BLOOD COMPOSITION OF THE REINDEER. I. HAEMATOLOGY

Renblod. I. Hematologi

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Abstract: The semi-domestic reindeer is a ruminant which exhibits a highly advanced adaptation to the marked seasonality of the northern environment. Since the reindeer has an economic importance and previous information about its blood composition is scanty in respect to age, season, calving and nutrition, the haematology of 578 reindeer were studied. The blood samples were taken from the jugular vein mainly in connection with the marking of calves during summer and at reindeer round-ups in autumn and winter at 10 reindeer rearing subunits in Northern Finland in various seasons in 1973-79.

The red blood cell count ($8x10^{12}$/l), haemoglobin (108 g/l), packed cell volume (35%), white blood cell count ($6x10^{9}$/l) and serum iron (26 μmol/l) were low in newborn calves and reached their adult levels in autumn at the age of 5 months (average 11 x 10^{12}/l, 182 g/l, 51%, $9x10^{9}$/l, 44 μmol/l, respectively). The total serum bilirubin was relatively stable and vitamin B_{12} high in the first days after birth. The stable serum bilirubin indicates a relatively small breakdown of foetal erythrocytes.

E-MCV of adult females was about 49 fl and the diameter of round erythrocytes about 5.5 μm and their thickness about 1.5 μm. No sickling was observed. The red cell osmotic fragility had a initial and final haemolysis points of 0.71 and 0.37% NaCl solution. The relative proportions of neutrophil, eosinophil and basophil granulocytes and agranular lymphocytes and monocytes were 52, 5, 2, 42 and 2 %, respectively.

The calving of the reindeer occurs without visible haemorrhage. The body weight, red blood cell count, haemoglobin, packed cell volume and serum iron of pregnant hinds dropped, however, during the early lactation period, and a relative anaemia developed is partly due to iron deficiency and, perhaps, also breakdown of foetal erythrocytes.

The means of body weight (range 50-70 kg), red blood cell count (8-11 x 10^{12}/l), haemoglobin (118-185 g/l), packed cell volume (42-51 %), white blood cell count (6-10 x 10^{9}/l), erythrocyte sedimentation rate (3-21 mm/hour) and serum iron (23-54 μmol/l) of free-grazing adult hind were highest in summer and autumn and decreased during winter. The lowest means were measured for the starved hinds in early spring. High body weight and blood haematological values were measured for the hinds fed on silage and molasses in winter.

Key words: Blood cells, neonatal period, serum bilirubin, iron, vitamin B_{12}

***RANGIFER** 1(1): 10—26*

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Yhteenveto: Puolivilli poro on märehtijä, joka on hyvin sopeutunut pohjoisen ympäristön suuriin vuodenaikaismuutoksiin. Koska poro on tärkeä hyötyeläin, jonka veren koostumuksesta tiedetään iän, vuodenajan, vasonnan ja ravitsemüstilan suhteen varsin vähän, tutkittiin työssä 578 poron hematologiaa. Verinäytteet otettiin poron kaulalaskimosta 10 eri paliskunnassa vasamerkinnän yhteydessä kesällä ja syys- ja talvierotuksissa vuosina 1973-79.

Vastasyntyneen vasan veren punasolumäärä (8 x 10^{12}/l) hemoglobiinipitoisuus (108 g/l) punasolujen tilavuus osuus (35%), valkosolumäärä ($6x10^{9}$/l) ja seerumin rautapitoisuus (26 μmol/l) olivat alhaiset ja saavuttivat aikuiset tasonsa syksyllä 5 kk:n iässä (keskimäärin 11 x 10^{12}/l, 182 g/l, 51 %, $9x10^{9}$/l, 44 μmol/l). Seerumin kokonaisbilirubiinipitoisuus pysyi suhteellisen vakiona ja B_{12}-vitamiini korkeana syntymän jälkeen. Bilirubiinipitoisuus osoittaa suhteellisen vähäistä sikiökauden punasolujen hajoamista.

Aikuisen vaatimen punasolun keskitilavuus (E-MVC) oli 49 fl ja pyöreän punasolun läpimitta 5.5 μm ja paksuus 1.5 μm. Sirppisoluja ei havaittu. Punansolujen alkava hemolyysi vastasi 0.71% NaCl-liuosta ja täydellinen hemolyysi 0.37% NaCl-liuosta. Neutrofiilisten, eosiniofiilisten sekä lymfosyyttien ja monosyyttien suhteelliset osuudet olivat 52, 5, 2, 42 ja 2 %. Vaikka vasonta tapahtuu ilman näkyvää verenvuotoa, kantavien vaadinten ruumiinpaino, punasolumäärä, hemoglobiinipitoisuus, punasolujen tilavuusosuus ja seerumin rautapitoisuus laskivat imetyksen alkuvaiheessa ja syntynyt anemia johtui mahdollisesti raudan puutoksesta tai raskauden ajan punasolujen häviämisestä.
Vapaana laiduntavan vaatimen ruumiinpaino (vaihtelu 50-70 kg), punasolumäärä (8-11 x 10^{12}/l), hemoglobiinipitoisuus (118-185 g/l), punasolujen tilavuusosuus (42-51%), valkosolumäärä (6-10 x 10^{9}/l), lasko (3-21 mm/t) ja seerumin rautapitoisuus (23-54 μmol/l) olivat korkeimmillaan kesällä ja syksyllä ja laskivat talvella. Alhaisimmat pitoisuudet mitattiin nälkiintyneille vaatimille varhaiskeväällä. Korkeat veriarvot ja ruumiinpainot mitattiin vaatimille, joita oli ruokittu talvella säilörehulla ja melassilla.

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Sammandrag: Renen, ett halvtamt boskapsdjur, är en idisslare med hög anpassningsförmåga till de stora omväxlingarna av de olika årstiderna som är karakteristiska för de nordliga regionerna. Eftersom renen är ekonomiskt betydelsesfull och man tidigare i ganska liten utsträckning undersökt dess blodsammansättning, undersöktes 578 renar hematologiskt. Blodproven togs från vena jugularis i samband med öronmärkning av kalvarna på sommaren och i samband med skiljning av 10 renbeteslag på hösten och vintern i norra Finland under olika säsonger 1973–79.

Hos nyfödda kalvar var följande värden låga: mängden av röda blodkroppar ($8x10^{12}/l$), hemoglobin (108 g/l), hematokrit (35%), vita blodkroppar ($6x10^9/l$), serumjärnhalt (26 μmol/l). Dessa värden nådde nivån av ett vuxet djur på hösten i en ålder av 5 månader (respektive medeltal $11x10^{12}/l$, 182 g/l, 51%, $9x10^9/l$, 44 μmol/l). Totalvärdet för serum bilirubin visade sig vara relativt stabilt och B_{12} vitaminhalten var hög under de första dagarna efter födseln. Det stabila serum bilirubinvärdet tyder på en relativt liten splittring av fetala erytrocyter.

