A FIELD STUDY OF MANAGEMENT STRESS IN *REINDEER (RANGIFER TARANDUS L)*

En fältstudie av stress hos ren i samband med olika hanteringsformer

C. REHBINDER, Department of Pathology, Faculty of Veterinary Medicine, Swedish University of Agricultural Sciences, Uppsala, Sweden.

L-E. EDQVIST, Department of Clinical Chemistry, Faculty of Veterinary Medicine, Swedish University of Agricultural Sciences, Uppsala, Sweden.

K. LUNDSTRÖM, Department of Animal Breeding and Genetics, Faculty of Agriculture, Swedish University of Agricultural Sciences, Uppsala, Sweden.

F. VILLAFAÑE, Department of Pathology, Faculty of Veterinary Medicine, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Abstract: The impact of stress was studied in semidomesticated reindeer subjected to various herding and handling methods.

In herded and handled animals, stress lesions were found, such as abomasal haemorrhage, muscular and myocardial degeneration and marked changes in blood constituents. The degree of change was dependent of the magnitude of stress the animal had been exposed to. Manual handling and restraint was found to be one of the major stress factors. There were evident indications of a cumulative effect of repeated stress events. The use of motor vehicles (helicopter and snow-scooter), for herding and transporting the animals, was found to be an important stress factor.
It is concluded that various herding and handling methods studied in the present investigation led to varying degrees of deleterious effects on the health of the animals and a poorer meatquality from slaughtered animals. Hence herding should be undertaken as carefully as possible, the time taken for manual handling should be minimized, and the corrals be so constructed as to cause a minimum of disturbance, capture and restraint. Transportation should be undertaken very cautiously with as little manual handling as possible during loading and unloading. To obtain a good meat quality, animals to be slaughtered should be subjected to a minimum of handling, i.e. slaughter should take place as quickly as possible. Transportation of live animals to slaughterhouses and the keeping of animals in corrals, pens or crates whilst awaiting slaughter will result in a lowered meat quality and should therefore be avoided.

Key words: *reindeer, management and handling stress, myopathy, abomasal haemorrhage, blood constituents.*

***Rangifer** 2 (2) : —2-21*

REHBINDER, C., EDQVIST, L-E., LUNDSTRÖM, K. & VILLAFAÑE, F. 1982.
En fältstudie av stress hos ren i samband med olika hanteringsformer

Sammanfatning: Betydelsen av stress hos ren studerades i hjordar i vilka olika typer av samlings- och hanteringsmetoder användes.

I samtliga hjordar som utsatts för olika former av drivning förelåg hos slaktdjur skador betingade av stress i form av magblödningar, muskelsönderfall och förändringar i blodbilden. De funna skadorna och förändringarna var beroende av den grad av stress som djuren utsatts för.

Manuell hantering och inskränkning av djurens rörelsefrihet befanns vara en av de huvudsakliga stressfaktorerna. Det förelåg även leds en stark indikation på en kumulativ effekt av upprepad stress. Användning av motorfordon (helikopter, snöskoter) vid drivning samt vägtransport av levande djur befanns vara betydande stressfaktorer.

Det kan fastsläs att de olika hanteringsformerna inneburit olika grader av stress. Graden av stresspåverkan innebär olika grader av negativa effekter dels allmänt för djurens hälsotillstånd dels för en försämrad köttkvalitet.

Sälunda bör drivningar företagas så försiktigt som möjligt och tiden för manuell hantering göras så kort som möjlig. Därtill bör gärdor konstrueras så att yttre störning, manuell hantering och begränsning av djurens rörelsefrihet minimeras. Transporter bör genomföras med försiktighet och med undvikande av manuell hantering vid lastning och lossning.

Slakt bör företagas omedelbart, dvs vid gärdan. Transport av levande djur, samt hållandet av djur i gärdor eller fållor i väntan på slakt innebär att köttkvaliteten försämras och bör således undvikas. ***Rangifer** 2 (2) : —2-21*

REHBINDER, C., EDQUIST, L-E., LUNDSTRÖM, K., VILLAFANE, F. 1982: Kenttätutkimus porojen stressistä erilaisten käsittelymuotojen yhteydessä.

Yhteenveto: Stressin merkitystä poroissa tutkitaan laumoissa, joissa käytetään erilaisia kokoamis- ja käsittelymenetelmiä.

Kaikissa laumoissa, jotka olivat joutuneet alttiiksi erilaisille ajomuodoille, oli teuraseläimissä stressin aiheuttamia vammoja mahaverenvuotojen, lihasrappeutumien ja verikuvan muutosten muodossa. Löydetyt vammat ja muutokset olivat stressin aiheuttamat siinä suhteessa kuin eläimet olivat siihen joutuneet.

Käsin pitely ja eläinten liikuntavapauden rajoittuminen havaittiin olevan yksi pääsiallisista stressintekijöistä. Oli esillä myös voimakas osoitus kasvavan vaikutuksen toistuvasta stressistä. Moottoriajoneuvojen (helikopteri, moottorikelkka) käyttö ajossa sekä elävien eläinten tiekuljetus näyttivät olevan merkittäviä stressitekijöitä.

Voidaan todeta, että erilaiset käsittelymuodot ovat aiheuttaneet stressin erilaisia asteita. Stressin vaikutuksen taso aiheutti eri asteisia negatiivisia vaikutuksia osittain huonontuneeseen lihan laatuun.

Näinollen pitää ajot suorittaa niin varovaisesti kuin mahdollista ja aika käsin pitelyyn tehtävä niin lyhyeksi kuin mahdollista. Sen lisäksi pitää aidat rakentaa niin, että ulkoista häirintää, käsin pitelyä ja eläinten liikuntavapauden rajoitusta vähennetään. Kuljetukset pitää suorittaa varovaisuudella ja koettaa välttää käsin pitelyä kuormauksessa ja purkauksessa.

Teurastaminen pitää suorittaa välittömästi, toisin sanoen aidan luona. Elävien eläinten kuljetus, sekä eläinten pitäminen aitauksissa tai tarhoissa teurastamista odotellessa aiheuttaa lihalaadun huonontumiseen ja pitää näin ollen välttää.

Rangifer *2 (2) : —2-21*

INTRODUCTION

Modern methods of reindeer herding differ considerably from the old, traditional herding methods. The latter involved a rather intimate relationship between the herdsmen and his animals, which contributed to a comparatively domesticated reindeer. Furthermore, the animals were kept in relatively small herds in those days.

Present herding methods imply lagerger herds of less domestricated animals. The traditional methods, which involved daily contact with the animals by walking or skiing herdsmen, have given way to territorial surveillance and round-ups of large herds, often with the help of snow-scooters and sometimes even helicopters. In addition, transport of reindeer by lorry for different purposes, is a common practice.

The objectives of the present investigation were to study the pathological and haematological responses in different reindeer herds subjected to different management methods.

MATERIAL AND METHODS

Investigated herds

A. ÖSTRA KIKKIJAURE (22. Aug.): Ten animals were killed, resting or grazing in the forest, by means of a rifle-shot in the head. (Of these animals, 6 were forest reindeer and 4 belonged to a mountain herd.) These animals were considered as unstressed controls (see Rehbinder & Edqvist, 1981) (Table 1).

B. ROMPERHEDEN (22. Jan.): About 1800 animals were herded into a large grazing corral of about 1,5 km². The animals were gathered by men on snow-scooters and skis. The following day the herd was driven into an ordinary corral (Romperheden, Fig. 1), using the same method. (Table 1). The herd was very calm and not reluctant to enter the corral. A few minutes thereafter most animals started ruminating and many lay down.

When the slaughter started, some of the animals were driven into a selection corral (Fig. 1) where those to be slaughtered were chosen and caught with a lasso, dragged out of the corral and stunned. The remaining animals were let out into a smaller grazing corral.

C. ROMPERHEDEN (23. Jan.): The same herd as for B had been kept overnight in a small (0,25 km²) grazing corral. In the morning the animals were driven by herdsmen on skis and snow-scooters into the ordinary large corral (Romperheden, Fig. 1).

The animals were rather reluctant to enter the corral. The average drive distance of less than 1 km took about 40 min (Table 1). Most of the snow was tranped into a dry slush and did not hinder the movements of the animals. Selection for slaughter was done in the same way as on the previous day (see B).

D. BRÄNDVALLEN (31 Jan.): Around 3000 animals of a mountain herd were grazing in the

forest not far from the corral. They had been gathered 3-4 days earlier by snow-scooter-borne herdsmen. On Jan. 31, about 1200 of these animals were driven into a corral by means of helicopter and at the end of the drive, by snow-scooters. The average herding distance was approximately 3-4 km. During the drive the animals were obviously seized with a panicky fear of the helicopter, but were prevented from escaping or stampede by thick snow cover (Plate 1). The drive took nearly 2½ hours. Inside the corral the animals continued to run and most of them never calmed down (Table 1, Plate 2). Six animals were found dead or dying, trampled down by other animals. After about 1 hour in the corral, parts of the herd were driven into a small selection corral, 15 m in diameter, where the animals were captured by hand. Those chosen for slaughter were put into a rectangular pen (Fig. 1) from which they were taken by hand for slaughter, or driven into lorries for transport to a slaughterplace (Brändåsen), 71 km away.

