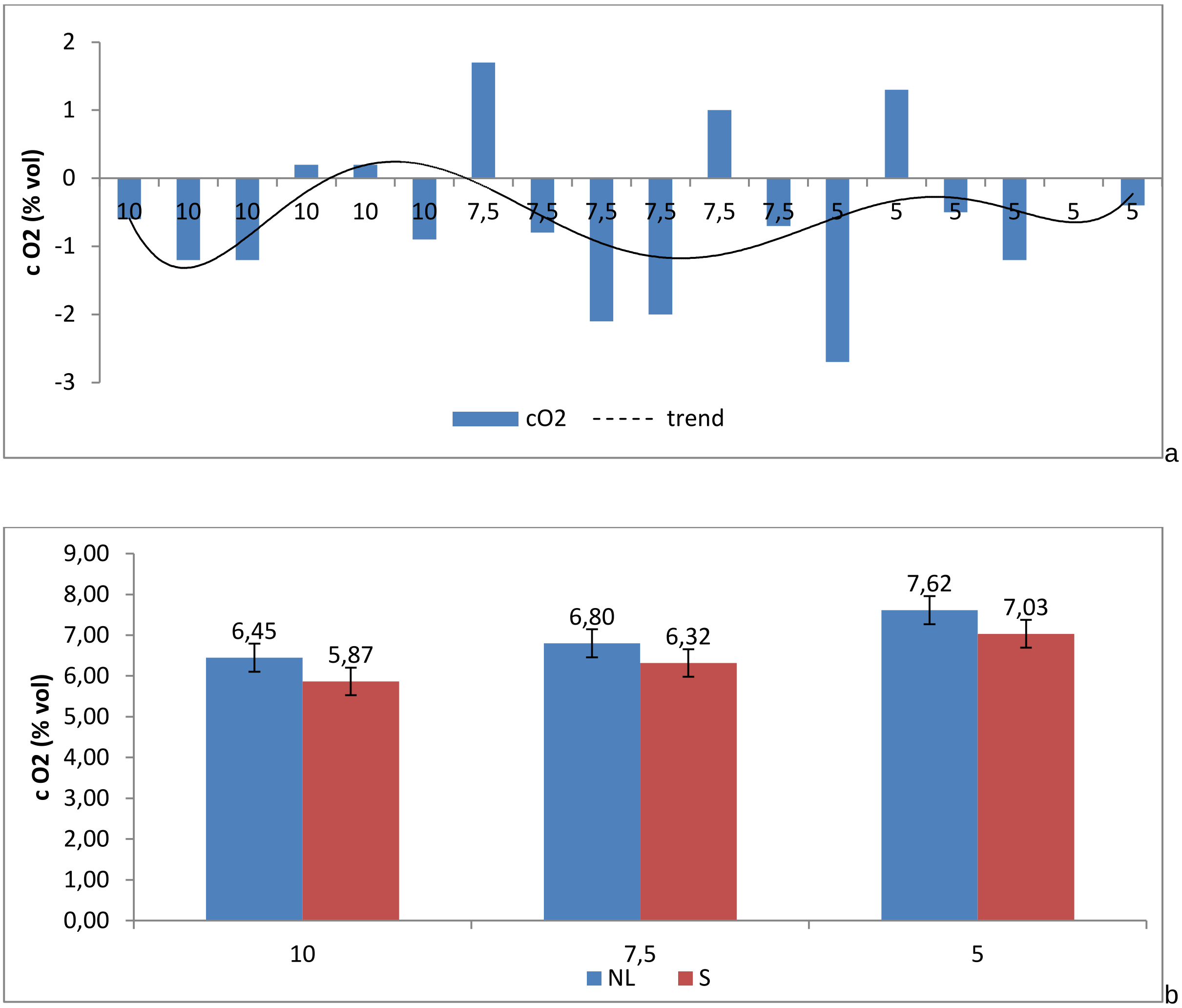
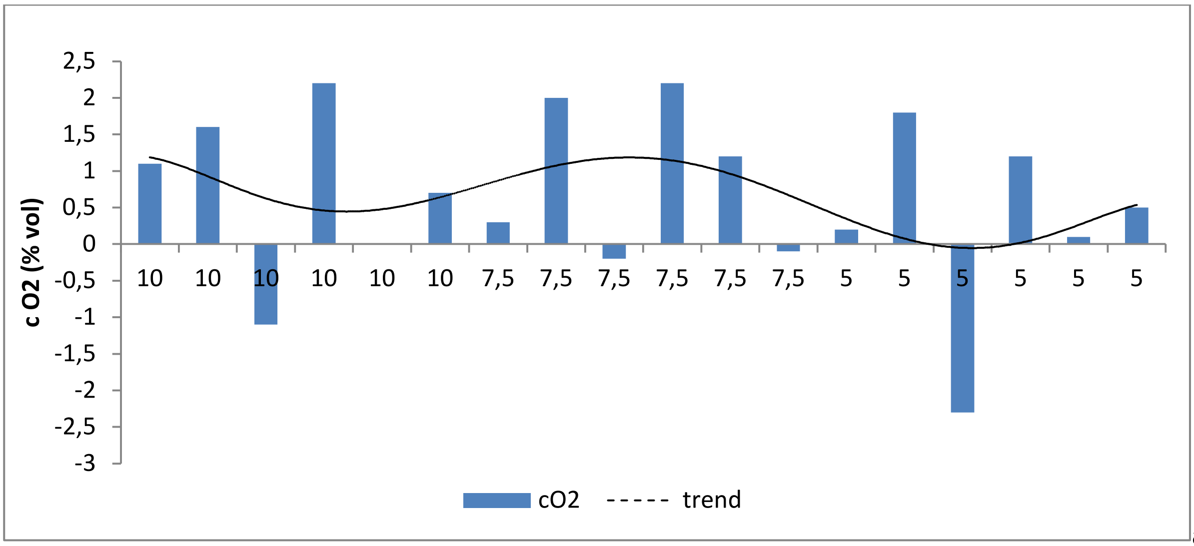
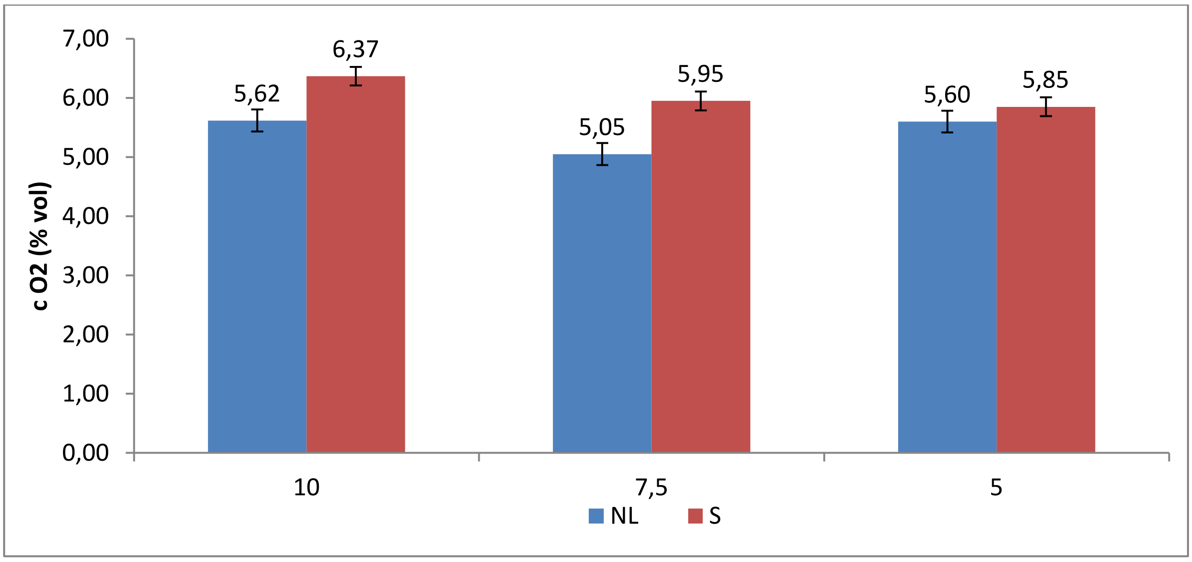


Figure appendix 4-25: Changes in oxygen volume measured in blood samples taken on 21 March (NL) and 22 March (S) 2011 per individual goat (a) and group average (b) per stocking density.



a



b

Figure appendix 4-26: Changes in oxygen volume measured in blood samples taken on 16 May (NL) and 17 May (S) 2011 per individual goat (a) and group average (b) per stocking density.

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