E-MCV hos vuxna renkor var ca. 49 fl, de runda erytrocyternas diameter ca. 5,5 μm och deras tjocklek ca. 1,5 μm. Några «sickligs» (skärvaktiga celler) kunde inte konstateras. De röda blodkropparnas osmotiska splittring startade i en NaCl-lösning av 0,71% och var total vid 0,37%. De relativa proportionerna av neutrofil-, eosinofil- och basofilgranulocyter samt av agranulära lymfocyter var respektive 52, 5, 2, 42 och 2%.

Renarnas kalvning sker utan synbar blödning. Hos gravida renkor sjänk mängden av röda blodkroppar såsom hemomglobin och hematokrit. Den under den första tiden av kalvarnas amning förekommande relativa anemin beror emellertid på järnbrist och eventuellt också på splittring av de fetala erotrocyterna.

Hos fritt betande vuxna renkor var följande värden som högst under sommaren och hösten och sjönk under vintern: medelkroppsvikt (50-70 kg), mängden av röda blodkroppar ($8-11x10^{12}/l$), hemoglobin (118-185 g/l), hematrokrit (42-51%), vita blodkroppar ($6-10x10^9/l$), erytrocytsänkan och serumjärnhalt (25-54 μmol/l). De lägsta medelvärden mättes tidigt på våren hos fastande renkor. Kroppsvikten och blodets hematologiska värden var höga hos sådana renkor, vilka om vintern matats med ensilage eller melasse.

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INTRODUCTION

In Finland, the semi-domestic reindeer, although an object of economic activity, still grazes almost like its wild ancestors, roaming freely in the forests or subarctic mountain areas beyond latitude 65°N and showing a high degree of adaptation to these conditions. During the short summer the reindeer eats mainly green vegetation, while during the long winter the main part of the food intake is usually afforded by lichens (*Cladonia* spp.) containing mainly carbohydrates (see Isotalo 1971; Nieminen 1980a). The reindeer is the only ruminant that feeds extensively on lichens during winter. In the southern parts of the reindeer rearing area in Finland, the reindeer can also eat arboreal lichens (*Alectoria* and *Bryoria* spp.) and frozen hay (*Deschampsia flexuosa*).

Although many studies now exist on the type and composition of food consumed by reindeer throughout the year, the seasonal changes in the nutritional state have not been investigated. The most critical period for the semi-domestic reindeer in Finland is usually late winter and early spring, and in recent years large numbers of reindeer have died of starvation, because of particularly adverse conditions (see Hyvärinen et al. 1977; Nieminen 1980b).

During the last century, the investigation of wild animals or of their relation to the environment has greatly expanded and descriptive natural history, although interesting, has been replaced by quantitative physiological information. It may be possible, by studies of appropriate blood parameters to gain insight into seasonally changing metabolic patterns, into the condition of the animals, and even into condition of their habitat. The objective of the present work is to provide information about changes in blood composition of the reindeer with special reference to age, growth, season, calving and nutrition. This paper concerns haematological values of the reindeer.

MATERIALS AND METHODS

Animals and diets

Altogether 578 semi-domestic reindeer (*Rangifer tarandus tarandus* L.) studied were divided into 47 groups according to age and season as presented in Table 1 which also describes the living conditions and food sources. The animals in the study are mainly the same as described in our earlier work (Timisjärvi et al. 1976; Nieminen 1980a,b; Timisjärvi et al. 1981). The samples were taken throughout the year at 10 reindeer

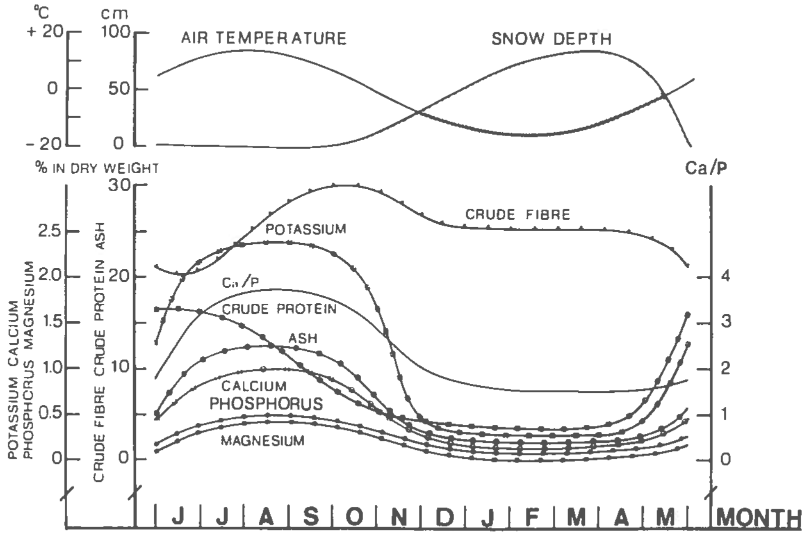

Fig. 1. Qualitative annual variation of the food of the reindeer (approximated diagram), and the monthly day lenght, mean air temperature and snow depth in Sodankylä (68°05'N, 27°11'E, altitude 246 m) in 1961-75 (Nieminen 1980a).

Variasjon i reinforets kvalitet gjennom året (tilnærmet diagram), dagens lengde månedlig, middel lufttemperatur samt snødybde i Sodankylä (68°05'N, 27°11'Ø, høyde o.h. 246 m i 1961-75 (Nieminen 1980a).

rearing subunits (paliskunta) as presented in Fig. 1. The chemical composition of the important plants is reported previously (Nieminen et al. 1980) and the living conditions and qualitative annual variation of the food of the reindeer are given in Fig. 2.

The reindeer were captured one at a time, using the so called «vimpa» (twisted loop at the end of an about 2 to 3 metres-long birch stick), foot-noose and also by lassoo in connection with the marking of calves during summer and at reindeer round-ups in autumn and winter. No immobilizing or sedative drugs were used in the handling of the animals. The effect of handling were studied, and only the specimens taken from the animals corralled for less than 6 hours are included (see Hyvärinen et al. 1976; Nieminen 1980a).

Blood samples

The blood samples were taken from the jugular vein with new plastic syringes containing EDTA (disodiummethylenediaminetetra-acetate) and heparin as anticoagulants or into centrifuge tubes within 5 minutes. After cooling the samples to +4°C the serum from coagulated blood was separated by centrifugation within 4 hr. The serum samples were kept at -20°C until analysed.

Analytical methods

Blood haemoglobin (Hb) was measured by the acid hematin (Cohen & Smith 1919) and cyanmethaemoglobin methods. Packed cell volume (PCV) was determined in a Clay-Adams autocrit TM centrifuge. Red and white blood cells (RBC and WBC) were calculated in a Neubauer counting chamber (new model, depth 0.100 mm and area 0.0025 mm²). Smears for the differential leucocyte count were made immediately after taking the sample. Blood smears were stained with May-Grünwald-Giemsa stain. Erythrocyte sedimentation rate (ESR) was determined using the method, in which 2 ml blood was added to 0,5 ml 3.8% sodium citrate solution, mixed and sedimentation read after 1 hour. Red cell osmotic fragility was estimated according to Dacie (1963). The serum iron and total iron binding capacity (TIBC) were measured by ferrozine method (Stookey 1970), the serum bilirubin by alkaline diazoreaction (Ichida & Nobuoka 1968) and the vitamin B_{12} by Phadebas B_{12} test (Pharmacia).