The opportunity was taken to perform castrations, dehornings etc. (Plate 4). Several persons stood around and inside the selection corral (herdsmen, spectators, slaughter personnel, etc.) (Plate 3). Mos of the animals inside the selection corral and pen were seized with fear and panic and showed abnormal behaviour such as hyperactivity, attempts to escape by jumping the fences, aggressiveness, but also lethargy.

About 4 hours after the start of the drive the first slaughters took place. Only animals slaughtered at the corral were investigated. The work with the animals proceeded for almost 15 hours, including the drive.

E. BRÄNDVALLEN-BRÄNDÅSEN (1 Febr.): Out of the same main herd (D) around 1800 animals were driven by helicopter and snow-scooters to the corral. This means that a mixture of animals that had and had not been in the corral the day before were driven, for selection. The drive by helicopter lasted around 2½ hours. The animals showed similar signs of panic as on the day before. Animals for slaughter were selected in the same way but only animals transported by lorries to the slaughterplace at Brändåsen were investigated. The transport distance was 71 km and took, on average, I½ hours. The unloading took about 30 min. (Table 1. The animals were let out into a small corral. (Fig. 1) From where they were taken by hand for slaughter. The selection of animals at Brändvallen and their slaughter at brändåsen continued throughout the day and late evening. Consequently it was impossible to establish the handling time for individual animals.

F. BRÄNDÅSEN (2 Febr.): The reindeer investigated were the last to be brought in by lorry around midnight the day before. These animals were allowed to rest during the night in the small corral at the slaughterplace (Fig. 1). They were fed small amounts of fodder but hardly any was eaten. These reindeer had been exposed to handling for more than 24 hours including the overnight stay in the corral (Table 1).

G. MAUSJAURE (2 July): A herd of around 400 animals was driven into a corral for calf marking. Blood samples were drawn from 10 animals captured by lasso. The animals were driven by walking herdsmen.

H. ÄNGSÅ (19 Sept.): A small herd of around 300 animals were scattered in the forest. An attempt to drive them into a corral had failed in the morning. Instead, some bulls were killed by a rifle-shot in the neck after the animals had been cautiously driven out of the forest by slowly walking herdsmen (Table 1).

I. ASPBERGET (19 Sept.): Around 300 animals were driven into a small corral (Fig. 1) during a period of around 4 hours. The slaughter started at once. The animals were caught with lasso, taken out of the corral and slaughtered (Table 1).

J. DIRIJÄRVI (20 Sept.): A herd of about 300 animals had been driven into a large grazing corral on September 18. The following day an additional 400 animals (approx). were driven into the same corral. On September 20 the animals were driven into the ordinary corral (Fig. 1). The handling was calm (Table 1). The animals were caught with a lasso and put into a pen from which they were taken by hand or with the lasso, dragged out and killed.

Numerous spectators, herdsmen etc. stood around the slaughter place and pen, and also inside the corral and the pen.

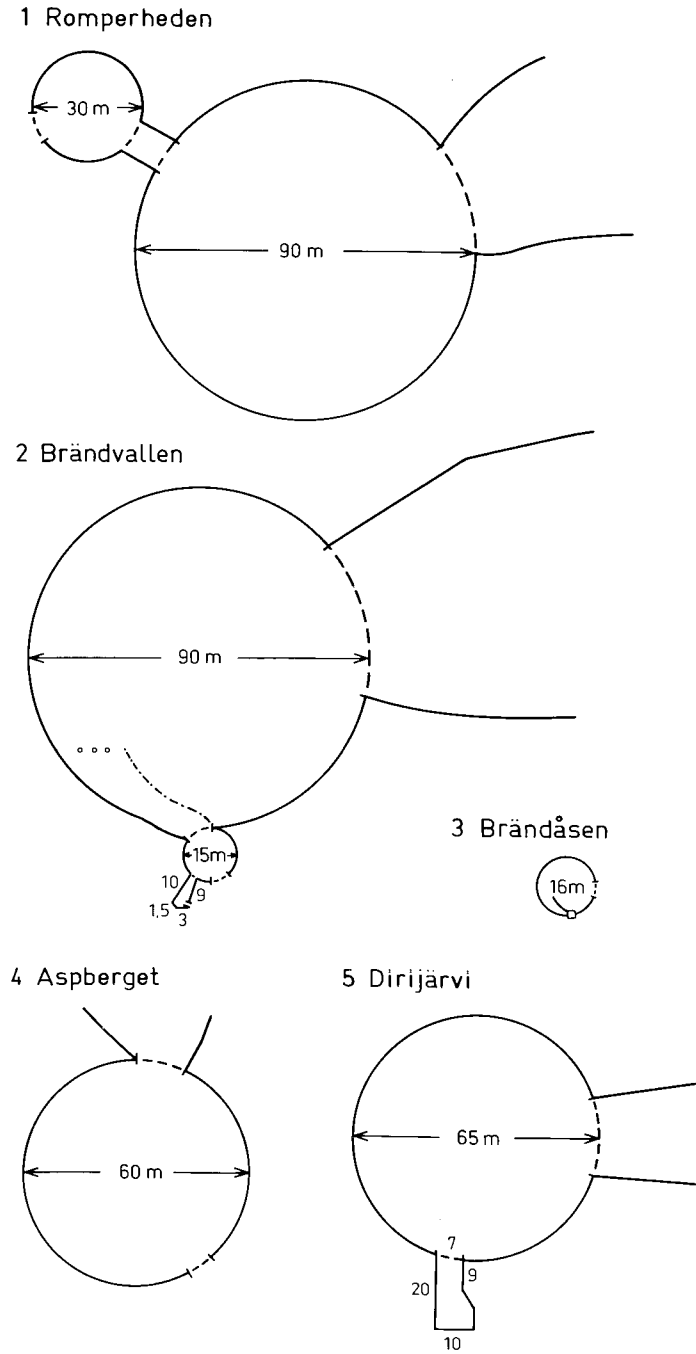

Fig. 1. The shape of the corrals used for the different herds investigated.
Utformningen av gärdorna använda för de undersökta hjordarna.

Plate 1. Herd of reindeer gathered and driven by helicopter. Note the snow cloud, above the herd, produced mainly by the slip stream generated by the helicopter when passing over the herd at low altitude.

Plåt 1. Renhjord driven av helikopter. Notera det snömoln som hänger över djuren och som i huvudsak orsakats av den starka vind helikoptern genererat när den på låg höjd flugit över djuren.

Conditions under which the investigations were undertaken

The conditions under which the animals were herded and handled are compiled in Table 1. The numbers of animals in the herds brought into the corral were estimated with the assistance of herdsmen. The herding distance was estimated by the herdsmen. The time taken to drive the animals to the corral was recorded for herds B, C, D, E, F and J and estimated by herdsmen for herds G and I.

n The tameness of the animals was judged from their escape distance and general behaviour. The ages of the animals which were subjected to sampling were judged from their appearance and the wearing of molar teeth.

Slaughter procedure

The animals were usually stunned with a bolt-pistol, but due to the very cold weather that to some extent prevented its use, most of the animals of herds B and C and some of herd D were stunned with a knife stab in the foramen occipitale magnum. The animals of herds A and H were shot

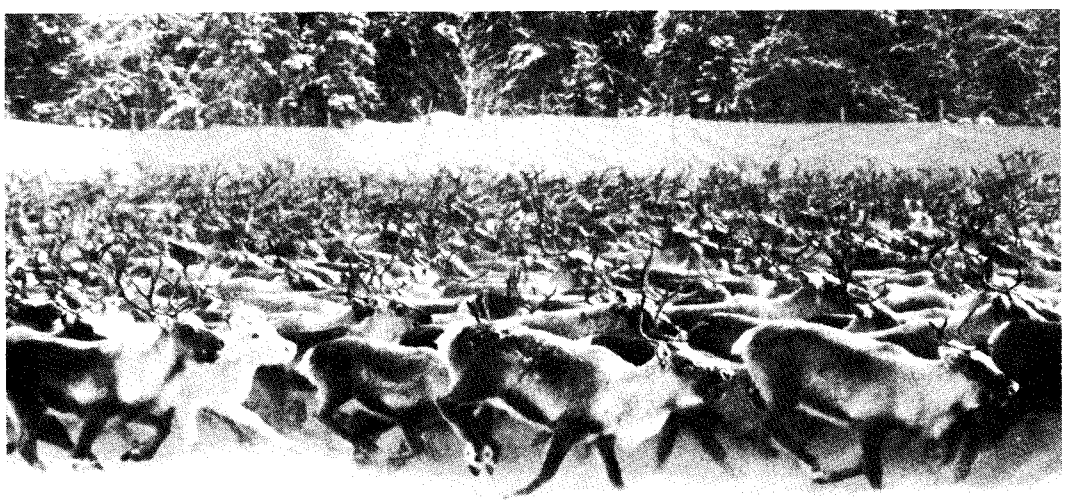

Plate 2. The same herd inside the corral. The animals are seized with panic. The picture is taken 1 hour after the animals entered the corral, but the animals are still running «senselessly».