Statistical analysis

The significances of the differences between the group mean values were calculated by standard t-test.

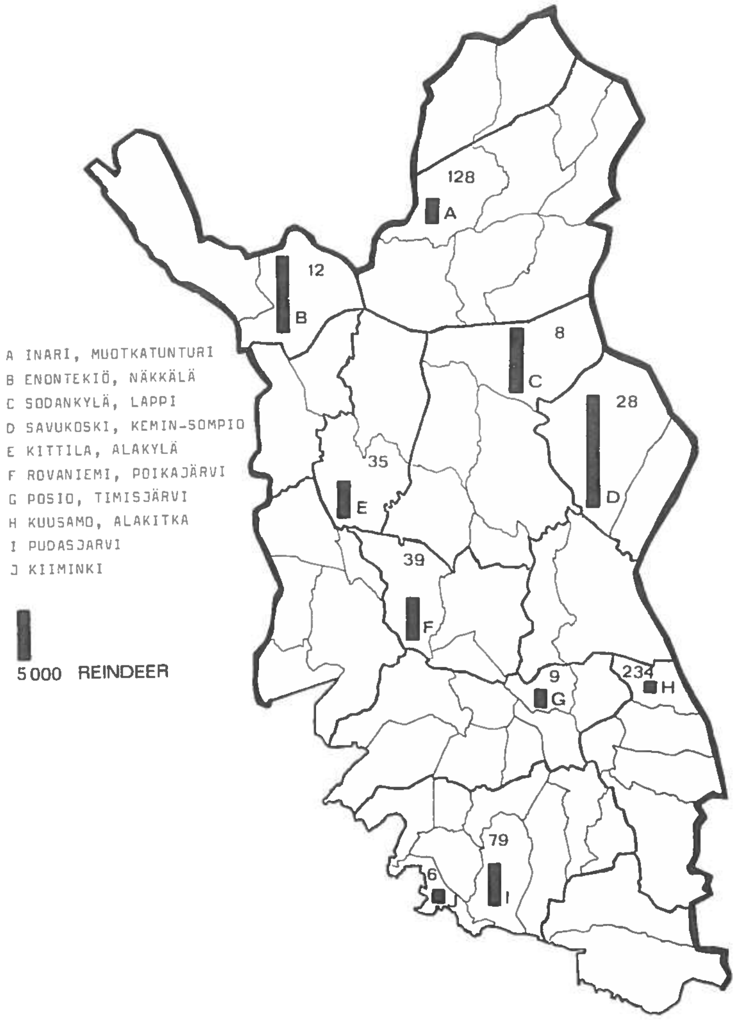

Fig. 2. The reindeer rearing area of Finland showing also the reindeer rearing subunits (*paliskunta*). The columns represent the numbers of reindeer of the subunits involved and the arabic numbers of the reindeer studied.

Området for reindrift i Finland med reindriftslag (paliskunta). Søylene viser antall rein som er med i undersøkelsen.

RESULTS

The morphology of the blood cells

The mean corpuscular volume (E-MCV) of adult females ranged from 44.8 to 51.7 fl (μm^3), averaging about 48.5 fl (see Table 2). From photographs of red blood cells, the diameter of round erythrocytes ranged from 5.3 to 5.8 μm and the thickness from 1.3 to 1.6 μm. No sickling was observed in the present study.

When the blood smears were stained with May-Grünwald-Giemsa stain typical neutrophil, eosinophil and basophil granulocytes and agranular lymphocytes and monocytes were distinguished (see Fig. 3) and their size ranged from 11 to 13, 12 to 15, 10 to 12, 9 to 13, 5 to 8 μm, respectively (see Nieminen 1980a).

The red cell osmotic fragility had initial and final haemolysis points of 0.71 (0.70 to 0.72) and 0.37 (0.30 to 0.45)% NaCl solution, respectively (see Timisjärvi et al. 1976).

Haematological values

The red blood cell count (RBC) varied between 7.9 and 11.8 x 10^{12}/l with the lowest level in the newborn reindeer calf and the highest in the 5-month-old calves and fully grown females in the autumn (see Table 2). The trombocyte and reticulocyte counts (stained with May-Grünwald-Giemsa) of adult hinds (n=9, group 27) gave mean values of 208 x 10^9/l (range from 96 to 340) and 0.1%, respectively. The trombocyte count of 5-month-old calves (n=9, group 28) was 288 x 10^9/l (range from 230 to 380) and the reticulocyte count 0.3%. The RBC coincided with changes in Hb (r=0.84).

The haemoglobin (Hb) concentration of the newborn reindeer calf was relatively low (108 g/l) and showed a slight but insignificant decrease during the subsequent two days (see Table 2). In the second week of life, the Hb concentration began a highly significant increase reaching its maximum (average 182 g/l) and adult level at about an age of 5 months.

The packed cell volume (PCV) of the newborn calf was relativly low (35.4 %) and showed only insignificant variations during the first week of life (Table 2). It began to rise significantly during summer and reached its maximum (average 52%) and adult level during autumn. The PCV rose coincidently with Hb (r=0.93) and with RBC (r=0.77).

The mean corpuscular volume (E-MCV), mean corpuscular haemoglobin (E-MCH) and mean corpuscular haemoglobin concentration (E-MCHC) values reflected the changes in Hb, PCV and RBC. E-MCV increased significantly ($P<0.01$) during the first 20 days of life and then decreased slightly (see Table 2). E-MCH showed realtively little variation in the first weeks, but it increased significantly towards the autumn ($P<0.001$). E-MCHC was slightly dependent on serum iron (r=0.59) and showed the highest values coincidently with Hb. Erythrocyte sedimentation rate (ESR) of the reindeer calves averaged about 1 mm/hour during the calfhood summer and autumn (Table 2).

The serum iron concentration of the newborn calf was rather low (26.4 μmol/l) but almost doubled during the first summer (Table 3). The serum iron values were slightly higher in calves than in hinds during summer and autumn. The total iron binding capasity (TIBC) of adult females (n=9, group 27) ranges from 24 to 50 μmol/l (average mean 36 μmol/l). The TIBC values of calves (n=9, group 28) ranged from 31 to 49 μmol/l (average mean 41 μmol/l) at about 5 months of age during autumn.

The total serum bilirubin concentration remained relatively constant in all age groups (see Table 3). The serum conjugated bilirubin concentration was significantly higher in calves than in adult hinds during present study. Vitamin B_{12} was highest in the neonatal period.

The white blood cell count (WBC) ranged from 6.1 to 10.1 x 10^9/l and showed a significant increase during the first weeks of life ($P<0.01$) reaching its maximum and adult level in autumn. The differential leucocyte count showed no significant age-related variation (see Table 4).

Seasonal changes

High haematological values were found for calves and hinds during autumn. The Hb and PCV of the free-grazing hinds and calves decreased slightly during winter. However, the highest Hb values were found for the pregnant hinds fed on silage and molasses during winter and early spring (group 44) (see Table 2). The Hb, PCV and RBC of the pregnant hinds (group 1) dropped, but WBC and ESR increased after parturition ($P<0.001$, $P<0.1$, $p<0.05$, $P<0.05$, $P<0.001$, respectively). The calculated E-MCV, E-MCH, and E-MCHC values reflected the changes in Hb, PCV and RPC values (Table 2).

Very low serum iron concentration was measured for the hinds (27.2 μmol/l) living in a poor nutritional state in late April (group 47, Table 3). Serum iron decreased significantly ($P<0.001$) but the total serum bilirubin concentration rose ($P<0.01$) after parturition in this study.

DISCUSSION

The reindeer is a typical seasonal breeder having its period of heat between the end of August and the end of October. Under favourable conditions calves may reach sexual maturity by an age of 5 to 6 months (Borozdin 1969; Roine 1974), but under poor conditions only at 3.5 years of age (see Holthe 1975). Gestation takes usually 208 to 228 days depending on ambient conditions (Varo 1964; McEwan & Whitehead 1972, Dott & Utsi 1973). The reindeer foetus gains weight slowly during the first months of gestation and six weeks before delivery the weight of the foetus is only about 2 kg (Roine 1974).

Calving commences usually in late April and reaches its peak in mid-May (Nieminen et al. 1978). A healthy calf gets up and begins to suck within half an hour or an hour after birth (Espmark 1971). The average birth weight is 4 to 6 kg but it depends on the grazing condition under which the hinds are kept. The maximum rate of live weight gain in the reindeer/caribou occurs at the time of weaning giving an excess of 0.3—0.4 kg/day (see McEwan & Whitehead 1971; Nieminen et al. 1980).

Although the developing reindeer foetus almost triples its weight during the six weeks before parturition (Roine 1974), the energy demands of the hind increases by only 15% (McEwan & Whitehead 1971). Calving in itself usually seems to be relatively easy in all species of Cervidae with only minor haemorrhage. The adult reindeer, nevertheless, may develop an iron deficiency anaemia during lactation (see McEwan 1968) regardless of ever increasing nutritional supply provided by fresh green herbage. In the present study the Hb, PCV and RBC values some days before calving were relatively high, as was serum iron. After calving relative anaemia developed, possibly due to lactation and the breakdown of erythrocytes. The higher ESR in hinds was also probably related to recent parturition.

The newborn calf is absolutely dependent on milk until rumen function develops, usually between 4 and 6 wk of age (see Leat 1970), and hence the survival and growth rate of offspring can bee correlated with milk production (Nieminen et al. 1980). The milk of the reindeer is outstandingly rich in protein (about 10%) and fat (about 20%, see Arman 1979), although lactation begins before all the snow has melted and the hinds are in a very lean condition, a negative energy balance obviously exists (White & Luick 1976). The milk energy output of reindeer is comparable with that of domestic species during the peak of lactation, although the high yields are not maintained for a long period. Linzell (1972) calculated that the energy content of reindeer milk ranges from 6.7 to 8.4 MJ/l during lactation, and it is far above the 3 MJ/l found in the average cow's milk (Porter 1978). LeResche and Davies (1971) reported that the calf rearing «cost» to the Alaskan moose was an 8 to 18 % reduction in the cow's July-August weight and the energy cost during pregnancy and lactation may approach 50% of maintenance level (Gasaway & Coady 1974).

The foetal Hb concentration as expressed by g/100 g of foetal body tissue decreases during the first weeks of development and is about 0.1 g/100 g in the seventh week (Irzhak & Moisejenko 1972) but increases thereafter and reaches the highest value at birth. At the age of 1 day, the reindeer calf has, however, a relatively low blood Hb concentration, PCV and RBC, and these values decrease during the first days after birth (McEwan & Whitehead 1969; Irzhak et al. 1973), and then increase having peak values at 3—4 months, followed by a gradual decrease to adult levels, as observed also for white-tailed deer (Tumbleson et al. 1970), cattle (Greatorex 1954), sheep (Ullrey et al. 1965), goat (Holman & Dew 1963) and pig (Wintrobe 1962). The Hb and RBC values of the newborn reindeer calves were similar to those reported for reindeer calves in the USSR (Irzhak et al. 1973) and also white-tailed deer (White & Cook 1974) and black-tailed deer calves (Cowan & Bandy 1969). As compared to caribou calves (see McEwan & Whitehead 1969), Hb and PCV values were much lower, but leucocyte values (WBC) were higher in the newborn reindeer calves.

The blood volume of the reindeer is large, about 106 to 139 ml/kg (see Timisjärvi 1978) which is of the same magnitude as the warmblooded race horse has. Splenic concentrations during the initial phases of handling stress are probably responsible for increases of the PCV, Hb and RBC in caribou (Karns & Crichton 1978). However, reindeer, like the other animals showing a high level of physical activity and performance, have larger blood values than the less active species. One explanation for high blood volume and Hb values may be adjustment of the vascular system to the demands for high oxygen carrying capasity in the reindeer (see Timisjärvi et al. 1981).

The Hb, PCV and WBC values of the adult hinds show clear seasonal changes, significantly higher levels being found in the autumn than in the spring, and the present series agrees with earlier findings on the Finnish reindeer (Timisjärvi et al. 1976) and barren ground caribou (Gibbs 1960; McEwan 1968) but differs slightly from those reported by Afanasev (1963), Dieterich (1970) and Dieterich and Luick (1971). White-tailed deer (White & Cook 1974), black-tailed deer (Cowan & Bandy 1969), mule deer (Anderson et al. 1970), Idaho elk (Vaughn et al. 1973), Alaskan moose (Franzmann et al. 1976), wild bighorn sheep and