Plåt 2. Samma hjord i gårda. Djuren är skräckslagna och i panik. Bilden är tagen 1 timme efter det att renarna kom in i gårdan men djuren springer fortfarande runt.

Plate 4. Dehorning reindeer before transport to the slaughter corral. This procedure means a prolonged restraint stress added to other stress events.

Plåt 4. Avhorning före transport till slaktplats. Denna åtgärd innebär en förlängd hanteringsstress kopplad till andra stressmoment.

in the head (A) or neck (H) with a rifle. After stunning, all animals were bled. Those of herd G were not slaughtered.

Materials for pathological, haematological and biochemical investigations

At slaughter, macroscopical inspection of carcasses and viscera was undertaken as detailed in Table 1. Thus in many instances considerably more slaughtered animals were inspected macroscopically than was the number of animals from which material was obtained for laboratory investigations.

From randomly chosen animals, blood samples and material for histopathological investigation were taken as detailed in Table 1.

Material for histopathological investigation was taken from M.semitendinosus, M.longissimus dorsi, myocardium, liver, kidney and abomasum. The material from semitendinosus and longissimus dorsi was taken blind, as the carcasses were sold for consumption and careful inspection of the muscles therefore was not permitted.

Plate 3. The selection corral at Brändvallen. Numerous herdsmen, spectators and others are present inside and outside the corral. Note how most of the animals are standing with heads against the fence.

Plåt 3. «Sil» (urvalskontor) vid Brändvallen. Fullt med folk utanför och inne i «silen». Notera hur flertalet djur vänder sig från människorna och mot staketet.

The tissues were fixed in 10% formalin, embedded in paraffin, cut in 5 µm thick sections and stained with haematoxylineosin, PTAH, van Gieson and Masson's trichrome. Frozen sections were stained with scarlet red.

Blood samples were taken from shot and stunned animals by means of a knife-cut in the jugular vein into tubes containing heparin or no anticoagulant. Blood samples from other animals were collected from the jugular vein using 10 ml vacutainer tubes (Becton-Dickinson). In herd I, blood samples were obtained from animals twice - directly when they were caught with the lasso, and then when they were stunned. Handling time between the two samples for these animals was around 3-5 min.

Blood smears were made at the time of collection and allowed to air dry and were later stained according to May-Grünewald-Giemsa.

Cortisol concentrations in blood plasma were determined by a competitive protein binding technique utilizing horse plasma as binding protein (Lundström et al., 1975). No efforts were made to separate cortisol from other corticosteroids showing cross-reaction in the assay system (e.g. corticosterone 32%, 11-desoxycortisol 20%). Urea values were determined by means of a glucose/urea/creatinine analyser (IL 919; Instrumentation Laboratories) using reagents and procedures recommended by the manufacturer.

Aspartate aminotransferase (ASAT) was determined by a kinetic technique on an LKB Reaction Rate Analyser according to the recommendations of the Scandinavian Committee on Enzymes (1974).

Statistical analyses

The animals were classified into three age classes: below 1 year, 1-3 years, and 4 years or above. In the statistical analysis, abomasa, skeletal muscles and myocardium were classified as unaffected (0) or affected (1). For muscle and myocardium the sum of the observed lesions was used in the calculation. The effects of treatment, sex, and age class were estimated simultaneously by the method of least-squares analysis of data with unequal subclass numbers, using the Statistical Analysis System (Helwig & Council, 1979). On the larger material (mainly macroscopically investigated abomasa) only the effect of treatment could be tested.

The two-way interactions were tested, but were found to be non-significant for all traits, and were thus deleted from the statistical model. Differences between means were tested with Duncan's multiple range test using error terms from the same model as above.

Blood constituents taken from 7 animals (herd I) before and after slaughter were compared by using a model containing the effect of slaughter and the effect of animal.

RESULTS

As seen in Table 1, numerous stress factors are involved in the management of reindeer, such as methods of gathering and herding the animals, conditions under which animals are herded, the extent of manual handling and contact with people, transportation etc. Also to be considered is the degree of tameness of the reindeer.

In the study undertaken, herds A and H were subjected to no - or minimal - herding and handling stress. Herd B, however, was driven during a 50-min period into the corral by herdsmen on skis and on snow-scooters over thick snow-cover, while herd I was subjected to a 4-hour drive for 6-7 km by men on foot. Herd G was in most respects exposed to herding and handling to the same extent as herds B and I.

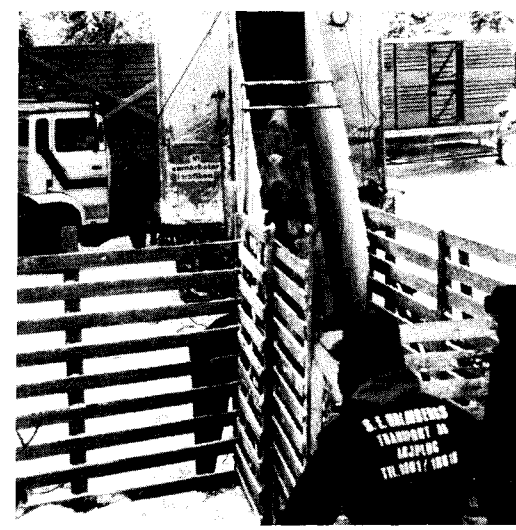

Plate 5. Transport to slaughter corral. Loading, transport and unloading are all factors causing stress in the animals.

Plåt 5. Transport till slaktplats. Lastning, transport och urlastning innebär olika stressmoment för renarna.

Plate 6. Abomasum with several mucosal haemorrhages. The animal was slaughtered 4 hours after the beginning of the helicopter drive.

Plåt 6. Löpmage med ett flertal blödningar i slemhinnan. Djuret slaktades 4 timmar efter helikopterdrivning börjat.

Herds C and J were both allowed to stand in a grazing corral overnight before slaughter, but the handling of the animals took an appreciably longer time and the disturbance by spectators and other was much more pronounced for herd J.

Herds D, E and F represent the herds most exposed to herding and handling stress and on an increasing scale, i.e. duration, transportation etc. (Plates 1-5).

The macroscopical investigation of slaughtered animals revealed, as a major finding, haemorrhages in the abomasa (Plate 6). These lesions were classified as mild, moderate, or severe according to their appearance, in size and number (Fig. 2).

Haemorrhages were found in the abomasa of animals from all herds except A and H. There were fewest in herds B, C and I, while herd J had more than these, but fewer than herds D, E and F ($P \leq 0{,}05$). It should be noted that haemorrhages were present in the material even after only 4 hours of handling and herding.

Microscopically, most of the lesions consisted of a local mucosal haemorrhage, oedema and constriction of submucosal vessels. These changes varied from minor mucosal haemorrhage to severe haemorrhages, coagulative necrosis and submucosal haemorrhages. Ulcers penetrating to the submucosa were not found. An evident inflammatory reaction with infiltration mainly of neutrophils was present in cases of more pronounced mucosal lesions (Plates 7-9).

In herds E and F subcutaneous traumatic haemorrhages were a common finding (Plate 10).

Of the 261 reindeer slaughtered at Brändåsen (F) (Febr. 1) 22 had large and 32 minor traumatic lesions. In addition 2 animals were found dead in the lorries. On February 2, of the 169 animals investigated, 8 had large and 19 minor traumatic lesions. One animal died during transport.

Additional pathological findings were nodular parasitic granulomas in the lungs of almost all inspected animals in all herds. In herds A, H, I and J, parasitic granulomas were found in the liver and in the kidneys of all animals and in addition also a mild to moderate infestation of *Setaria* sp.

In herds A, B, C, H, I and J all animals were also infested by *Onchocerca tarsicola* along tendons and around joint capsules.

Lesions in the skeletal muscles and myocardium were not observed at the macroscopical investigation.

The histopathological investigation of muscular tissues, taken blind, revealed degenerative lesions in both skeletal muscles and myocardia. These changes ranged from loss of striation, fragmentation, to hyalinization and necrosis, and the extent of the lesions varied from minor focal lesions to larger areas of necrosis (Plates 11-12). In cases of necrosis, an inconstitent cellular reaction by histiocytes was observed, characterized by the presence of fibroblasts, macrophages, lymphocytes and occasional neutrophils.