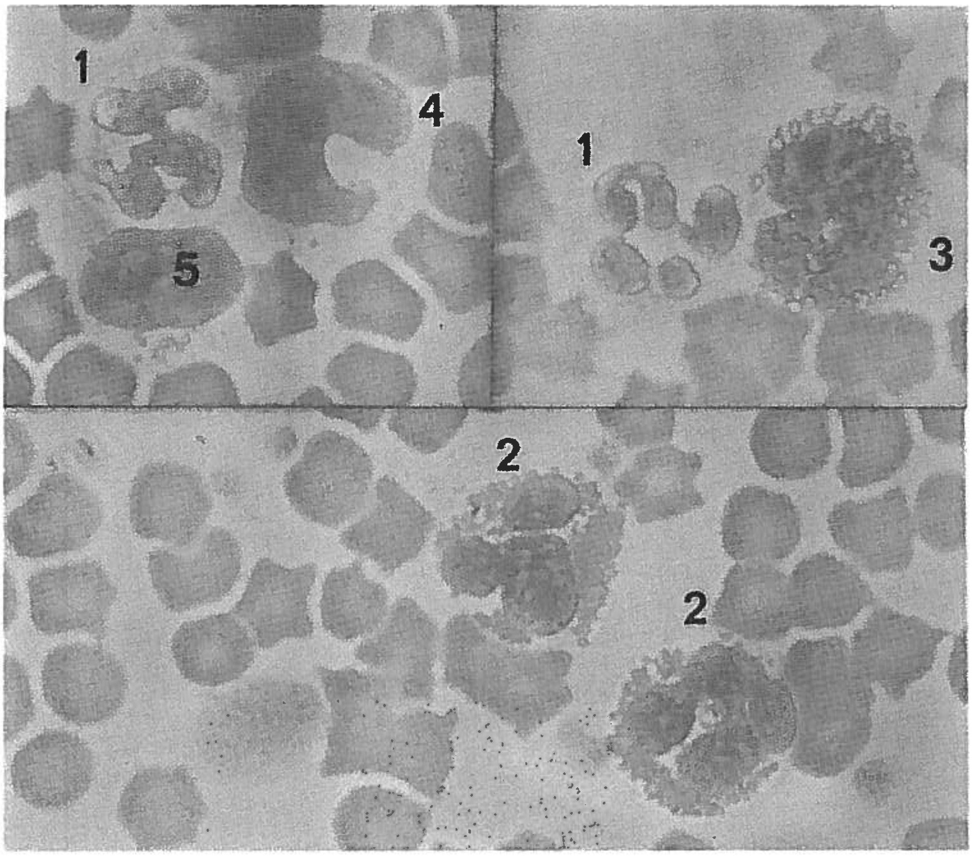

Fig. 3. A smear for different leucocyte count of reindeer blood (magnification x 1000) showing neutrophil granulocyte (1), eosinophil granulocyte (2), basophil granulocyte (3), monocyte (4) and lymphocyte (5). Stained with May-Grünwald-Giemsa stain.

Utstryk for differensialtelling av leukocyter i reinsdyrblod (1000 x forstørrelse). Det viser neutrofile (1), eosinofile (2) og basofile (3) granulocyter, monocyter (4) og lymfocyter (5). Farget med May-Grünwald-Giemsa farge.

also American bison (Marler 1975) have blood values similar to those of the reindeer (see Nieminen 1980 a,b) while e.g. goat and sheep have somewhat lower values (Ullrey et al. 1965). The very high PCV (56-58%, Krog et al. 1976) in Spitzbergen reindeer is somewhat surprising as one usually finds lower PCV in the late winter and spring (Nieminen 1980b). The hinds maintained under very poor nutritional conditions (group 47) had very low serum iron values slightly higher ESR, but Hb, PCV and RBC values were only slightly lower.

The WBC values agree with the former observations made by Afanasev (1963) and Dieterich (1970). The low ESR values for the reindeer calves are similar to those reported for white-tailed deer (White & Cook 1974) and mule deer calves (Kitts et al. 1956). The ESR of the adult hinds varies from 3 to 22 mm/hour (Dieterich & Luick 1971). The ESR varies more widely (1-61 mm/hour) in white-tailed deer, and it tends to be higher in weaker animals than in stronger ones (Teeri et al. 1958).

Sickling of erythrocytes in Cervidae is usual. Sickled deer erythrocytes are often similar in shape to those seen in human sickle cell anaemia, and it is interesting that this phenomenon was first recognised in deer (Gulliver 1840), 70 years before the human condition was noticed. Sickle cells have so far been found e.g. in red deer, fallow deer, white-tailed deer and Idaho elk (see Unditz et al. 1960), and it has been suggested that the condition can occur in all species of Cervidae. No sickling of erythrocytes s, however, observed in reindeer (see Nieminen 1980a,b), and it agrees closely with the results eported by Hawkey (1975). The size of erythrocytes agrees with earlier findings on eindeer (Dieterich 1970), caribou (McEwan 1968) or other cervids, but the osmotic fragility Timisjärvi et al. 1976) differs from that noted in nany other species.

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Table 1. Animals used in the study and the sampling conditions. (Numering of groups according to age and season. F=female, M=Male).
Dyr anvendt i undersøkelsen. Forholdene ved prøvetaking. (Nummerering av grupper i h.h.t. alder og årstid. F=hunndyr, M=hanndyr).

Group *Gruppe*	n *n*	Sex *Kj.*	Age *Alder*	Weight(kg) $\bar{x} \pm SE$ *Vekt (kg)*	Sampling time *Dato for prøvetak*	Locality *Lokalitet*	Living conditions before sampling (at least 1 month) *Leve- og beiteforhold for prøvetaking (min. 1 mnd.)*
1	15	F	3-5 years (pregnant)	67.6±1.4	10.5.-	Inari (69°10'N)	In captivity outdoors. Snow conditions diffucult for digging *Cladonia* lichens Fed on dry horesetails (*Equisetum* spp.) and molasses.
2	13	F	3-5 years (lactating)	60.2±1.4	10.6.1977	"	"
3	20	F,M	1 day	5.3±0.2	"	"	Calves of the hinds in groups 1 and 2. Main food milk from the hind.
4	20	F,M	3 days	6.1±0.2	"	"	"
5	20	F,M	6 days	6.9±0.3	"	"	"
6	20	F,M	10 days	7.8±0.3	"	"	"
7	20	F,M	20 days	10.1±0.5	"	"	"
8	11	F	3-5 years (lactating)	57.7±2.0	20.6.1978	Rovaniemi (66°70'N)	Freely grazing on good summer pasture. Good supply of *Betula* and *Salix* leaves and green grasses.
9	10	F,M	1 month	11.6±0.7	"	"	Calves of the hinds in group 8. Main food milk and *Betula* and *Salix* leaves.
10	10	F	3-5 years (lactating)	57.1±1.2	27.6.1977	Kuusamo (66°30'N)	Freely grazing on especially good sommer pasture. Living conditions as group 8.
11	10	F,M	1 month	12.4±0.8	"	"	Calves of the hinds in group 10. Living conditions as group 9.
12	32	F	3-9 years (lactating)	56.2±1.1	30.6.1973	"	Freely grazing on good summer pasture. Living conditions as group 8.
13	33	F,M	1 month	14.8±0.5	"	"	Calves of the hinds in group 12. Living conditions as group 9.
14	7	F,M	2 months	23.6±1.2	2.7.1975	"	Calves grazing on good summer pasture. Living conditions as group 9.
15	24	F	3-9 years	66.3±1.3	2.-5.10.1973	"	Freely grazing in the forests. Good supply of mushrooms (*Boletus* spp.) and green grasses.
16	15	F,M	5 months	35.7±0.8	"	"	Calves of the hinds in group 15. Main food the same as for the hinds, but most were also still suckling.
17	8	F	3-5 years	66.3±1.3	4.10.1978	"	Freely grazing in the forests. Living conditions as group 15.
18	8	F,M	5 months	41.4±1.2	"	"	Calves of the hinds in group 17. Living conditions as group 16.
19	9	F	3-5 years	66.3±1.5	6.10.1977	"	Freely grazing in the forests. Living conditions as group 15.
20	8	F,M	5 months	40.1±1.4	"	"	Calves of the hinds in group 19. Living conditons as group 15.
21	27	F	3-5 years	66.3±0.9	10.10.1973	Pudasjärvi (65°40'N)	Freely grazing in the forests. Living conditions as group 15.
22	14	F,M	18 months	48.6±1.2	"	"	"
23	11	F,M	5 months	46.2±0.8	"	"	Calves of the hinds in group 21. Living conditons as group 16.
24	10	F	3-5 years	65.0±1.3	10.10.1975	Kittilä (67°70'N)	Freely grazing in the forests. Good supply *Deschampsia flexuosa* grass and *Cladonia* lichens.

25	2	M	3-5 years	78.2±2.4	"	"	"
26	23	F,M	5 months	36.3±0.9	"	"	Calves of the hinds in group 24. Living conditions as the hinds, but most were also still suckling.
27	9	F	3-5 years	65.8±1.5	10.10.1978	Rovaniemi (66°70'N)	Freely grazing in the forests. Living conditions as group 24.
28	9	F,M	5 months	45.1±3.2	"		Calves of the hinds in group 27. Living conditions as group 26.
29	4	F	3-5 years	61.3±0.7	3.11.1975	Pudasjärvi (65°40'N)	Freely grazing in the forests. Living conditions as group 24.
30	7	F,M	18 months	50.1±2.0	"	"	"
31	16	F,M	6 months	38.4±1.2	"	"	"
32	18	F	3-9 years	70.3±1.9	6.-9.2.1974	Kuusamo (66°30'N)	Freely grazing in the forests at timber-cutting sites. Snow conditions farourable for digging for *Cladonia* and grass. Good supply of *Alectoria* and *Bryoria* spp.
33	5	F,M	9 months	40.3±1.8	"	"	"
34	4	F	3-5 years	65.6±3.2	8.2.1978	Savukoski (67°90'N)	Freely grazing in the forests and mountain areas. Snow conditions difficult for digging for *Cladonia* lichens.
35	8	F,M	9 months	40.3±1.0	"	"	"
36	6	F	3-5 years	67.2±1.3	18.2.1978	Kuusamo (66°90'N)	Freely grazing in the forests. Snow conditions difficult for digging for *Cladonia* lichens, but good supply of arboreal lichens (*Alectoria* and *Bryoria* spp.).
37	6	F,M	9 months	38.2±0.8	"	"	
38	6	F	3-5 years	64.7±1.4	22.2.1979	Savukoski (67°90'N)	Freely grazing in the forests or mountain areas. Snow conditions very difficult for digging for *Cladonia* lichens.
39	10	F,M	9 months	36.2±0.9	"	"	"
40	7	F	3-9 years (pregnant)	63.2±2.5	9.-14.3.1973	Kuusamo (66°30'N)	In captivity outdoors. Fed om dry hay (ad libitum), dry leaves *Betula* and *Cladonia* lichens.
41	11	F	3-9 years (pregnant)	61.1±1.4	"	"	Freely grazing in the forests. Living conditions as group 32.
42	7	F	3-5 years (pregnant)	62.3±1.2	23.3.1979	"	In captivity out of doors. Living conditions as group 40.
43	10	F,M	10 months	38.1±0.6	"	"	"
44	6	F	3-5 years (pregnant)	67.8±2.1	29.3.1979	Kiiminki (65°10'N)	In captivity, fed on silage and molasses during 3—4 months before sampling.
45	12	F	3-9 years (pregnant or aborted)	55.2±1.3	13.4.1973	Enontekiö (68°30'N)	Freely grazing in the forests or mountain areas. Hard crust on the snow and digging conditions for *Cladonia* lichens very difficult. During sampling a large number reindeer in this area died of malnutrition.
46	9	F,M	11 months	40.6±1.4	21.4.1976	Posio (66°10'N)	In captivity outdoors. Fed on dry hay (*Phleum pratense*), dry leaves of *Betula* and *Salix* lichens (*Cladonia* spp.) and molasses.
47	8	F	3-5 years (pregnant or aborted)	(50-55)*	30.4.1979	Sodankylä (68°10'N)	Freely grazing in the forests or mountain areas. Living conditions as group 45.

*Approximated body weight.

Table 2. Haematological values ($\bar{x}$±SE) for the reindeer in different groups as presented in Table 1. (The statistical significances are given in the text).
Blodverdier ($\bar{x}$±SE) for reinsdyr i forskjellige grupper som vist i Tabell 1. (Den statistiske sikkerhet er gitt i teksten).