Degenerative muscular lesions were not found in herd A. Herds B, C and H were significantly less affected than herds D, E, F, I and J (Fig. 3).

In livers and kidneys only parasitic lesions were found, mainly in herds A, H, I and J.

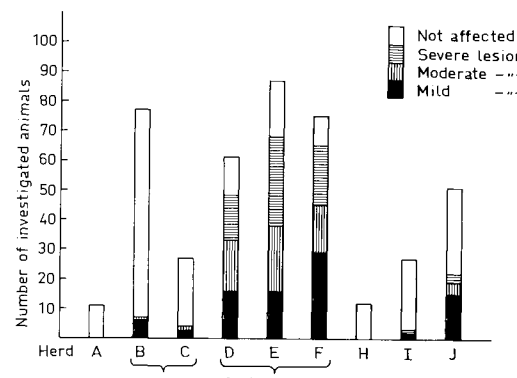

Fig. 2. Distribution of abomasal lesions.
Fördelning av löpmagsblödningar.

The results of the blood constituents studied are presented in Tables 2-5 and Figs. 4-6. In herd A no differences were found between mountain and forest reindeer.

The levels of significance for the effects of treatment, sex and age class are presented in Table 2. When comparing the coefficients of determination for the full model and a model only comprising treatment (Table 2) it is obvious that the effect to treatment is of major importance, while sex and age class are of secondary importance.

Age significantly influenced the number of eosinophils and lymphocytes and the level of urea (Table 3). The very quick response in the corticosteroid levels of the animals from herd I between initial sampling (I_1) and sampling at slaughter (I_2) is remarkable.

The effects of management stress are reflected by an increase in both immature and mature neutrophils and a decrease in lymphocytes correlated to the degree of stress the animals have been exposed to. Prolonged exposure produces a remarkable decrease in the number of eosinophils (Table 4, Fig. 4).

The corticosteroid levels were found to be significantly lower in shot animals (herds A and H) than in handled animals (Table 4, Fig. 5). The shot animals of herd H, however, show a wider range. The lowest cortisol levels in handled animals were found in herds B and C, and the highest in herds F and J.

Urea levels were found to be lower in herds B, D, H and I than in animals shot during August (herd A), while animals kept overnight in grazing or

Table 2. Levels of significance for the effects studied and coefficients of determination for the full model an for a modell including treatment only.

Tabell 2. Signifikansnivå för de studerade effekterna samt determinationskoefficienten för hela modellen och för en modell med enbart behandling.

Trait *Effekter på*	Level of significance *Signifikansnivå* Treat-ment *Behandling*	Sex *Kön*	Age class *Ålders-grupp*	Coeff. of determination *Determinationskoeffi* Full model *Hel modell*	Model with only treatment *Modell for enb. behandling*
Muscle lesions					
Muskelskador					
M. longissimus dorsi	***	n.s.	n.s.	41	35
M. semitendinosus	***	n.s.	n.s.	44	43
Myocardium	n.s.	n.s.	n.s.	14	10
Abomasal lesions					
Löpmageskador	***	ns.	n.s.	42	38
Differential counts					
Differential räkning					
Immature neutrophils	***	n.s.	n.s.	70	69
Umogna neutrofiler					
Segmented neutrophils	***	n.s.	n.s.	57	55
Segmenterade neutrofi					
Basophils	***	*	n.s.	38	33
Basofila					
Monocytes	*	n.s.	n.s.	28	22
Monocyter					
Lymphocytes	***	n.s.	*	52	46
Lymfocyter					
Corticosteroids, nmol/l	***	n.s.	n.s.	57	56
Urea, nmol/l	***	n.s.	*	79	78
ASAT, µkat/l	***	n.s.	n.s.	20	16

Levels of significance *(Signifikansnivå)*: n.s. (not significant) = $P>0.05$; * = $P\leq 0.05$; ** = $P\leq 0.01$; *** = $P\leq 0.001$.

resting corrals (herds C, F and J) revealed significantly higher values than animals from all the other herds (Table 4, Fig. 6).

Significantly increased ASAT values were found only in herd F (Table 4) but individual animals with high levels were also found in herds B, C and E. A tendency toward comparatively higher levels of ASAT was found in herd E (Fig. 8).

Table 3. Least-square ± standard errors for the three age classes (only given when the effects of age were significant).

Tabell 2. Minsta-kvadrats medeltal ± standardfel för de tre åldersklasserna (redovisas endast när effekt av ålder var signifikant)

Trait *Effekter på*	Age class, years and (class) *Åldersklass, år och (klass)*			Significant differences (P≤ 0.05) *Signifikanta olikheter*
	< 1 (1)	1-3 (2)	> 3 (3)	
Differential count, %				
Eosinophils	7.7±2.3	14.4±1.3	15.5±1.2	1-2; 1-3
Lymphocytes	34.6±3.2	31.0±1.8	25.8±1.7	1-3; 2-3
Urea, nmol/l	9.2±	7.1±0.5	6.7±0.5	1-2; 1-3

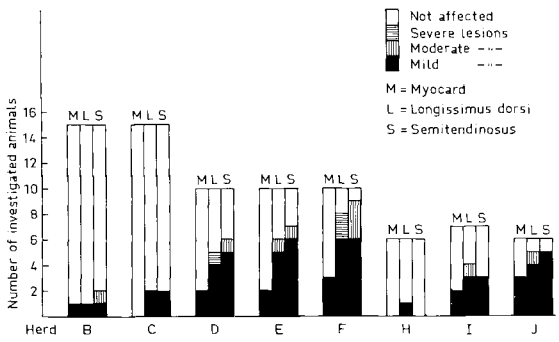

Fig. 3. Distribution of degenerative muscular lesions.
Fördelning av degenerativa muskelskador.

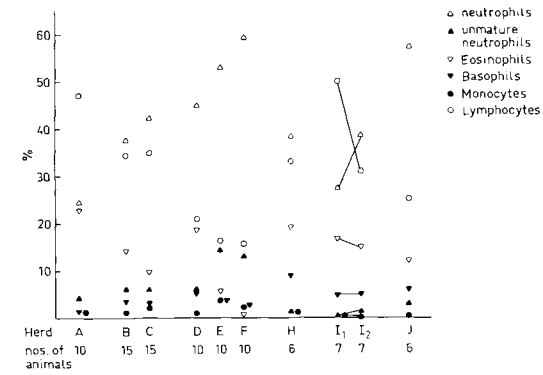

Fig. 4. Differential counts of leucocysts.
Differentialräkningar av vita blodkroppar.

DISCUSSION

The herds investigated, except herd A, had all been subjected to varying levels of stress.

The animals of herd A which were shot while resting or grazing are considered to be unstressed. The animals of herd H were also shot, though some of them apparently did not die directly from the shot in the neck but were only paralysed, which was reflected by the presence of blinking reflex. This may explain the wide individual differences in the blood parameters encountered in these animals.

Herds B, C and I were subjected to a comparatively mild herding stress and a brief handling stress. Herd J was exposed to a moderate degree of herding stress but a pronounced handling stress.

Herds D, E and F all suffered a severe herding and handling stress. In addition, herd E - and especially herd F - were subjected to transportation and prolonged stress.

The muscular and myocardial lesions and the hamatological values in animals subjected to prolonged herding and handling are all characteristic of physical exertion and acute mental stress (Jönsson and Johansson, 1974; Bartsch et al., 1977; Rehbinder & Edqvist, 1981).

It should be noted that the various methods used for blood sampling (needle and vacutainer for groups I_1 and G, or knife-cut through the jugular vein for the remaining groups) may have influenced the results of the blood analysis. Such possible

Table 4. Overall means and standard deviations (S.D.) for blood oonstituents studies obtained after the various treatments.

Tabell 4. Totalmedeltal och standardavvikelse (S.D.) för de undersökta blodparametrarna för respektive grupp.

	Treatment																	
	A (n=10)		B (n=15)		C (n=15)		D (n=10)		E (n=9)		F (n=10)		H (n=6)		I*2 (n=7)		J (n=6)	
Trait	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Differential count, %																		
Immature neutrophils	4.6 a,b	1.7	6.9 a	2.1	6.8 a	2.4	7.2 a	2.0	15.2 c	5.6	13.0 c	4.3	1.7 b	1.2	1.9 b	1.7	3.5 b	1.6
Segmented neutrophils	22.6 a	6.6	39.1 b	13.5	44.1 b	11.9	46.5 b,c	4.7	55.8 c,d	5.4	61.5 d	4.2	38.2 b	17.0	48.7 b,c	14.0	55.5 c,d	8.9
Eopsinophils	21.6 a	7.6	14.1 b,c	8.8	9.8 c,d	9.9	18.9 a,b	6.7	6.1 d,e	6.0	1.1 e	0.9	19.2 a,b	7.6	15.7 a,b c	12.7	12.0 b,c d	6.4
Basophils	1.8 a	0.8	3.9 a,b	2.0	3.5 a,b	2.6	5.3 b,c d	2.9	3.7 a,b	2.1	1.6 a	0.5	7.8 d	5.4	6.6 c,d	4.4	4.3 a,b c	1.5
Monocytes	2.0 a,b	0.7	2.1 a,b	1.0	12.5 a	2.4	1.4 a,b c	0.5	2.6 a	1.2	2.4 a	1.3	1.3 a,b c	0.8	0.4 c	0.5	0.8 b,c	0.8
Lymphocytes	49.7 a	9.4	34.7 b	15.4	35.7 b	12.2	21.5 c,d	7.0	17.8 d	5.0	21.7 c,d	7.2	33.2 b,c	15.5	26.0 b,c d	7.2	25.2 b,c d	6.7
Corticosteroids, nmol/l	3.5a	1.6	66.1 b	27.7	59.1 b	26.9	70.5 b,c	24.5	95.3 c,d	35.5	102.3d	28.7	31.0 a	28.5	79.0 b,c d	15.5	102.8 d	49.0
Urea, mmol/l	7.1 a	1.9	3.2 b	0.9	9.7 c	3.3	2.3 b	0.8	5.6 a	2.3	17.0 d	5.9	1.4 b	1.1	2.9 b	1.2	15.2 d	4.0
ASAT, µkat/l	1.3 a	0.3	1.8 a	2.4	3.4 a,b	6.6	1.1 a	0.2	2.7 a,b	2.5	5.3 b	3.1	1.2 a	0.2	1.4 a	0.4	1.6 a	0.4

Means with the same letter are not significantly different (Duncan test; P> 0.05).
*Blood sampled at stunning.

Medelvärden med samma bokstav är inte significant olika.
**Blod prov taget vid bedövning.*

Table 5. Least-squares means ± standard errors (S.E.) for the animals sampled before and after stunning (Group h and I2) and level of significance for the effect of handling in connection with stunning.

Tabell 2. Minsta-kvadrat medeltal ± standardfel (S.E.) för blodprover tagna före och efter bedövning och signifikansnivån för effekten av slakthantering.

Trait *Faktor*	Before stunning *Innan bedövning* Least-squares mean ± S.E.	After stunning *Efter bedövning* Least squares mean ± S.E.	Level of significance
Differential counts, %			
Immature neutrophils	0.3±0.4	1.9±0.4	*
Segmented neutrophils	25.7±3.7	48.7±3.7	**
Eosinophils	17.3±3.2	15.7±3.2	n.s.
Basophils	3.9±1.2	6.6±1.2	n.s.
Monocytes	1.3±0.2	0.4±0.2	*
Lymphocytes	55.4±5.1	26.0±5.1	**
Corticosteroids, nmol/l	58.1±2.3	79.0±2.3	***
Urea, nmol/	2.9±0.1	2.9±0.1	n.s.
ASAT, µkat/l	1.3±0.0	1.4±0.0	n.s.

Levels of significance: n.s. (not significant) = P>0.05; * = P≤ 0.05; ** = P≤ 0.01; *** = P≤ 0.001.

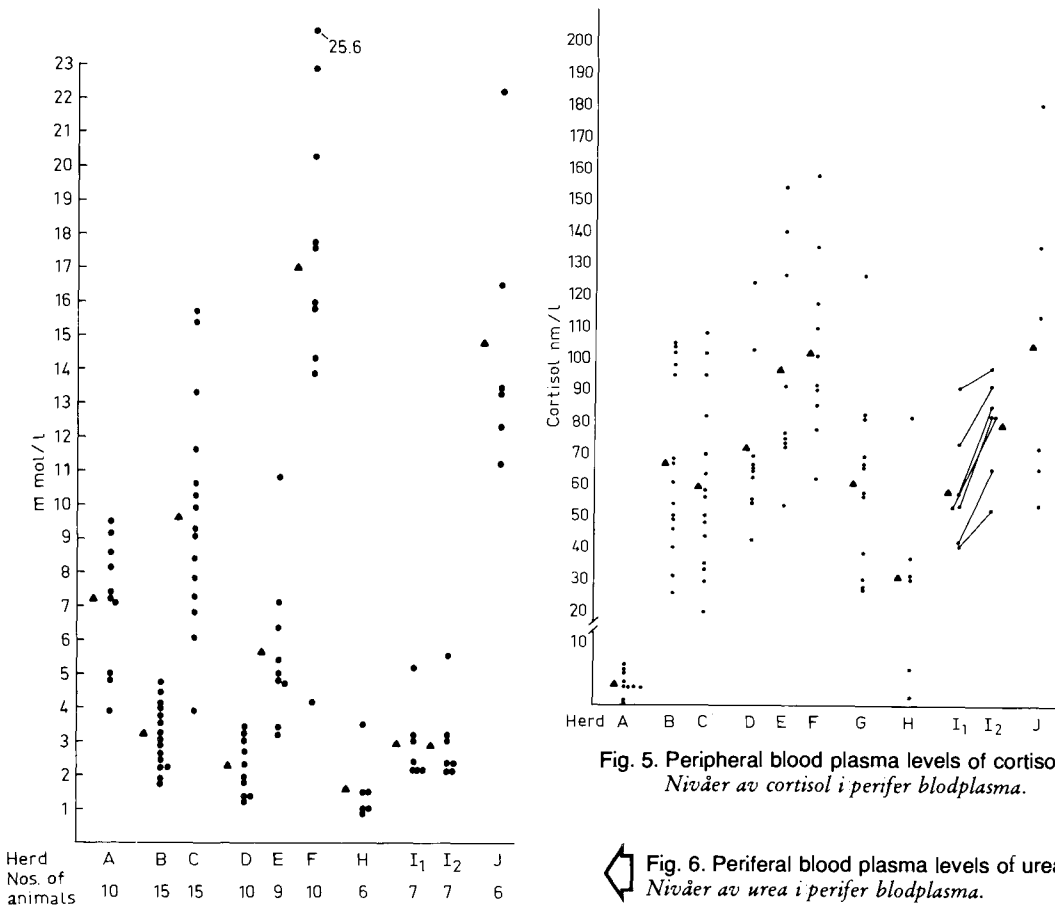

Fig. 5. Peripheral blood plasma levels of cortisol.
Nivåer av cortisol i perifer blodplasma.

Fig. 6. Periferal blood plasma levels of urea.
Nivåer av urea i perifer blodplasma.

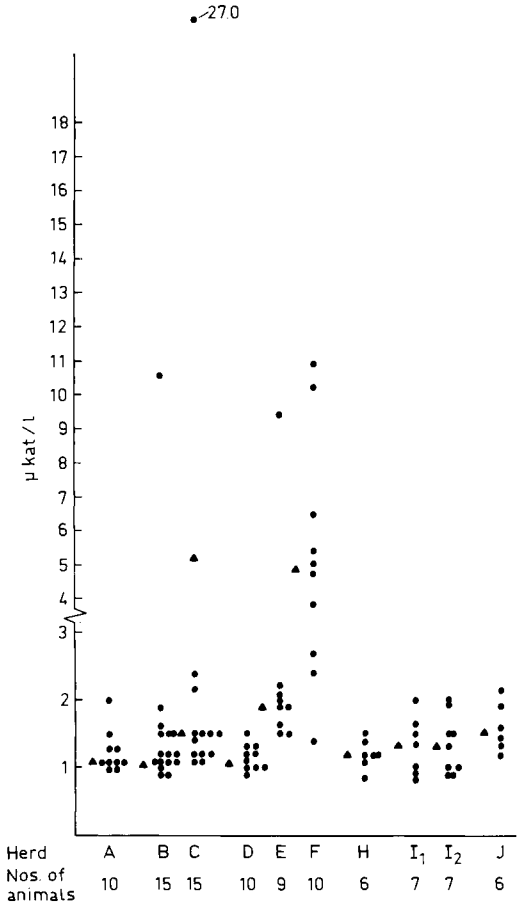

Fig. 7. Periferal blood plasma levels of ASAT.
Nivåer av ASAT i perifer blodplasma.

changes have not been taken into consideration and it is worth pointing out that the blood samples from Group A (the unstressed controls) were taken after a knife-cut in the jugular vein.

Abomasal haemorrhages are also characteristic of stress in many different species (Brodie et al., 1963, Iversen et al., 1972; Johansson et al., 1973; Kirst & Freimark, 1973) and gastric ulcers due to acute and prolonged stress have been observed in cervidae (Annon., 1980; Presidente, 1978).