Group *Gruppe*	Season *Årstid*	Age *Alder*	Hb *(g/l)*	PCV *(%)*	RBC *($10^{12}/l$)*	E-MCHC *%*	E-MCV *(fl)*	E-MCH *(pg)*	ESR *(mm/h)*
1	Spring	3-5 years (pregnant)	156.4±5.4	44.8±0.9	10.3±0.7	35.2±1.0	45.5±1.0	15.3±0.8	4.2±0.2
2	"	3-5 years (lactating)	118.3±3.6	42.2±0.9	8.4±0.4	28.4±1.3	51.4±2.8	15.0±0.9	21.4±0.4
3	"	1 day	108.1±5.2	35.4±1.2	7.9±0.4	30.6±1.1	46.4±2.3	14.6±1.3	1.0±0.2
4	"	3 days	101.4±4.2	34.6±1.4	8.1±0.6	29.6±1.0	45.3±2.7	13.2±0.8	1.0±0.2
5	"	6 days	106.6±5.3	36.0±1.4	8.6±0.5	30.1±1.6	44.1±3.4	12.8±0.8	0.9±0.2
6	"	10 days	119.6±4.5	40.2±1.0	9.5±0.5	29.9±1.0	43.7±1.9	13.1±0.5	1.0±0.2
7	"	20 days	118.0±3.7	43.1±0.9	8.1±0.4	26.9±0.7	54.9±2.1	14.8±0.7	1.0±0.5
8	Summer	3-5 years (lactating)	132.2±2.0	40.0±0.9	8.2±0.7	33.1±0.9	48.8±1.3	16.1±0.8	8.4±0.4
9	"	1 month	126.2±4.5	40.0±1.0	8.0±0.5	31.6±1.1	50.0±1.9	15.8±0.6	1.0±0.3
10	"	3-5 years (lactating)	135.4±3.2	43.4±0.8	8.4±0.3	31.2±0.8	51.7±1.2	16.1±0.6	10.8±0.6
11	"	1 month	140.3±2.8	44.2±0.6	9.8±0.4	31.7±0.8	45.1±1.0	14.3±0.8	2.2±0.2
12	"	3-9 years (lactating)	126.9±5.1	40.0±1.0		31.4±1.3			
13	"	1 month	135.7±2.9	48.0±1.0		27.7±0.5			
14	"	2 months	145.2±6.1	52.0±0.0	10.1±0.4	28.0±1.1	51.5±1.2	14.3±0.6	2.4±0.3
15	Autumn	3-9 years	143.5±6.5	49.1±1.1		29.2±1.0			
16	"	5 months	145.4±5.0	51.4±0.5		28.3±0.6			
17	"	3-5 years	185.2±3.2	51.4±0.8	11.2±0.4	36.0±0.6	45.8±1.0	16.3±0.7	4.0±0.5
18	"	5 months	182.1±2.4	53.6±0.9	11.8±0.5	33.3±0.4	45.4±1.1	15.1±0.6	1.4±0.4
19	"	3-5 years	184.3±4.8	51.0±0.7	10.9±0.3	36.3±1.1	47.2±1.2	17.0±0.7	4.1±0.6
20	"	5 months	183.5±3.7	54.3±0.6	11.8±0.3	34.7±0.4	45.7±1.1	15.9±0.5	2.0±0.4
21	"	3-5 years	177.0±3.0	45.0±0.8	9.1±0.3	39.3±0.3	49.1±1.0	19.5±0.4	4.2±0.4
22	"	18 months	181.0±2.9	47.0±0.8	8.9±0.3	38.7±0.2	54.4±1.7	21.0±0.6	
23	"	5 months	180.0±3.1	47.0±0.9	9.0±0.2	38.3±0.4	54.7±3.1	20.5±0.5	
24	"	3-5 years	172.0±4.0	47.8±1.2		35.5±0.6			
25	"	3-5 years	183.4±2.7	51.2±0.8		35.8±0.4			
26	"	5 months	186.0±4.0	51.0±0.7		36.3±0.7			
27	"	3-5 years	178.4±2.1	51.0±0.8	10.6±0.4	35.0±1.1	48.1±2.2	16.8±0.8	4.4±0.7
28	"	5 months	180.6±3.8	48.6±1.0	9.8±0.7	37.2±0.8	49.6±1.6	18.4±0.9	1.0±0.4
29	"	3-5 years	196.7±1.4	48.0±0.8	10.2±0.7	40.4±0.6	47.0±2.1	19.4±0.2	
30	"	18 months	156.0±1.3	40.0±3.7	8.6±0.6	39.5±0.8	46.0±1.4	18.0±0.3	
31	"	6 months	193.0±5.0	49.0±1.1	10.3±0.2	37.0±0.6	47.0±0.4	19.0±0.2	
32	Winter	3-9 years	158.3±3.0	50.9±1.0		31.1±0.9			
33	"	9 months	159.8±1.8	51.0±2.0		31.3±1.4			

(Continued p. 22)

(Table 2 cont.)
(Tabell 2 forts.)

34	"	3-5 years	167.8±6.4	47.6±1.9	10.7±0.8	35.3±0.3	44.8±1.1	15.8±0.4	3.5±0.6
35	"	9 months	166.0±5.6	49.4±1.7	11.4±0.3	33.5±0.5	43.6±2.4	14.7±0.8	2.2±0.8
36	"	3-5 years	174.6±4.2	49.2±1.5	10.1±0.3	35.5±0.4	48.7±0.7	17.2±1.0	3.0±0.4
37	"	9 months	178.0±3.6	49.5±0.8	9.1±0.5	36.0±0.2	54.4±0.8	19.5±0.7	1.6±0.2
38	"	3-5 years	162.3±3.6	46.4±1.2	9.3±0.7	35.0±0.5	49.9±0.9	17.5±0.8	4.0±0.6
39	"	9 months	165.6±4.6	47.2±0.8	10.8±0.8	35.1±0.6	43.7±0.4	15.3±0.7	1.2±0.4
40	Early spring	3-9 years (pregnant)	151.7±9.8	47.4±0.8		32.0±0.6			
41	"	3-9 years (pregnant)	153.3±3.9	47.8±1.0		32.1±0.8			
42	"	3-5 years (pregnant)	170.3±5.6	46.3±1.5	9.1±0.3	36.8±0.4	50.9±0.5	18.7±1.0	9.6±1.2
43	"	10 months	182.0±7.3	49.7±0.8	9.1±0.5	36.6±0.2	54.6±0.8	20.0±0.7	5.8±0.8
44	"	3-5 years (pregnant)	196.7±4.8	49.3±0.9	10.3±0.8	39.9±0.3	47.9±0.6	19.1±0.8	5.6±0.6
45	"	3-9 years (pregnant or aborted)	156.0±4.4	44.6±2.0		34.9±0.4			
46	"	11 months	176.4±3.8	48.2±1.8		36.6±0.5			
47	"	3-5 years (pregnant or aborted)	164.2±3.8	47.0±0.9	9.4±0.8	34.9±0.6	50.0±0.8	17.5±0.7	17.4±1.3

Table 3. Serum iron, bilirubin and vitamin B_{12} values ($\bar{x}$±SE) for the reindeer in different groups as presented in Table 1 (the statistical significances are given in the text).
Verdier av serumjern, bilirubin og vitamin B_{12} ($\bar{x}$±SE) hos reinsdyr i forskjellige grupper vist i Tabell 1 (statistisk sikkerhet er gitt i teksten.

Group *Gruppe*	Season *Årstid*	Age *Alder*	Iron (μmol/l) *Jern*	Total bilirubin (μmol/l) *Total bilirubin*	Conjugated bilirubin (μmol/l) *Bundet bilirubin*	Vitamin B_{12} *Vitamin B_{12}*
1	Spring	3-5 years (pregnant)	51.0±1.5	2.4±0.1	2.0±0.2	227.0±14.5
2	"	3-5 years (lactating)	30.7±1.7	4.9±0.9	2.9±0.4	228.5±12.9
3	"	1 day	26.4±3.4	6.2±0.8	4.3±0.7	360.2±50.4
4	"	3 days	34.5±3.9	6.6±1.4	4.6±1.1	324.0±27.9
5	"	6 days	44.3±5.6	7.5±0.6	5.2±0.7	313.8±23.6
6	"	10 days	37.7±5.2	7.4±0.7	6.0±0.8	253.5±26.6
7	"	20 days	43.0±5.2	6.1±0.5	4.7±0.5	242.2±15.9
8	Summer	3-5 years (lactating)	25.3±1.2	4.8±0.6	3.1±0.7	292.4±13.1
9	"	1 month	42.0±5.1	4.8±0.8	4.2±0.6	230.1±17.3
10	"	3-5 years (lactating)	23.2±0.8	4.6±0.6	2.9±1.0	302.4±14.2
11	"	1 month	41.8±0.7	4.7±0.6	4.0±1.2	212.5±13.2
14	"	2 months	40.2±0.6	4.8±0.7	4.3±0.8	221.2±12.3
17	Autumn	3-5 years	39.2±2.1	4.6±0.6	2.8±0.3	240.2±10.1
18	"	5 months	42.3±4.0	5.1±0.8	3.1±0.2	237.6±9.8
19	"	3-5 years	37.5±3.2			
20	"	5 months	44.0±2.6			
21	"	3-5 years	23.0±1.2			
22	"	18 months	16.0±1.2			
23	"	5 months	21.0±0.9			
24	"	3-5 years	36.4±2.6	4.9±0.5	3.6±0.4	146.3±10.7
25	"	3-5 years	42.3±1.8	4.7±0.6	3.3±0.5	143.0±11.0
26	"	5 months	46.8±1.2	5.1±0.4	3.6±0.2	156.4±8.7
27	"	3-5 years	54.2±1.6	4.8±0.8	2.7±0.3	234.3±10.2
28	"	5 months	44.2±2.1	5.0±0.6	4.3±0.5	203.6±15.0
29	"	3-5 years	22.0±2.0	3.4±0.4	1.8±0.2	125.4±17.0
30	"	18 months	23.2±2.4	3.0±0.3	1.7±0.2	116.4±8.8
31	"	6 months	22.7±1.6	4.2±0.4	2.0±0.2	123.8±10.2
34	Winter	3-5 years	29.4±1.8			
35	"	9 months	30.1±2.2			
36	"	3-5 years	28.2±3.1			
37	"	9 months	29.6±2.4			
[illegible]	"	3-5 years	29.1±2.2			