When analysing pathological changes and alterations in haematological values in relation to treatment (stress), sex, and age class, it is obvious that stress significantly influences most parameters studied (Table 2). Consequently the degree of stress applied is more or less directly reflected in pathological lesions and in changes in blood constituents.

Thus the distribution of abomasal and muscular lesions and changes in the blood constituents must be considered to reflect a general response correlated to the stress which the animals have been exposed to. Muscle samples, however, were taken blind and the severity and extent of these lesions is therefore uncertain.

The differences in some blood constituents in different age classes, e.g. higher urea values and the lower eosinophil count, indicate that calves may be rather more sensitive to stress. The higher urea levels in younger animals could be due, amongst other things to the comparatively more vigorous physical exertion of these animals (Rehbinder & Edqvist, 1981). The lower lymphocyte and higher eosinophil counts in the older animals, however, might be attributable to a more pronounced parasitic infestation in these animals (*Elaphostrongylus rangiferi, Setaria tundra* and *Onchocerca tarsicola*). Parasites are regular findings in forest herds (Rehbinder et al., 1979).

The herding stress applied to herds B, C and I was comparatively mild and the handling stress was low. Herd H had also been subjected to a very low degree of herding stress. The handling stress applied was also short. In these herds were also found the lowest incidences of pathological lesions and also less pronounced haematological changes.

Herd G, from which only cortisol values were obtained, was exposed to a moderate herding and handling stress. The cortisol values are comparable to those of herds B, C and I, indicating herd similarities under stress exposure. If there is any difference in the adrenocortical function between seasons as stated by Yousef et al (1971), this is probably masked by the stress-induced changes.

When a prolonged handling is applied as in the case of the 7 animals of herd I, this is reflected in a significant increase in immature neutrophils and segmented neutrophils and a decrease in monocytes and lymphocytes, accompanied also by a marked increase in cortisol levels (Table 5; Figs. 4-5). These changes were apparently attributable to the short period of restraint stress. Prolonged and repeated handling - but moderate herding stress - was applied to herd J and was reflected in a marked increase in pathological lesions and alterations in the blood constituents studied. Thus prolonged and repeated manual handling as such appears to be the most important factor producing

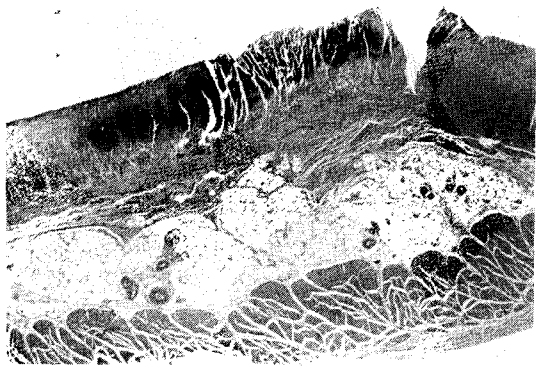

Plate 7. Local Mucosal haemorrhage in abomasal fold. Note submucosal oedema. HE, x20.

Plåt 7. Mikroskopisk bild av blödning i slemhinneveck från löpmage med ödem under slemhinnan.

stress lesions. Consequently, in reindeer mental stress, sheer fear, as earlier stated by Rehbinder & Edqvist (1981), and as reported in pigs (Johansson et al., 1982) seen in restrained (Ader, 1971; Franzman et al., 1975) or trapped animals (Iversen et al., 1972; Jacobsson et al., 1978) appears to be a most significant factor in the development of stress-induced lesions.

The use of helicopter or snow-scooters when herding animals (herds D, E and F) can cause severe mental stress when the animals try to escape from these vehicles. Overstraining when trying to escape is bound to contribute to the pathological lesions found. It was previously reported that low-flying aircraft provoke a strong escape or panic response (Calef et al., 1976; Miller & Gunn, 1979). When this effect is used to herd the animals, the response may be severe mental and exertional stress, especially when the animals are hindered in their escape attempts by snow and when deep snow also prevents an early escape.

«Capture myopathies» in wild ungulates usually develop within 4 hours (Harthoorn 1977; Bartsch et al., 1977). These findings correspond closely to those in the present investigation, although microscopical muscular lesions and macroscopical abomasal lesions were found to appear even earlier. It is said, however, that capture stress and capture myopathy may be inflicted in a matter of a few minutes (Harthoorn, 1977).

Fowler (1977) stated that non-specific responses involving the hypothalamic-pituitary-adrenocortical axis are cumulative. Thus repeated stress, viz. handling and/or herding, may result in more pronounced and advanced stress-induced lesions. The increase in abomasal and muscular lesions and the marked changes in the blood constituents seen in the herds subjected to prolonged or repeated handling or herding are strongly indicative of such a cumulative response in the semidomestic reindeer.

Whether the muscular degeneration observed can be related to an increased catabolism exerted by cortisol remain to be elucidated.

Apparently, repeated and prolonged stress may result in elevated urea and ASAT values, the latter probably due to a progressive muscular degeneration. Väyrynen (1974) and Hyvärinen et al. (1976) found elevated urea values in connection with reindeer gatherings. Furthermore the values were correlated to the distance of the drive and time spent in the corral. These findings are consistent with the values found here for herds B, C and D, E, F and for herd J. The comparatively high urea values in the unstressed control animals (herd A), sampled in August were probably related to a higher protein intake (Hyvärinen et al., 1975; Bjarghov et al., 1976).

No kidney lesions such as described by Harthoorn (1977) and Bartsch et al. (1977) were recorded. However, the animals in the present investigation were killed within 24 hours after herding and/or handling stress and chronic lesions are not likely to appear after such a short time.

It is obvious from the present investigation that manual handling elicits a stress response in reindeer. In this respect the method of selection and consequently the construction of the corral

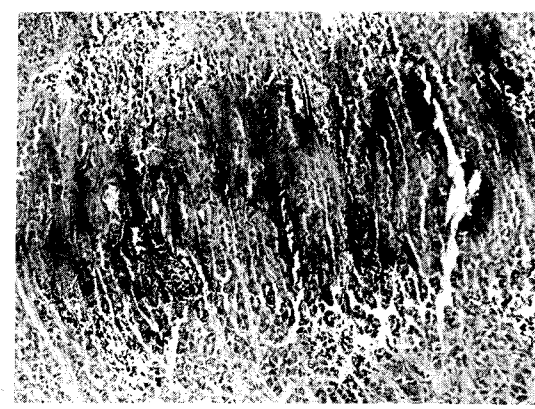

Plate 8. Minor mucosal haemorrhage located in middle part of mucosa. HE, x320.

Plåt 8. Mindre blödning i löpmagsslemhinna.

Table 1. Animals and conditions during which different samples were taken.
Tabell 1. Djurmaterial och förhållanden under vilka olika prover tagits.

Herd *Hjord*	A	B	C	D	E	F	G	H	I	J
Date *Datum*	21,8	23,1	24.1	31.1	1.2	2.2	2.7	19.9	19.9	20.9
Herding distance, km *Drivning, km*	-	2,5	<1	3-4	3-4	3-4	10	2-3	6-7	1
Duration of herding, min *Varaktighet för drivning, min*	-	40	40	315	130	(2)	360	-	240	120
Herd size *Hjordstorlek*	(1)	1800*	1700*	1200*	1800*	169	400*	(1)	300*	800*
Grazing corral *Beteshage*	-	+	+	-	-	+	-	-	-	-
Snow cover, cm *Snödjup, cm*	-	60	60	>60	>60	-	-	-	-	-
Ambient temperature, °C *Genomsn. temperatur*	+12	-36	-38	-18	-26	-27	+25	+16	+6	+8
Herded *Driving* Walking or skiing *Till fots eller skidor*	-	+	+	-	-	-	+	+	+	+
Snow-scooter *Snö-scooter*	-	+	+	+	+	+	-	-	-	-
Helicopter	-	-	-	+	+	+	-	-	-	-
Recultance to driving *Motstånd mot drivning*	-	0	+	+++	+++	+++	0	-	0	0
Resting time in corral before handling, min *Vilotid i gärdet före hantering*	-	40	35	60	50	50	90	-	-	30
Aninals appearance in corral *Djurens beteende i gärdet*	undisturbed *inte oroade*	calm *lugna*	calm *lugna*	panic *panik*	panic *panik*	panic *panik*	calm *lugna*	calm *lugna*	calm *lugna*	calm *lugna*

Tameness of animals *Renens tamhetsgrad*	**	**	**	*	*	*	**	***	***	***
Lorry transport *Biltransport*	-	-	-	-	90 min	90 min	-	-	-	-
Duration of slaughter or handling, hours (3) *Varaktighet av slakt eller hantering, timmar*	-	6	3	4	13	28	3	-	4	10
Disturbance by spectators etc. *Störning av åskådare eller annat*	-	-	-	+++	+	-	+	-	++	+++
Extent of manual handling *Varaktighet av fasttagning och hantering*	-	5 min	5 min	30 min	30 min	30 min	5 min	-	5 min	10-20 min
No. of macroscopically inspected animals *Antalet undersökta djur*	10	77	27	61	87	75	-	12	27	51
No. of animals from which samples were obtained *Antalet provtagna djur*	10	15	15	10	10	10	10	6	7	6

*) Estimated number of animals
Uppskattat antal djur

(1) Scattered animals
Spridda djur

(2) Same herd as E; resting in a small corral during night hours
Samma hjord som E; vilande över natten i en liten gärda

(3) The time during which samples were obtained

* Escape distance > 100 m
Flyktavstånd > 100 m
** Escape distance 30 - 50 m
*** Escape distance 30 m

Plate 10. Slaughtered reindeer, after transport, with several subcutaneous haemorrhages.

Plåt 10. Slaktdjur efter transport med ett flertal underhudsblödningar.

system is of importance. When the various corral systems used in the investigated herds are compared, that used for herds B and C (Romperheden Fig. 1) represents a construction which is the most likely to reduce the animals' exposure to handling stress. In fact the animals allowed back to the herd are rarely captured and in most cases not manually handled.

The use of a selection corral and pens in which manual handling is enforced should consequently be avoided.

Transportation is found to cause severe stress in domesticated animals (Dvořàk, 1975; Simensen et al., 1980) and most likely provokes an even more severe stress response in semidomesticated animals. In connection with the transportation of reindeer, traumatic lesions are commonly found (Andersen, 1978) and were also observed here in the transported animals of herds E and F. The trauma will also act as a stress factor, but as it is often the result of aggression by other animals in the crate it may also be considered a result of stress behaviour.

Repeated or prolonged handling must be regarded as unfavaourable for the semidomesticated reindeer, as is the case with wild ungulates (Harthoorn, 1977). The degree of tameness is consequently of importance. Harthoorn (1981) reported considerably reduced death rates, due to capture myopathies when wild ungulates were trained (i.e. partly tamed) to accept the presence of humans before the animals were crated and transported.

It is apparent from this study that stress is not alleviated in animals allowed to stand overnight in an ordinary or grazing corral. It is also obvious that stress can affect the health of all animals and not only the quality of the meat of those slaughtered.

A marked stress response with gastric lesions will affect the digestive tract and its utilization of fodder. A considerably lower weight gain among reindeer calves subjected to intensive herding, compared with wild reindeer calves, was reported by Reimers (1972). Handling stress was considered the major factor underlying the differences in growth. Similarly a negative significant correlation between cortisol levels and growth rate has been observed in cattle (Purchas et al., 1980). Moreover, stress has a detrimental effect on the immune system (Simensen et al., 1980) and animals suffering from stress may thus have an icreased susceptibility to infectious diseases.

In wild ungulates, death due to capture myopathy has been reported to occur as late as 30 days after capture. The possibility that some severely stressed reindeer may succumb later on, after release from the corral, cannot be excluded.

The high urea values and numerous muscle lesions found in animals subjected to prolonged or repeated stress events can be detrimental to the meat quality.

It is clear that herding and handling stress is an important factor to be considered in reindeer

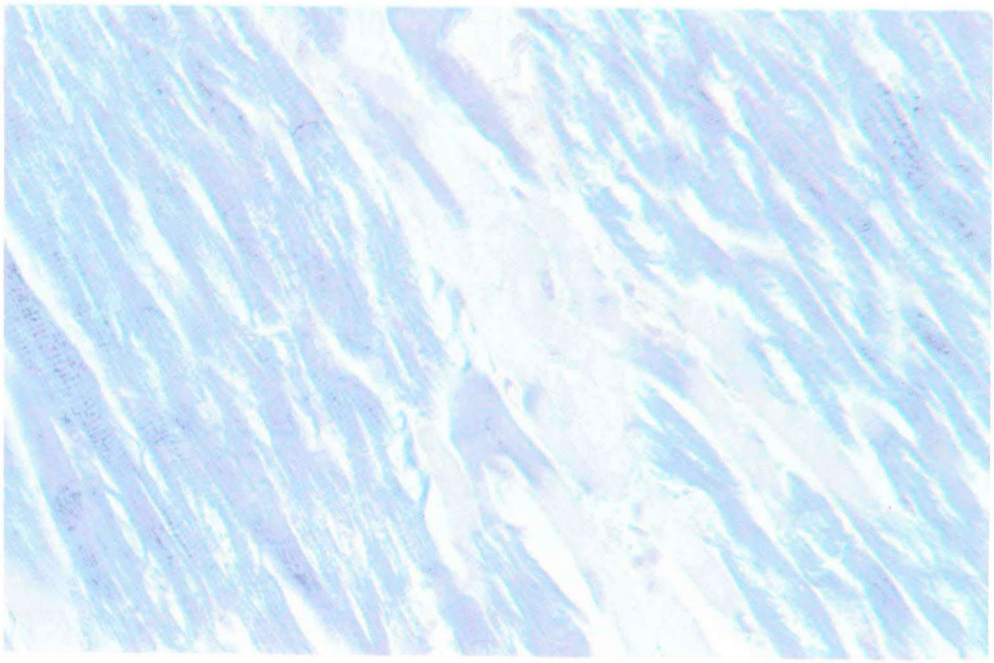

Plate 11. Myocardium. Note loss of striation, swelling, and hyalinization of affected muscle cells. PTAH, x440.

Plåt 11. Hjärtmuskel. Förlust av striering; svullna och hyaliniserade muskelceller.

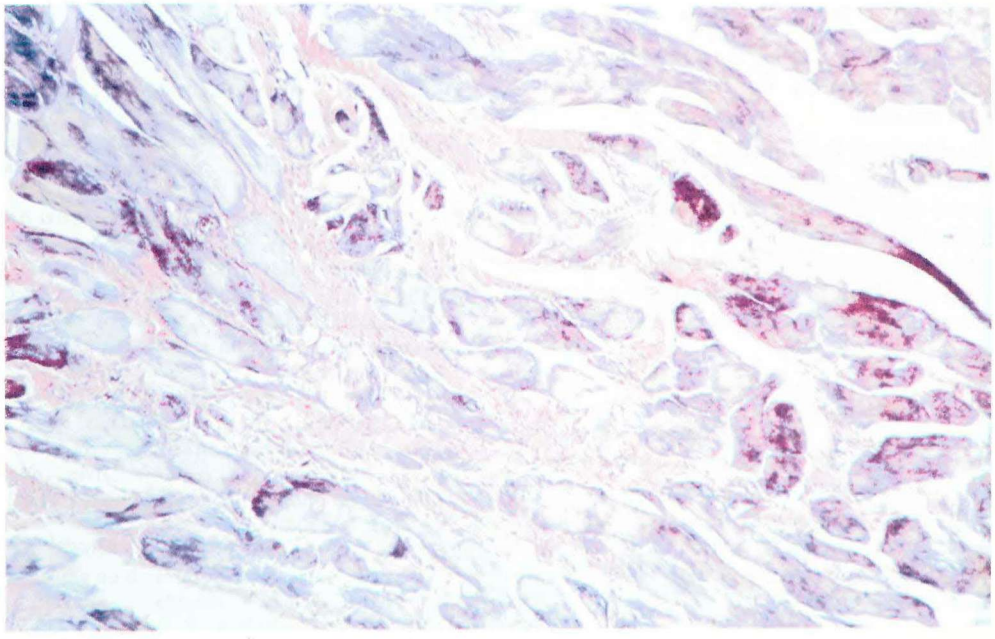

Plate 12. Skeletal muscle (semitendinosus). Note the almost complete destruction of the normal configuration, hyalinization, fragmentation, necrosis, and reaction by histiocytes. PTAH, x270.

Plåt 12. Skelettmuskel (semitendinosus) med nästan total destruktion av normal struktur, hyalinisering, fragmentering, nekros och reaktion av histiocyter.