(Continued p 24)

(Table 3 cont.)
(Tabell 3 forts.)

39	"	9 months	29.4±1.8			
40	Early spring	3-9 years (pregnant)	30.6±2.4			
41	"	3-9 years (pregnant)	27.5±1.9			
42	"	3-5 years (pregnant)	31.6±2.2	3.9±0.3	2.8±0.5	168.4±8.0
43	"	10 months	33.4±1.8	4.4±0.4	3.0±0.8	181.7±7.1
44	"	3-5 years (pregnant)	42.6±2.0	4.8±0.6	3.0±0.4	142.3±7.6
45	"	3-9 years (pregnant or aborted)	29.1±1.3			
46	"	11 months	30.2±2.1			
47	"	3-5 years (pregnant or aborted)	27.2±2.9	3.1±0.3	2.3±0.2	150.4±8.4

Table 4. White blood cells and differantial leucocyte count ($\bar{x}\pm SE$) for the reindeer in different groups as presented in Table 1 (the statistical differences are given in the text).
Hvite blodceller og differansialtelling av leukocyter ($\bar{x}\pm SE$) bos reinsdyr i forskjellige grupper vist i Tabell 1 (statististisk sikkerhet er gitt i teksten).

Group *Gruppe*	Season *Årstid*	Age *Alder*	WBC (10^9/l)	Lympho-cytes (%)	Neutro-philes (%)	Eosino-philes (%)	Mono-cytes (%)	Baso-philes (%)
1	Spring	3-5 years (pregnant)	6.4±0.2	40±2	45±3	11.1±1.5	1±0.4	4±0.5
2	"	3-5 years (lactating)	7.0±0.2	41±3	38±3	13.2±1.5	2±0.5	5±1.0
3	"	1 day	6.1±0.2	33±2	61±2	0.8±0.3	3±0.4	2±0.8
4	"	3 days	6.3±0.3	39±2	54±2	0.2±0.2	6±0.8	1±0.2
5	"	6 days	7.5±0.3	35±2	56±2	0.5±0.2	6±0.6	1±0.2
6	"	10 days	7.2±0.3	39±3	56±3	0.2±0.1	4±0.7	1±0.0
7	"	20 days	7.5±0.3	42±3	54±4	0.4±0.2	3±0.5	1±0.1
8	Summer	3-5 years (lactating)	7.8±0.4	36±3	40±4	14.3±0.5	3±0.2	4±0.2
9	"	1 month	7.5±0.3	32±2	50±3	5.6±0.2	2±0.4	2±0.2
10	"	3-5 years (lactating)	7.7±0.2	35±9	36±3	18.1±2.3	5±0.8	5±0.9
11	"	1 month	7.4±0.3	34±4	59±4	8.8±0.3	1±0.1	5±1.4
14	"	2 months	6.2±0.5	58±7	27±7	9.4±2.1	3±0.8	3±1.1
17	Autumn	3-5 years	8.6±0.9	22±6	56±4	9.1±2.4	2±0.6	5±1.1
18	"	5 months	8.4±0.7	28±3	42±4	9.0±0.8	1±0.2	6±0.7
19	"	3-5 years	10.1±0.8					
20	"	5 months	10.0±0.8					
21	"	3-5 years	4.8±0.7	21±5	59±4	9.0±0.2	1±0.1	5±0.7
22	"	18 months	6.0±0.9	28±2	44±3	17.1±0.4	1±0.1	12±0.8
23	"	5 months	3.5±0.8	22±3	54±4	9.0±0.7	1±0.1	10±1.1
24	"	3-5 years	4.2±0.8	29±3	36±6	16.6±2.0	2±0.6	4±0.6
25	"	3-5 years	5.6±0.6	32±2	46±3	5.7±0.8	4±0.5	3±0.9
26	"	5 months	4.8±0.7	33±3	43±3	10.2±1.2	5±0.6	8±2.2
27	"	3-5 years	7.8±0.1	42±3	52±2	5.1±0.4	2±0.3	2±0.2
28	"	5 months	7.8±0.4	40±4	53±3	5.5±0.3	5±0.4	3±0.1
29	"	3-5 years	4.7±1.6	42±7	39±4	10.1±2.1	2±0.3	5±0.9
30	"	18 months	3.4±0.6	39±8	36±4	19.3±3.2	1±0.3	5±0.8
31	"	6 months	5.6±0.7	43±8	33±3	13.0±1.4	2±0.3	9±0.9
34	Winter	3-5 years	7.7±0.8					
35	"	9 months	7.9±0.5					
36	"	3-5 years	6.2±0.4					
37	"	9 months	7.4±0.6					
38	"	3-5 years	8.5±1.0					
39	"	9 months	8.6±1.2					

(Continued p. 26)

(Table 4 cont.)
(Tabell 4 forts.)

40	Early spring	3-9 years (pregnant)	7.6±0.8					
41	"	3-9 years (pregnant)	6.9±0.6					
42	"	3-5 years (pregnant)	6.1±0.3	38±3	50±3	11.3±2.2	2±0.3	5±1.9
43	"	10 months	7.3±0.6	39±5	53±4	7.4±1.8	3±0.2	5±1.4
44	"	3-5 years (pregnant)	7.6±0.4	40±2	38±7	10.1±0.9	4±0.3	3±0.8
45	"	3-9 years (pregnant or aborted)	7.8±0.3					
46	"	11 months	8.4±0.6					
47	"	3-5 years (pregnant or aborted)	8.6±0.4	41±3	44±2	18.3±1.6	1±0.5	5±0.4