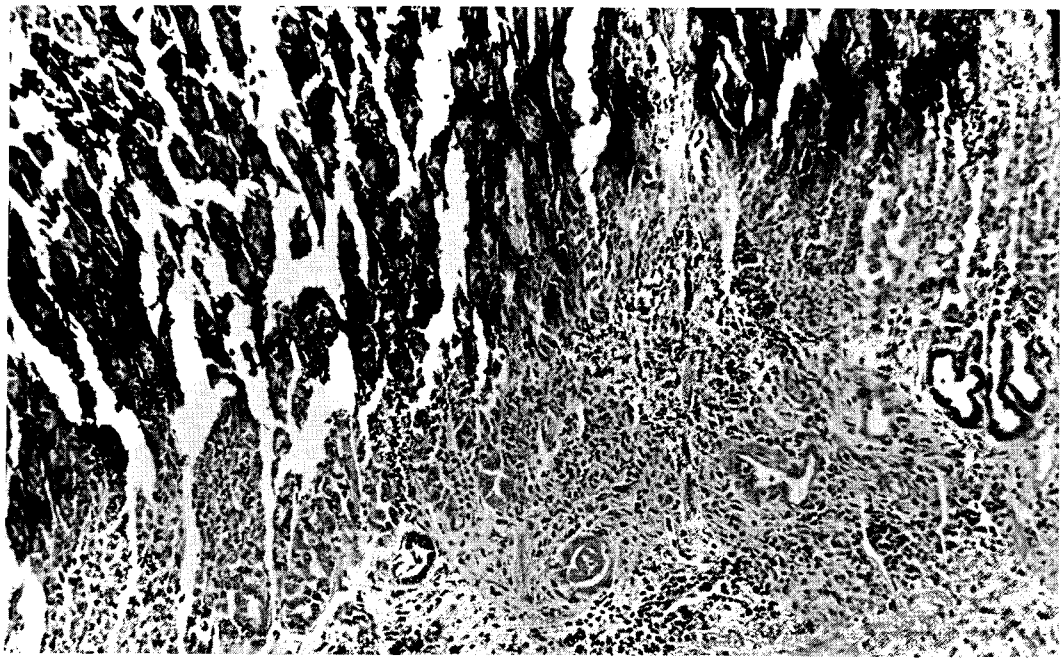

Plate 9. Mucosal haemorrhage of more extensive type and of longer duration. Note coagulative necrosis and infiltration of neutrophils. HR, x130.

Plåt 9. Kraftig blödning i löpmagsslemhinna med koagulativ död av epitelceller och infiltration av neutrofiler.

management. Thus herding must be undertaken as carefully as possible, especially when motor vehicles are used.

To obtain a good meat quality, animals should be selected almost directly from the herd and subjected to a minimum of manual handling, i.e. slaughter should take place with as little delay as possible. Transportation of live animals and the keeping of animals in corrals overnight or in pens or crates while waiting for slaughter should be avoided.

ACKNOWLEDGEMENT

The authors wish to thank A. Rydberg for valuable discussions. The highly skilled technical help of Verena Glatthard is gratefully acknowledged.

Offprints may be requested from: C. Rehbinder, Department of Pathology, Faculty of Veterinary Medicine, Swedish University of Agricultural Sciences, S-750 07 Uppsala, Sweden.

REFERENCES

ADER, R. 1971. Experimentally induced gastric lesions. - Adv. Psychosom. Med. 6: 1-39.

ANDERSSEN, G. 1978. Transportskader på rein vid ulike transportmidler. - Norsk Veterinaertidskrift, 90: 543-553.

ANNON. 1981. laboratory reports. Whangarei Animal Health Laboratory. Fallow fawn losses associated with weaning stress. - N.Z. Surveillance 7 (3): 6-7.

BARTSCH, R.C., McCONNELL, E.E., IMES, G.D. & SCHMIDT, J.M. 1977. A review of exertional rhabdomyolysis in wild and domestic animals and man. - Vet. Pathol. 14: 314-324.

BJARGHOV, R.S. FJELLHEIM, P., HOVE, K., JACOBSEN, E., SKJENNEBERG, S. & TRY, K. 1976. Nutritional effects on serum enzymes and other blood constituents in reindeer calves (*Rangifer tarandus tarandus*). - Comp. Biochem, Physiol, 55: 187-193.

BRODIE. D.A., HARLEY, M.H., SINES, J.O. & ADER, R. 1963. Current research on gastric ulcers. - J. Neuropsychiat. 4: 388-395.

CALEF, G.W., De BOCK, E.A. & LORTIE, G.M. 1976. The reaction of barren-ground caribou to aircraft. - Arctic 29. (4): 201-212.

DVORÀK M. 1975. Adrenocortical activity of young calves in relation to transport and traumatic stress. - Docum. vet. Brno 8: 119-126.

FOWLER, M.E. 1977. Restraint mortality in wild animals. - Curr. vet. therap./Small anim. pract. 4: 723-726.

FRANZMANN, A.W., FLYNN, A. & ARNESON, P.O. 1975. Serum corticoid levels relative to handling stress in Alaskan moose. - Can. J. Zool. 53: 1424-1426.

HARTHOORN, A.M. 1977. Problems related to capture. - Animal Regulation Studies. 1: 23-46.

HARTHOORN, A.M. 1981. Comparison of two methods of capture of wild animals. - Vet. Rec. 108: 37.

HYVÄRINEN, H., HELLE, T., VÄYRYNEN, R. & VÄYRYNEN, P. 1975. Seasonal and nutritional effects on serum proteins and urea concentration in the reindeer *(Rangifer tarandus tarandus L).* - Br. J. Nutr. 33: 63-72.

HYVÄRINEN, H., HELLE, T., NIEMINEN, M., VÄYRYNEN, P. & VÄYRYNEN, R. 1976. Some effects of handling reindeer during gatherings on the compostition of their blood. - Anim. Prod. 22: 105-114.

IVERSEN, J.O., HOFF, G.L., YUILL, T.M. & HANSON, R.P. 1972. Gastric lesions in the snowshoe hare. J. Wildl. Dis. 8: 7-9.

JACOBSSON, H.A., KIRKPATRICK, R.L., BURKHART, H.E. & DAVIS, J.W. 1978. Haematologic comparisons of shot and live trapped cottontail rabbits. - J. Wildl. Dis. 14: 82-88.

JOHANSSON, G., JÖNSSON, L., LANNEK, N. & LINDBERG, P. 1973. An experimental approach to the porcine stress syndrome. - Acta vet. scand. 14: 764-766.

JOHANSSON, G., OLSSON, K. HÄGGENDAL, J., JÖNSSON, L. & THORÉN-TOLLING, K. 1982. Effect of stress on myocardial cells and catecholamines in normal and amygdal ectomized pigs. - Canad. J. Comp. Med. 46: 176-182.

JÖNSSON, L. & JOHANSSON, G. 1974. Cardiac muscle cell damage induced by restraint stress. - Virchows Arch. B. Cell. Path. 17: 1-12.

KRISTT, D.A. & FREIMARK, S. J. 1973. Histopathology and pathogenesis of behaviourally induced gastric lesions in rats. - Am. J. Path. 73: 411-424.

LUNDSTRÖM, K., BOSU, W.T.K. & GAHNE, B. 1975. Peripheral plasma levels of corticosteroids in Swedish landrace and Yorkshire boars. - Swedish J. agric. Res. 5: 81-89.

MILLER, F.L. & GUNN, A. 1979. Responses of peary caribou and muskoxen to turbo-helicopter harassment, Prince of Wales Island, Northwest Territories, 1976-77. - Canadian Wildlife Service, Occasional Paper 40 pp 90. cat. No C.W 69-1/40.

PRESIDENTE, P.J.A. 1978. Diseases and parasites of captive rusa and fallow deer in Victoria - Australian Deer. 3: 23-38.

PURCHAS, R.W., BARTON, R.A. & KIRTON A.H. 1980. Relationships of circulating cortisol levels with growth rate and meat tenderness of cattle and sheep. - Aust. J. Agric. Res. 31: 221-232.

REHBINDER, C. CHRISTENSSON, D. & FORSSEL, J. 1979. Investigations on parasitic visceral granulomas in reindeer. - Nord. Vet. Med. 31: 282-283.

REHBINDER, C. & EDQVIST, L-E. 1981. Influence of stress on some blood constituents in reindeer (*Rangifer tarandus* L). - Acta. vet. scand. 22, 480-492.

REIMERS, E. 1972. Growth in domestic and wild reindeer in Norway. - J. Wildl. Mgmt. 36: 612-619.

SAS. User's Guide. Eds. Helwig J.T. & Concil K.A. SAS Institute Inc. 1979. Raleigh N.

SIMENSEN, E., LAKSESVELA, B., BLOM, A.K. & SJAASTAD, Ø. V. 1980. Effects of transportations, a high lactose diet and ACTH injections on the white blood cell count, serum cortisol and immunoglobulin G in young calves. - Acta vet. scand. 21: 278-290.

VÄYRYNEN, P. 1974. The effects of gatherings on blood glucose and actatic acid concentration. - MSc. Thesis Dept. Zoology, University of Oulu, pp 37.

WILKINSON, J.S. 1980. Pituitary and adrenal function. - In Clinical Biochemistry of Domestic Animals. Ed. Kanneko. J.J. Academic Press. New York p.p. 448-484.

YOUSEF, M.K., CAMERON, R.D. & LUICK, J.R. 1971. Seasonal changes in hydrocortisone secretion of reindeer, *Rangifer tarandus.* - Comp. Biochem. Physiol. 40 (A): 495-501.

Accepted 5.10.1982